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Fire Safety Optimization through Assessment of Active and Passive Fire Protection Systems in High-Rise Structures

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Abstract: *Fire incidents in high-rise buildings continue to pose significant threats to human life, property, business continuity, and the environment. Rapid urbanization, increasing population density, and the growing demand for mixed-use high-rise developments have amplified the complexity of fire safety management in modern buildings. Mixed-use high-rise structure accommodate diverse occupancies such as residential, commercial, office, retail, and recreational facilities within a single structure, thereby increasing fire risks and presenting unique challenges in fire prevention, detection, suppression, evacuation, and emergency response.*

The present study aims to evaluate the effectiveness, adequacy, and operational performance of fire protection systems installed in selected mixed-use high-rise buildings in Indore city. The study focuses on both active fire protection systems, including fire detection and alarm systems, automatic sprinkler systems, fire hydrants, hose reels, smoke management systems, and portable fire extinguishers, as well as passive fire protection measures such as fire-resistant construction, compartmentation, fire doors, protected escape routes, and emergency exits.

A combination of quantitative and qualitative research methodologies was adopted to achieve the objectives of the study. Primary data were collected through site inspections, structured questionnaires, interviews with facility managers and fire safety personnel, document reviews, and fire safety audits. The performance of various fire protection systems was assessed using a risk-based evaluation framework and compliance criteria based on the National Building Code (NBC) of India, relevant Bureau of Indian Standards (BIS) provisions, and fire safety best practices. Performance indices and statistical analysis techniques were employed to evaluate system effectiveness and identify deficiencies affecting overall fire safety performance.

The findings of the study indicate that while most buildings have installed essential fire protection systems, several shortcomings exist in system maintenance, periodic testing, occupant awareness, emergency preparedness, evacuation planning, and integration between active and passive fire protection measures. The study further reveals that the effectiveness of fire safety management depends not only on the availability of fire protection equipment but also on regular inspection, maintenance, training, and adherence to fire safety regulations.

The research concludes that optimal fire safety in mixed-use high-rise buildings can be achieved through a comprehensive and integrated approach that combines effective fire protection systems, robust fire safety management practices, regulatory compliance, and continuous improvement mechanisms. The recommendations provided in this study are expected to assist building owners, facility managers, safety professionals, and regulatory authorities in enhancing fire safety performance and reducing fire-related risks in high-rise developments..

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Keywords: Fire Protection Systems, Fire Safety Management, Mixed-Use High-Rise Buildings, Fire Risk Assessment, Fire Safety Optimization, Active and Passive Fire Protection, Emergency Preparedness, NBC 2016, Industrial Safety Engineering etc

I. INTRODUCTION

The rapid growth of urbanization has led to the increasing development of high-rise buildings as an effective solution to accommodate rising population density and the shortage of urban land. Since the 19th century, high-rise buildings have evolved significantly with advancements in construction technology and the integration of modern life-support systems such as elevators, HVAC systems, lighting, and ventilation, making them comparable in comfort to low-rise structures.According to the National Fire Protection Association (NFPA) and the National Building Code (NBC) of India, a high-rise building is defined as a structure exceeding 15 meters in height measured from the lowest level of fire department access to the highest occupiable floor. In the Indian context, fire safety has become a critical concern, with the National Crime Records Bureau reporting 20,377 fire incidents in 2014 alone, resulting in 19,513 deaths and 1,889 injuries—many of which could have been prevented through effective fire safety measures.Despite the presence of modern fire protection technologies, high-rise buildings continue to present significant fire safety challenges. These include limited accessibility for fire-fighting operations due to height, complex vertical evacuation issues such as stairwell congestion and the stack effect, inadequate fire safety management across different floors, and frequent modifications in building usage that compromise original fire safety designs. Additionally, complex mechanical systems such as HVAC ducts further contribute to fire and smoke propagation risks.In the Indian urban context, particularly in cities like Indore, several fire incidents in commercial high-rise buildings—such as SwarnBagh (2022), Golden Gate Hotel (2019), IDA Building (2022), and Satpura Bhawan (2023)—highlight the persistent gaps in fire safety compliance and system effectiveness. Therefore, this study aims to evaluate the adequacy and effectiveness of structural and physical fire protection systems in commercial high-rise buildings, with a focus on addressing inherent fire safety challenges. The findings are expected to contribute to improving fire safety design, compliance, and risk mitigation strategies in high-rise buildings.

