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Evaluation of Fire Protection Systems in Commercial Highrise Buildings for Fire Safety Optimization

A Case of Nairobi Central Business District

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Abstract- Among different types of occupancies, a commercial highrise building presents a greater challenge to fire protection due to its functionality, complexity and economic value. The key objective of the present paper was to examine the situation of physical (as opposed to non-physical) fire protection systems in fourteen randomly selected commercial highrise buildings in the Nairobi CBD for fire safety optimization. Methods used include; physical observations, document review and interviews. A multi-attribute evaluation model/approach was applied to establish sufficiency and/or suitability of fire protection systems in the light of the national regulations and approved standards. The study findings show that, save for the facilities of the disabled and the firefighting/evacuation lifts, other fire protection systems are mainly provided in the buildings. However, insufficient maintenance and/or unsuitable elements renders their safety performance low. The results of the analysis showed that portable fire extinguishers had the highest performance with 78.57% of the buildings sufficiently and suitably in terms of number, locations, servicing etc., while 0% of the building was sufficiently and/or suitably installed with a sprinkler system i.e. they all exhibited some deficiency in terms of coverage and maintenance issues. This could be associated with the cost factor. The results of other systems were as follows: Fire detection and alarm (14.29%); Escape route (50%); Emergency lighting (64.29%); Smoke control System (50.00%); Compartmentation (64.29%), Riser mains, hose reels and hydrants (64.29%); Fire Brigade access and facilities (64.29%); Safety signs and notices (7.14%); Portable fire extinguishers and Fire assembly points (28.57%). In view of the findings, it's recommended that increased efforts in inspection and maintenance of fire protection systems are considered to address the identified shortfalls throughout the project life. Provision for firefighting/evacuation lifts and facilities for the disabled persons should be considered during design of the commercial high-rise buildings.

Index Terms- Fire Protection Systems, Maintenance, Provision, Optimization, High rise buildings

I. Introduction

The advent of high-rise buildings in the 19th Century marked the beginning of sophisticated human habitation borne out of the ever-increasing competing demands for limited space in cities (NFPA, 2007). Coupled with its ability to accommodate many operations and people, high-rise buildings/occupancies are the best alternative available to many municipal governments in allocation of dwindling land sizes and spiralling prices experienced in many cities across the globe (CTBUH, 1999). High-rise buildings have continuously increased in numbers in all parts of the globe under the aegis of technological advancement and scientific innovations that have seen to it incorporation of requisite human life support systems. Air circulation, lighting, ease of movement supported by elevators and lifts have made high-rise occupants have equal comfort just as those using low-rise buildings. The National Fire Protection Association (NFPA, 2007) defines a highrise building as a building taller than 75 ft (23 meters) in height measured from the lowest level of fire department vehicle access to the floor of the highest occupiable storey.

In developed countries where inventories of most fire episodes and estimation of loss is undertaken, it has been established that each year, estimated 350,000 fires occur in the UK resulting to 10,000 injuries and material losses where about 180,000 fires occur in the workplaces. In England and Wales, the cost of fire has been estimated at ₤7.7bn annually, with domestic fire costing an average of ₤25,000 (Prem Chhetri, et al, 2009). According to a research carried out by Georgia Institute of Technology (1977), the United States consistently led other industrialised nations in various measures of fires loss i.e. lives, property, environmental degradation, time lost, and business among others.

Apart from conventional fire protection challenges in many occupancies, a high-rise building is also faced with other inherent, intractable challenges. They are such challenges as inaccessibility by fire equipment due to height factor; stair egress and smoke stack effects; discordant fire safety management within and between different floors; re-designing and changes from initial intended use and; complex vertical utility services especially the heating ventilating and air conditioning conduits (HVCAs). As opposed to non-structural fire protection systems/methods such as training, fire drills which are undertaken during operational phases of a project etc., most of physical systems and methods are installed during building design.

As elsewhere in the modern world, the emerging and existing high-rise buildings in the Nairobi CBD are also found in the milieu of fire protection challenges as evidenced by such fire episodes in Kimathi House (2012), Afya Centre (2010), the Utalii House (2010) and International Lifehouse (2009). Many unreported and reported small fires are also experienced annually in many commercial high-rise buildings in the CBD.