II FIRE PROTECTION SYSTEMS

Conceptually, optimal fire protection can onlybe achieved through integration of three key fire safetyelements. These are fire prevention, protection, and suppression. The conceptin figure 1.0 below is used to demonstrate how an integrated fire safety planning and management system can be used to offer an overall fire safety in commercial high-rise buildings as illustrated below.

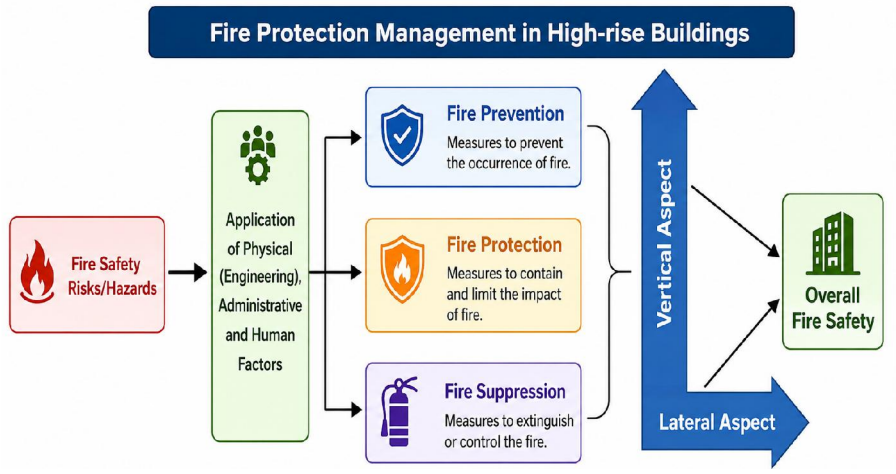

Figure 1.0: Systems Approach for Fire safety Management

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Fire prevention and suppression are concerned with control of fire from taking place and extinguishment respectively. Fire protection is a mechanism involving both fire prevention and suppression at design and occupation of a building. Normally, each of the three fire safety elements exhibit three critical safety controls i.e. physical control, management control and human control in fire safety management.

The NFPA guide to fire safety and NBC, in respect to these controls, hierarchically provides that, where possible, risk should be avoided, risks which cannot be avoided should be assessed and evaluated and that risks should be combated at source, control measures should adapt to technical progress and dangerous substances /articles should be replaced by the non- dangerous or less dangerous. It further provides that, coherent overall prevention policy should be developed, which covers technology, organization of work and the influence of factors relating to the working environment and that priority should be given to collective protective measures and employees should be given appropriate instruction. In practice, fire protection involves provision of fixed fire protection systems during construction of a building and thereafter installation and maintenance of specific fire protection equipment and installations. In time, most of fire protection systems will lose their vitality and functional capability due to myriad factors such as outright decay or obsolescence, vandalism, negligence, interference or change of user. All fire safety installations need to be tested individually, but interdependent fire safety installations need to be tested collectively to demonstrate satisfactory interfacing/ interlinking etc. Further, arrangements should be made for all fire protection systems such as fire detection and alarm systems, fire door control mechanisms, stair and lobby pressurization systems, evacuation and the fire-fighting lifts, portable and fixed fire extinguishers, emergency lighting systems and standby power systems to be regularly inspected and maintained.

Despite lack of sufficient and solid legislation and policy framework for fire protection in Kenya, there still exist scattered statutes relevant to general fire safety in occupancies. A law specially formulated for the purposes of fire protection in high- rise buildings is non-existent. The Occupational Safety and Health Act is the main legislation governing general safety and health in workplaces. The key provisions in the Act related to fire protection include sections and safe place of employment, Fire prevention, Safety provisions in case of fire and Evacuation procedures. The Factories and Other Places of Work (Fire Risk Reduction) rules and the National Buildings code Maintenance Policy which provides for effective maintenance that ensures adequate health, safety and environmental standards, return on investment, convenience and comfort for the building users. The legal requirement for fire protection systems provide in high-rise buildings is provided in the sections below:

Building Code (NBC) of India specifies various active and passive fire protection measures that must be incorporated into high-rise buildings.

1. Automatic Water Sprinkler System:-As per Section 7.10.7 of Part 4 of the National Building Code (NBC), automatic sprinkler systems are mandatory in basement parking areas and other high-risk locations where combustible materials are stored. Sprinklers are designed to detect and suppress fire at its early stage, thereby minimizing fire spread and property damage. Generally, each sprinkler head covers an area of approximately 6.96 m², and separate sprinklers should preferably be provided for individual parking bays. The sprinkler system may be connected to the building's main fire water storage tank and pumping system; however, the capacity of the water tank and pumps must be increased accordingly to meet the additional demand.

2. Fire Detection and Alarm System:-Section 7.9 of Part 4 of the NBC requires the installation of fire detection and alarm systems in high-rise buildings. Different types of detectors, including smoke, heat, and flame detectors, are selected based on the risk associated with specific areas. Detection zones are typically established floor-wise or according to occupancy risk. Buildings exceeding 15 m in height must be provided with both manual fire alarm systems and automatic fire alarm systems. Manual call points, automatic detectors, and public address systems should be interconnected to ensure prompt communication during emergencies. Installation and maintenance of fire alarm systems should comply with IS 2189.

3. Means of Escape:-According to Section 8.2.5 of Part 4 of NBC, all buildings must provide adequate means of escape for occupants during fire emergencies. Escape routes should be properly designed, adequately illuminated, ventilated,

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and maintained free from obstructions. Staircases and exit corridors should facilitate safe evacuation and be clearly identifiable under emergency conditions.

4. Emergency Lighting System:-The National Building Code requires an independent emergency power supply to provide illumination during power failures caused by fire or other emergencies. Emergency lighting systems assist occupants in identifying exit routes and enable safe evacuation from the building.

5. Smoke Control System:-Smoke inhalation is a major cause of fatalities during fire incidents. Therefore, high-rise buildings should be equipped with smoke management systems to control the movement of smoke and toxic gases. These systems may include smoke exhaust fans, pressurization systems for stairwells, and mechanical ventilation systems designed to maintain tenable conditions during evacuation.

6. Wet Risers, Hose Reels, and Hydrant System:-The NBC mandates the installation of wet risers, hose reels, and hydrant systems in buildings exceeding prescribed height limits. These systems provide a reliable water supply for firefighting operations. The fire water supply system must be designed to deliver adequate flow rate and pressure to all portions of the building. Hose reels and hydrants should be strategically located for easy access during emergencies.

7. Facilities for Persons with Disabilities:-Fire safety provisions for persons with disabilities are addressed in the NBC through requirements such as evacuation lifts, firefighting lifts, refuge areas, handrails, visual signage, and accessibility features. Building management must establish procedures for the safe evacuation of persons with special needs during emergencies.

Figure 2.0: Fire protection system in high rise building

8. Fire Safety Signs and Notices:-Appropriate fire safety signage is essential for effective emergency response. NBC guidelines require clearly visible and properly illuminated signs indicating exit routes, firefighting equipment locations, assembly points, and emergency instructions. These signs assist occupants in navigating safely during evacuation.

9. Portable Fire Extinguishers:-As per Section 7.10.4 of Part 4 of the NBC and IS 2190, portable fire extinguishers must be installed throughout the building as first-aid firefighting equipment. Depending on the fire hazard classification, suitable extinguishers such as water, foam, carbon dioxide (CO_2), or dry chemical powder (DCP) types should be provided at designated locations.

10. Fire Assembly Point:-A designated fire assembly point should be established outside the building at a safe distance from potential fire hazards. Following evacuation, occupants assemble at this location for headcount verification,

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emergency communication, and medical assistance. The assembly point also facilitates coordination between emergency responders and building management during rescue operations.

III MATERIAL AND METHODS

3.1 Description of Case studies

The project boundary is defined by the Indore City found in the Madhypradesh, India. Most of the high-rise buildings in the Indore are found within the plane area. A request letter accompanied by an introduction letter from was used to get the permission to conduct the research in their buildings. The buildings involved in the survey exhibited mixed-use character with varied types of businesses such as schools, health centers, retail shops, especially clothing and office blocks, and restaurants among others. Others have some floors partitioned to create space for establishment of stalls commonly referred to as exhibitions. The situations of the buildings are as contained in the table 1:

Table 1: The buildings involved in the study

S. No.	Building Code	No. of Floors	Year of Construction	Occupancy Type
1	B-1	25	2021	Mixed Use
2	B-2	17	2015	Residential
3	B-3	16	2000	Hotel
4	B-4	16	2015	Residential
5	B-5	16	2015	Residential
6	B-6	16	2015	Residential
7	B-7	15	2015	Residential
8	B-8	15	2015	Residential
9	B-9	15	2003	Hospital
10	B-10	24	2020	Residential
11	B-11	15	2015	Residential
12	B-12	10	2008	Commercial
13	B-13	15	2015	Mixed Use
14	B-14	15	2015	Residential