In view of the preceding, this paper aims to evaluate the level of provision of structural/physical fire protection systems and methods in the realm of fire protection challenges inherent to commercial highrise buildings. Ultimately, it's envisaged that the findings of this research will immensely contribute in the optimization of fire safety in commercial high-rise buildings.

II. Fire Protection Systems

Conceptually, optimal fire protection can only be achieved through integration of three key fire safety elements. These are fire prevention, protection, and suppression. The concept in 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.

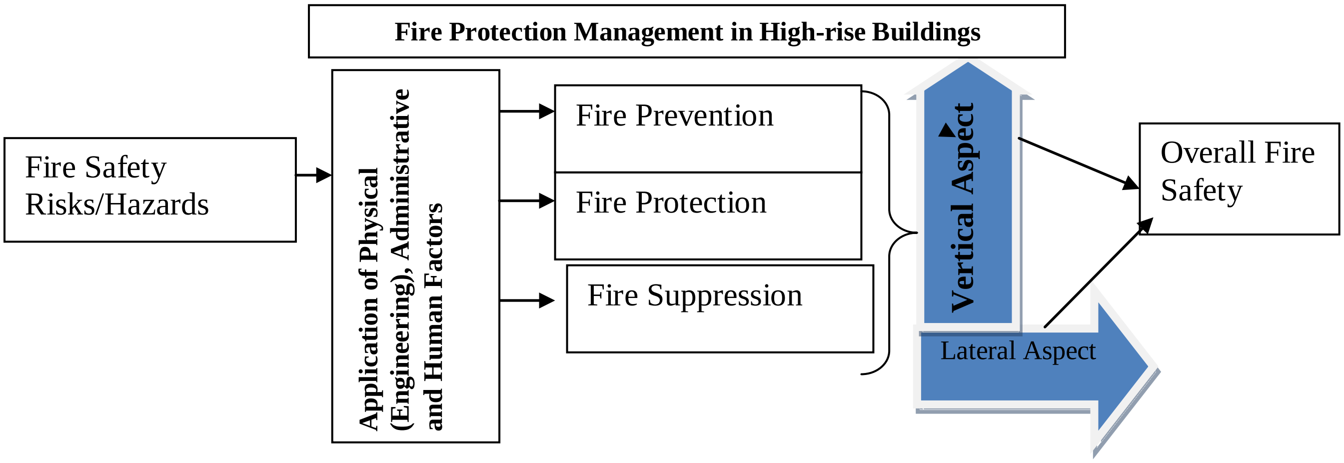

Figure 1.0: Systems Approach for Fire safety Management, (modified from P. Rama Murthy (2006) by author),

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 (2007), 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 (CBTUH, 2007, ED Soja, et al 2000). 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 (Muckett and Furness, 2010).

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 (2007) is the main legislation governing general safety and health in workplaces. The key provisions in the Act related to fire protection include section 77-Access and safe place of employment, Section 78-Fire prevention, Section 81-Safety provisions in case of fire and Section 82-Evacuation procedures. The Factories and Other Places of Work (Fire Risk Reduction) rules Legal Notice 59, 2007 and the National Buildings 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:

Automatic water sprinkler: The legal provision for provision of automatic water suppression system is contained in the National Planning and Building Regulations, 2014, regulation SS 37. The Regulation requires that, with some exceptions, any building exceeding 30 meters in height or a basement storey more than 500m ^{2} or in any other storey which exceeds 500 m^2 in total floor area and such storey is not provided with breakable or openable panels be installed with an approved sprinkler system.

Fire detection and alarm system: The key statutory requirements for fire detection and alarm systems are found in the provisions of Fire Risk Reduction Rules, 2007, under rule No. 26 and No 28 and in the National Planning and Buildings 2014, regulation SS32.

Escape route: In the National Planning and Building Regulation, 2014 the requirement for provision escape route is contained in regulation SS18.1. The regulation requires that all buildings be provided with one or more escape routes that can be used in case of fire or other emergencies. The regulations also provide for the specifications for appropriate lighting and ventilation of such escape routes and stairways. The escape route should be well maintained, free of any obstructions, well light and provided with essential furniture to aid in movement and visibility of the route.

Emergency lighting: The building regulations require that, an independent supply of power is provided to provide energy for lighting during emergencies as per Reg.SS31 in the National Planning and Building Regulations, 2014.