3.2 Sampling Design

A cross-sectional survey by use of mixed methods, quantitative and qualitative, was done on fourteen randomly selected commercial high-rise buildings in the Indore Metrocity. A requisite sample was generated by use of random tables where all the identified commercial high-rise buildings in the city were listed and involved in the sampling process Registry records from the department of City Planning and Architecture showed that the it has over 100 mixed use high-rise buildings. By use of random tables, the researcher selected 25No buildings. However, in only 14No (9.3%) of the buildings, the request to conduct research was accepted. Individual interview participants were selected through convenience and snowball sampling techniques (Mugenda and Mugenda, 2003). Some of the key resource persons from the Indore Fire Brigade (fire investigations section), Ministry of Public Works, Directorate of Occupational Safety and Health Services and the building managers and security in all the buildings involved in the survey.

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3.3. Methods and Techniques

Physical observations and inspections by use of a pre- designed fire safety risk assessment checklist (NFPA, 2008) and NBC Chapter-IV. Literature/document (inspection/maintenance reports, improvement orders) and; interviews to building managers and security staff, occupants and professionals in the construction sector were used in data collection. Each fire protection systems was checked or inspected against requirements of the NBC and standards to determine its sufficiency and/or suitability. International standards and practices were consulted where the local were deficient or non-existent. Due to diversity of fire protection systems and methods available for fire protection a multi-attribute Evaluation Model/Approach (Rasbash et al, 2004) was used. This helped compute the aggregate performance of the systems in respective buildings. An ordinal scale representing hierarchical levels A, B and C were used in determination of performance of each system or method in respective buildings where, A represented sufficient and/or suitable system, B represented insufficient or unsuitable system while C representedabsence of a particular system or method.

IV. RESULTS AND ANALYSIS

The analysis are based on the results of the observations or inspections of the various fire protection systems involved in the study as contained in table 2. As indicated in the section above A represents sufficiency and suitable situation of the system while B represents insufficiency and/or unsuitable situation. C represent absent or missing system.

Table 2: Status of fire protection systems status in buildings

Building Name		Sprinkler system	Fire Detection &Alarm	Escape route	Emergency Lighting	Smoke control system	Compartmentation	Riser mains, hose reels	Facilities for the disabled	Fire brigade access	Firefighting and	Safety signs and Notices	Portable Fire extinguishers	Fire Assembly Points
B-1		B	B	A	A	A	A	A	C	A	C	B	A	A
B -2		B	B	A	B	A	B	A	C	B	C	B	A	B
B -3		B	B	A	A	A	B	A	C	A	C	B	A	A
B -4		C	B	B	B	A	A	B	C	B	C	B	B	B
B -5		B	B	A	A	A	A	A	C	A	C	B	A	C
B -6		C	B	C	C	C	C	B	C	B	C	B	B	C
B -7		B	A	B	A	A	A	A	C	A	C	B	A	A
B -8		B	B	B	A	B	B	A	C	A	C	B	A	C
B -9		B	B	B	A	B	A	A	C	A	C	B	A	C
B -10		B	B	B	C	B	B	B	C	B	C	B	B	C
B -11		B	B	B	B	B	A	B	C	A	C	B	A	C
B -12		B	A	A	A	B	A	B	C	A	C	B	A	B
B -13		B	B	A	A	B	A	A	C	B	C	B	A	C
B 14		B	A	A	A	A	A	A	C	A	C	A	A	C
No of Buildings	A	0	3	7	9	7	9	9	0	9	0	1	11	4
	B	12	11	6	3	6	4	5	0	5	0	13	3	3
	C	22	0	1	2	1	1	0	14	0	14	0	0	7

Key: A= Sufficient and Suitable B= Insufficient /Unsuitable C =Missing/Not available The results of the analysis are presented in table 3

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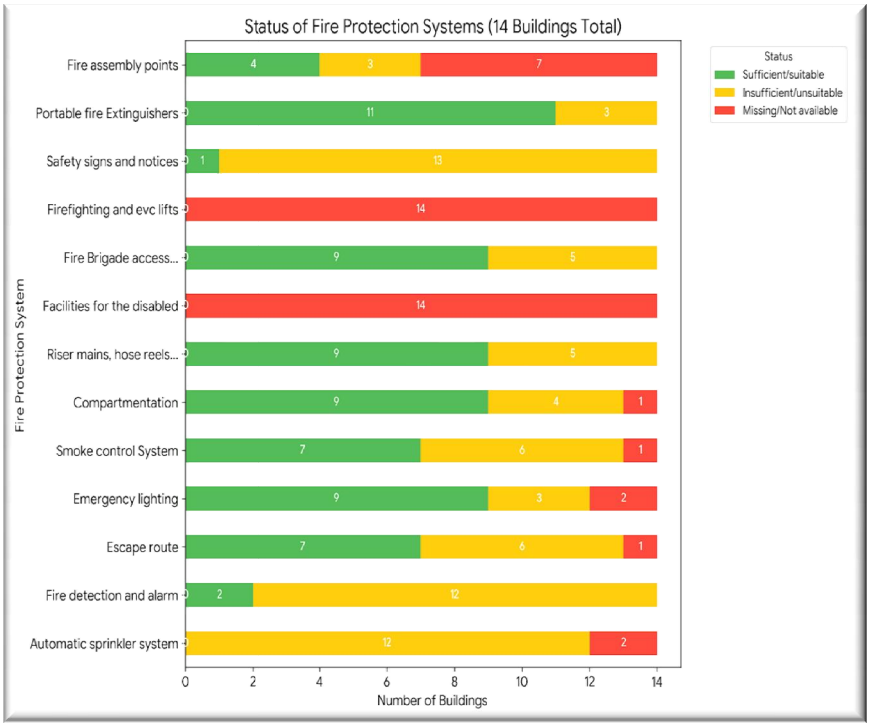
Table 3: Summary of the status of fire protection systems

System No.	Sufficient/ suitable		Insufficient /unsuitable		Missing/ Not available	
	No. of Buildings	(%)	No. of Buildings	(%)	No of Buildings	(%)
Automatic sprinkler system	0	0	12	85.71	2	14.29
Fire detection and alarm	2	14.29	12	85.71	0	0
Escape route	7	50	6	42.86	1	7.14
Emergency lighting	9	64.2	3	21.43	2	17.79
Smoke control System	7	50	6	42.86	1	7.14
Compartmentation	9	64.2	4	28.57	1	7.14
Riser mains, hose reels and hydrants	9	64.2	5	35.71	0	0
Facilities for the disabled	0	0	0	0	14	100
Fire Brigade access and facilities	9	640.	5	35.71	0	0
Firefighting and evacuation lifts	0	0	0	0	14	100
Safety signs and notices	1	7.14	13	92.86	0	0
Portable fire Extinguishers	11	78.5	3	21.43	0	0
Fire assembly points	4	28.57	3	21.43	7	0



4.2 Results, findings and discussions

Automatic water sprinkler system: Although 85.71% of the buildings in the sample were found to be installed with water sprinkler systems, they exhibited insufficiency, while 14.29% had no sprinkler systems at all.

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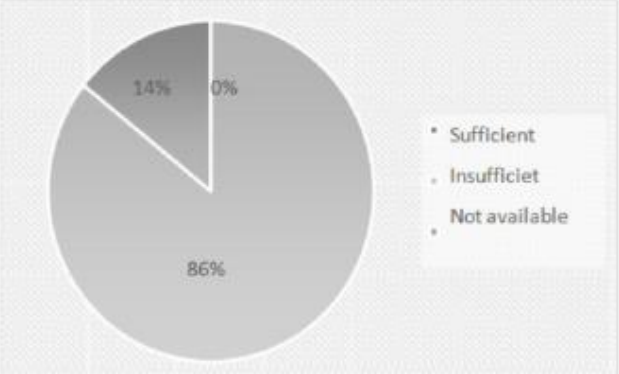

Figure 3: The proportion of buildings with or without sufficient and or/ suitable automatic water sprinkler system

Visual observations and review of internal and external inspections and maintenance reports showed that damag sprinkler heads, poor housekeeping (leading to dusty conditions which could trigger activation of alarm system), inadequate reserve water and poor implementation of the maintenance program after inspection as key factors that rendered the system insufficient. According to the fire experts in the construction industry, cost factors in installation of sprinkler systems is very high and it times can escalate the cost of a project by three percent up hence making distribution limited to basements only. According to the Fire brigade fire investigations none of the sprinkler systems in buildings have ever actuated during fire episode hence putting doubt to their effectiveness. From the findings of the study, it's critical that, apart from provision of sprinkler systems they be inspected, tested and maintained at all times. It is also important that housekeeping is maintained to prevent unwanted alarms.

Fire detection and alarm system: The essence of an alarm system is to detect fire and/or smoke and keep the building occupants and fire attendants alert and evacuate the buildings if the danger of fire became eminent. In the survey all the buildings were found to be installed with an fire detection and alarm system. However deficiencies persisted. In the survey, it was found that 57.14% of the buildings had a sufficient and suitable fire detection alarm system. However, 42.86% exhibited insufficiency or unsuitability.