Smoke control system: The Factories and Other Places of Work (Fire Risk Reduction) rules, Rule No 18 and regulation SS43 of the National Planning and Building, 2014 provide for provision of such facilities for control of smoke and/or fumes in workplaces or occupancies.

mains, hose reels and hydrants: The provision for riser mains, hose reels and hydrants for fire purposes are contained in various regulations in the National Planning and Building Regulations, 2014. Regulation SS34.1 requires that rational design of a fire installation make provision for water to be supplied in the quantity and at the pressure and rate of flow in accordance with BS 5306: Part1 to 7 of Regulation SS35.1 provides for hoses installation in any building of two or more storeys in height or in any single storey building of more than $250m^2$ in floor area at a rate of 1 hose reel for every $500m^2$ or part thereof of floor area of any storey. Regulation SS36.1 requires that they are provided in any building exceeding 12 m in height. The Fire Risk Reduction rules, Rule No 29 (1) requires that occupiers provide means of extinguishing fire at the workplace, while Section (4) 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.

Facilities for the disabled: The National Building Regulations, 2014 provide for provision of firefighting and evacuation lifts and specifies the requirements for stretchers that can be used by persons with disability or the injured during emergency as provided under regulation SS50.1. Further, regulation SS 67.4 requires that every owner or occupier of a building shall have shall have arrangements for the evacuation of persons with special needs from a building in the event of a fire or other hazardous materials emergency. The Persons with Disabilities Act, 2003 provide for accessibility and movements of the disabled in workplaces and public buildings such as hand rails, visual signs etc.

Fire brigade access and facilities: The provision for fire brigade access and facilities are provided in regulation SS57, Section (1) of the regulation requires that no building should be erected on any site unless such site is provided with suitable access for the purposes of firefighting and rescue by the Fire Services of the local authority.

Fire safety signs and notices: The National Planning and Building Regulations, 2010 provide clear guidelines on requisite specification for fire safety signs and notices under regulation SS30 and regulation SS46. Regulation SS30.1 subsection (a) requires that any building having emergency routes be clearly marked and signposted to indicate the direction to be travelled in the case of any emergency.

Fire Extinguishers: These are first-aid fire extinguishers which are installed in the building for emergency purposes. They include among other portable CO2, dry chemical and powder, foam and water extinguishers strategically sited within the building premises. It is a legal requirement under the Fire Risk Reduction, rule 29 (1) to provide firefighting appliances includes, among others, fire extinguishers. Rule 30 subsection (1) requires that every occupier ensure that all means of extinguishing fire are properly maintained and provides the requirements for inspection and testing, record keeping and timing of examination and testing. Rule 31 provides specific requirements for distribution of the various types of fire extinguishers in workplace.

Fire assembly point: The essence of a fire assembly point for emergency is to provide a place where head count of the persons who are involved in the fire is done. It also used as a temporary station where people who are injured can be offered first aid or can be picked for more attention to the hospital by rescue personnel. The requirement for fire assembly point is provided in Rule No 24 of the Factories and Other Places of Work (Fire Risk Reduction) rules, 2007.The rule requires every occupier identify a location in the workplace where every worker shall assemble in the event of a fire.

III. Material and Methods

3.1 Description of Case studies

The project boundary is defined by the core Nairobi City (62 Km Sq) found in the larger Nairobi Metropolitan. Most of the high-rise buildings in the Nairobi Metropolitan are found within the CBD (encompasses areas within Wetland's, Upper Hill, Community, Parklands and the section bordered by Uhuru highway, Haile Selassie, Kirinyaga Road, University way). A request letter accompanied by an introduction letter from the Institute of Energy and Environmental Technology 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, salons, cash transfer outlets, cyber cafes 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:

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Table 1: The buildings involved in the study

No	Name of the building	Date of Construction	No of floors	Location within the CBD
	Re-insurance plaza	1982	20	Harambee Avenue
	Anniversary Towers	1992	26	The University Way
	KICC	1973	31	City Hall Way
	Electr. House	1974	18	Harambee Avenue
	Eco bank	1983	19	Muindi Mbingu
	Tembo House	1985	7	Moi Avenue
	Rahim. Tower	1999	18	Upper Hill
	Afya center	1987	17	Tom Mboya Street
	Lonrho House	1990	20	Standard Street
	Stanbank House	1970	10	Moi Avenue
	Bandari Plaza	1985	14	Westlands
	Fedha	2008	10	Westlands
	ICEA	1981	19	Kenyatta Avenue
	I&M	2001	18	Loita Street