Figure 4: The proportion of buildings with or without sufficient and or/ suitable automatic fire detection and alarm system

Data from the responses from building managers, fire experts and occupants indicated that the shortfalls on fire detection and alarm system originate from maintenance-related issues such as rampant false alarms due to poor house-keeping (dusty conditions), smoke from smoking and kitchen, component loss or breakdown or sheer lack of maintenance. To achieve a reliable fire and alarm system, there is a need to maintain cleanliness in the buildings, conduct regular inspections and implementable maintenance schedules. There is also a need education or awareness creation among the occupants.

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Escape route: In the survey it was found that only 7.14% of the buildings had sufficient or suitable means of escape to safety, 85.71% were found to insufficient and/or unsuitable fire elements and 7.14% had no escape stairs or other means ofescape.

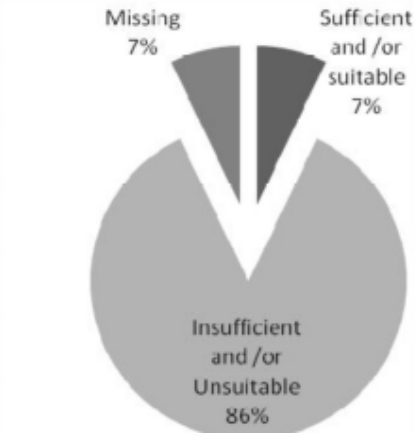

Figure 5: The proportion of buildings with or without sufficient and or/ suitable fire escape route

In the survey it was found that the deficiencies are in escape routes are connected to such factors as unclear or no exit signage leading to difficulties in finding the exact location of the escape route, obstructions, locking, etc.; smoke entering the escape route and escape stair due to poor escape route planning and the condition of fire doors, that is, either broken, locked, not self- locking etc. Inspection and maintenance is essential to achieve a safe (free of any obstructions) escape route. It should be well light and provided with essential furniture to aid in movement and visibility of the route. The occupants should be inducted on the use of the escape routes through fire drills.

Emergency lighting: The survey found out that, 64.29 % of the buildings had sufficient and suitable emergency lighting, 21.43% were either insufficient or unsuitable while 14.29% of the buildings had no supply dedicated for emergency

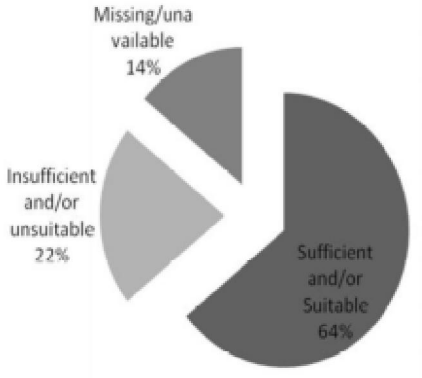

Figure 6: The proportion of buildings with or without sufficient and or/ suitable emergency lighting

The deficiency was found to be due to poor or improper maintenance and/or sheer negligence. Batteries kept for supplying power to the lights during emergencies are rarely checked to ascertain their condition nor replaced after they are commissioning.

Smoke control system: NBC Life safety chapter IV provide for provision of such facilities for control of smoke and/or fumes in workplaces or occupancies. Smoke control is mainly done mechanically through stair and lobby pressurization to prevent smoke from spreading and entering the escape route or other areas in the building. As presented in the

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analysis above, 14.29% of the buildings had sufficient and suitable smoke control systems, 78.57% were insufficient or unsuitable and 7.14% had no any smoke control mechanism.

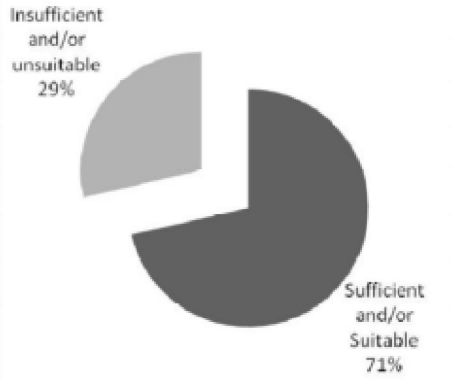

Figure 7: The proportion of buildings with or without sufficient and or/ suitable smoke control system Insufficiency or unsuitability of the smoke control systems and the ventilating systems was to compromise to fire doors, for instance, hinged, broken etc., poor workmanship during repairs and poor or improper maintenance and inspection of the systems. The survey shown that, the systems are rarely tested to confirm their efficacy due to the cost factor and lack of expertise. Tests on stair and lobby pressurization are a rigorous process that will require experts.

Riser mains, hose reels and hydrants: The Fire Risk Reduction rules, requires that occupiers provide means of extinguishing fire at the workplace, requires that, where fire hose reels are provided and occupiers ensure that there is at least one fire hose reel are within the radius of 30 meters. In view of the above requirements, the survey found out that 50.00% had sufficient and/or suitable components while the rest i.e. 50.00% were insufficient and /or unsuitable. The challenges and problems were found to be: blocking of the breaching inlets or outlets; lack of delivery hoses or inappropriate locations vis-à-vis access to the firefighters i.e. they cannot easily be reached or accessed due to long distances or blockage; deficiencies or lack of adequate water supply and improper maintenance of the facilities.

Facilities for the disabled: In buildings, all persons are supposed to be provided with a means to access and a means for evacuation during emergencies. Facilities for the disabled are those that would assist persons with disabilities i.e. persons with visual impairment, expectant mothers, the sick etc., in the event of fire emergency. Such facilities include temporary fire refuges or lifts and specially made evacuation lifts. In the survey it was found that none of the buildings had any facilities for the disabled in time of emergency. This can be partly attributed to the shortfalls in the Building Codes and also due to high expenditure that would be realized when a complete set of facilities for the disabled are provided in the building costs. Interviews with the built environment indicated that the main provisions for access, movement and safety in a building are considered for the majority user population. All the interviewees agreed that there is a need to consider facilities for the disabled during costing and design of a project.

Fire brigade access and facilities: In regard to the provision of the regulation, the survey found out that 57.14% were sufficient and suitable while 42.86% were not. The survey found that; lack of facilities to access internal upper parts of tall buildings especially firefighting lifts; protected firefighting lobbies for the fire personnel; blocked access routes to the buildings by vehicles and other infrastructures; blocked inlets and water sources; missing components such as delivery hoses, insufficient water supply and; inadequate information in the building to guide firemen and protect them from hazardous installations or materials as the challenges in maintenance of in fire brigade access and facilities.

Safety signs and notices: The fire legislations require that buildings be installed with requisite signs and notices that meet minimum criteria. They include directional signs and notices, warning signs and notices, prohibitory notices and signs. The survey found that only 7.14% of the buildings had sufficient and suitable fire signs and notices and 93.86% were found to be deficient or unsuitable. The findings indicate that, though most of buildings have been installed with signs and notices they are many problems associated with them. The key problems in regard to provision of fire safety signs and notices included improper locations, blocking and unclear messages or signs

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Fire Extinguishers: These are first-aid fire extinguishers which are installed in the building for emergency purposes. It is legal requirement under the Fire Risk Reduction, rule to provide firefighting appliances includes, among others, fire extinguishers. The survey found that 78.57% of the buildings were well provided with sufficient and suitable fire extinguishers and 21.43% were not. It was observed that the main factors that highly constituted insufficiency and unsuitability included poor siting in the light of the type of fire or fire hazard, improper servicing, misuse of hose reels e.g. for floor cleaning, vandalism of nozzles and other accessories.

Fire assembly point: The requirement for fire assembly point is provided in Rule No 24 of the Factories and Other Places of Work (Fire Risk Reduction) rules. The rule requires every occupier identify a location in the workplace where every worker shall assemble in the event of a fire. The research showed that 28.57% had adequate fire assembly point, 21.43% were not while 50% had no fire assembly point. The key challenges found with the provision of assembly point was lack of adequate space in the city to locate the assembly point, other unrelated uses e.g. car wash, car park, storage of waste and other items.

V. CONCLUSION AND RECOMMENDATIONS

Conclusion

In conclusion, it is observed that although many multiple-use high-rise buildings are equipped with basic fire protection systems such as fire detection and alarm systems, as well as portable and fixed fire extinguishers, the overall maintenance of these systems remains inadequate.

A major limitation identified is the lack of proper implementation of recommendations made after fire safety inspections. In many cases, corrective actions suggested during inspections are either delayed or not implemented at all, which significantly reduces the effectiveness of installed fire safety measures.

Furthermore, the survey reveals a critical deficiency in fire safety infrastructure, as 100% of the buildings lack essential systems such as firefighting and evacuation lifts, as well as facilities for persons with disabilities. This represents a serious gap in ensuring safe evacuation and effective emergency response in high-rise buildings.