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 Nairobi Metropolis. A requisite sample was generated by use of random tables where all the identified commercial high-rise buildings in the Metropolis were listed and involved in the sampling process (Kothari, 2014). Registry records from the department of City Planning and Architecture showed that the CBD has over 150 commercial 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 Nairobi Fire Brigade (fire investigations section), Ministry of Public Works (Buildings section), Directorate of Occupational Safety and Health Services (DOSHS- Nairobi County) and the building managers in all the buildings involved in the survey.

3.3. Methods and Techniques

Physical observations and inspections by use of a pre-designed fire safety risk assessment checklist (NFPA, 2008), literature/document (inspection/maintenance reports, improvement orders) and; interviews to building managers, occupants and professionals in the construction sector were used in data collection. Each fire protection systems was checked or inspected against requirements of the national laws 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 represented absence of a particular system or method.

IV. Analysis and Results

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 and	Facilities for the disabled	Fire brigade access &	Firefighting and evacuation lif	Safety signs and Notices	Portable Fire extinguishers	Fire Assembly Points
Reinsurance plaza	B	B	A	A	A	A	A	C	A	C	B	A	A
Anniv.Towers	B	B	A	B	A	B	A	C	B	C	B	A	B
KICC	B	B	A	A	A	B	A	C	A	C	B	A	A
Electricity House	C	B	B	B	A	A	B	C	B	C	B	B	B
Eco-Bank House	B	B	A	A	A	A	A	C	A	C	B	A	C
Tembo House	C	B	C	C	C	C	B	C	B	C	B	B	C
Rahim. Tower	B	A	B	A	A	A	A	C	A	C	B	A	A
Afya center	B	B	B	A	B	B	A	C	A	C	B	A	C
Lonrho House	B	B	B	A	B	A	A	C	A	C	B	A	C

ISSN 2250-3153

Stanbank House		B	B	B	C	B	B	B	C	B	C	B	B	C
Bandari Plaza		B	B	B	B	B	A	B	C	A	C	B	A	C
Fedha Plaza		B	A	A	A	B	A	B	C	A	C	B	A	B
ICEA		B	B	A	A	B	A	A	C	B	C	B	A	C
I&M Building		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	2	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.

Table 3: Summary of the status of fire protection systems

System	**Sufficient/suitable**		**Insufficient /unsuitable**		**Missing/ Not available**	
	No. of Buildings	**Percent (%)**	**No. of Buildings**	**Percent (%)**	**No of Buildings**	**Percent (%)**
Automatic sprinkler system	0	0.00	12	85.71	2	14.29
Fire detection and alarm	2	14.29	12	85.71	0	0.00
Escape route	7	50.00	6	42.86	1	7.14
Emergency lighting	9	64.29	3	21.43	2	14.29
Smoke control System	7	50.00	6	42.86	1	7.14
Compartmentation	9	64.29	4	28.57	1	7.14
Riser mains, hose reels and hydrants	9	64.29	5	35.71	0	0.00
Facilities for the disabled	0	0.00	0	0.00	14	100.00
Fire Brigade access and facilities	9	64.29	5	35.71	0	0.00
Firefighting and evacuation lifts	0	0.00	0	0.00	14	100.00
Safety signs and notices	1	7.14	13	92.86	0	0.00
Portable fire extinguishers	11	78.57	3	21.43	0	0.00
Fire assembly points	4	28.57	3	21.43	7	50.00

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.