Recommendations

To achieve optimal fire safety standards in multiple-use high-rise buildings, the following recommendations are proposed:

a) Maintenance of fire protection systems should be made a core responsibility of building occupiers and management authorities. It should not be treated as an additional cost but as an essential component of the overall building investment and safety strategy.

b) Regular and thorough fire safety inspections must be conducted, and the findings should be properly documented. Effective feedback mechanisms and timely remedial actions should be ensured to safeguard life, property, and the environment.

c) Future high-rise building projects must incorporate firefighting and evacuation lifts at the design stage itself. In addition, facilities for persons with disabilities should also be integrated into building planning to ensure inclusive and safe evacuation during emergencies..

REFERENCES

[1]. C.R Kothari (2014), “Research Methodology: Methods and Techniques’, 2nd Ed, New Age International Publishers

[2]. C.Ray Astahi and David W. Rieski (2010), Industrial Safety and Health Management, 6th Ed. Pearson Education Inc, New Jersey

[3]. Ed Soja et al (2011), Fire protection in Highrise Buildings; BCC, Melbourne, Victoria

[4]. FPA, (2009), Fire Prevention, Fire Engineers Journal: The internationaljournal for fire professionals, FPA [5]. Furness and Muckett (2010), “Introduction to Fire Safety Management”, Elsevier Ltd, Burlington, UK

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[6]. Government of Kenya (2007).Occupational Safety and Health Act, 2007; Government Press, Nairobi
[7]. Government of Kenya (2007), "Factories and Other Places Work (Fire RiskReduction) Rules, L.N 59, 2007", Government Press, Nairobi
[8]. Government of Kenya, (2010), "National Planning and Building Regulations, 2010", Government Press, Nairobi
[9]. HSE (2009) Safety and Health in Highrise Occupancies, HSE, London [10]. http://www.ctbuh.org/ accessed 23rd April 2014
[11]. R. Kumar, Fire Safety Engineering in Buildings, McGraw Hill Education, 2018.
[12]. B. L. Gupta and A. Gaur, Fire Safety and Risk Management, Standard Publishers, 2019.
[13]. S. K. Sharma, Fire Protection and Safety Engineering, S. Chand Publishing, 2020.
[14]. Various authors, "Fire safety in high-rise buildings and evacuation systems," Safety Science / Fire Safety Journals.
[11]. http://www.emporis.com/statistics/tallest-buildings-nairobi Kenya accessed29th April 2014
[12]. Mugenda and Mugenda, (2003), "Research Methods (Quantitative and Qualitative Approaches)" 3rd Ed. ACTS, Nairobi
[13]. NFPA 550 (2007), "Fire Safety Concepts Tree", National Fire Protection Association, Division Quincy, MA
[14]. R. Kumar (2005). Research Methodology 2nd Ed. (A step-by-step guide for beginners), Sage Publications, and London
[15]. Rasbash, D.J et al., (2004), "Evaluation of Fire Safety", John Wiley andSons, England. [16]. Yatim, Y.M. and Harris, D.J., (2007), 'An Evaluation of Provision ofEscape Routes in High
[17]. Rise Residential Buildings – Malaysian Experience', Journal Alam Bina, Universiti Teknologi [18]. Malaysia, Jld, 09 No.04, pp.67 c 81
[18]. Bureau of Indian Standards, National Building Code of India 2016, New Delhi, India, 2016.
[19]. Government of India, Factories and Other Places of Work (Fire Risk Reduction) Rules.
[20]. BIS IS 2189, Selection, Installation and Maintenance of Automatic Fire Detection and Alarm Systems – Code of Practice, BIS, New Delhi.
[21]. BIS IS 3844, Code of Practice for Installation and Maintenance of Internal Fire Hydrants and Hose Reels, BIS, New Delhi.
[22]. BIS IS 2190, Selection, Installation and Maintenance of Portable First Aid Fire Extinguishers, BIS, New Delhi.
[23]. BIS IS 1641, Code of Practice for Fire Safety of Buildings (General Principles), BIS, New Delhi.
[24]. BIS IS 15105, Fire Safety Design and Installation of Fire Detection and Alarm Systems in Buildings, BIS, New Delhi.
[25]. National Fire Protection Association, NFPA 101: Life Safety Code, USA.
[26]. National Fire Protection Association, NFPA 13: Standard for Installation of Sprinkler Systems, USA.
[27] Ministry of Housing and Urban Affairs, Model Building Bye-Laws 2016, Government of India.