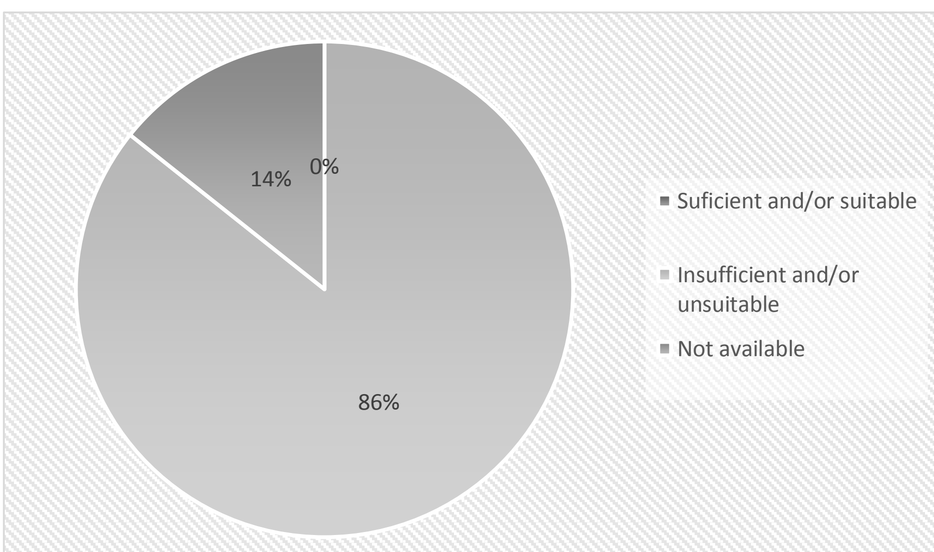

Figure 1: The proportion of buildings with or without sufficient and or/ suitable automatic water sprinkler system

Visual observations and review of internal and external inspections and maintenance reports showed that damage to 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 in the CBD 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.

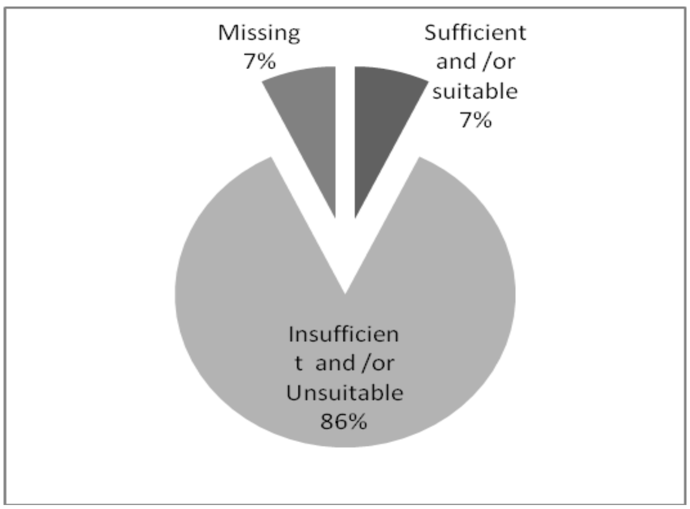

Figure 2: The proportion of buildings with or without sufficient and or/ suitable automatic fire detection and alarm system

Data from the responses from bulding 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 realiable fire and alarm system, there is a need to maintain cleaniliness in the buildings, conduct regular inspections and implementable maintennace schedules. There is also a need education or awareness creation aomgn the occupants.

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 of escape.

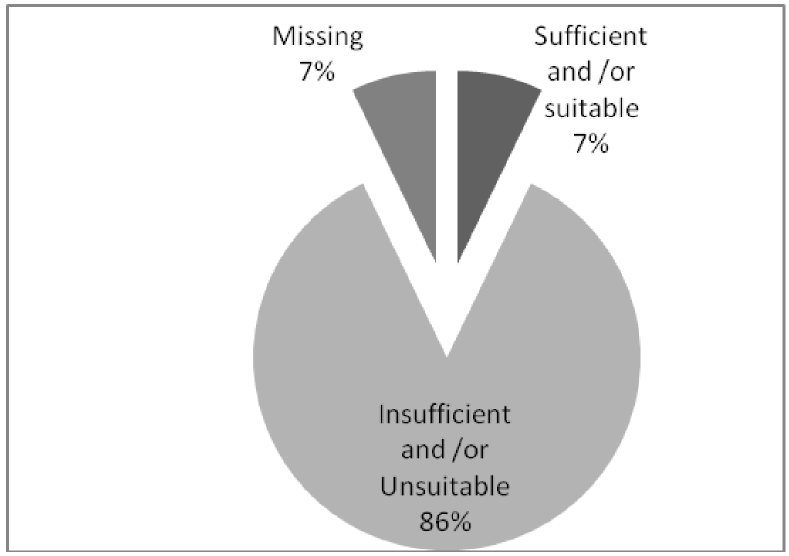

Figure 3: The proportion of buildings with or without sufficient and or/ suitable fire escape route

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.

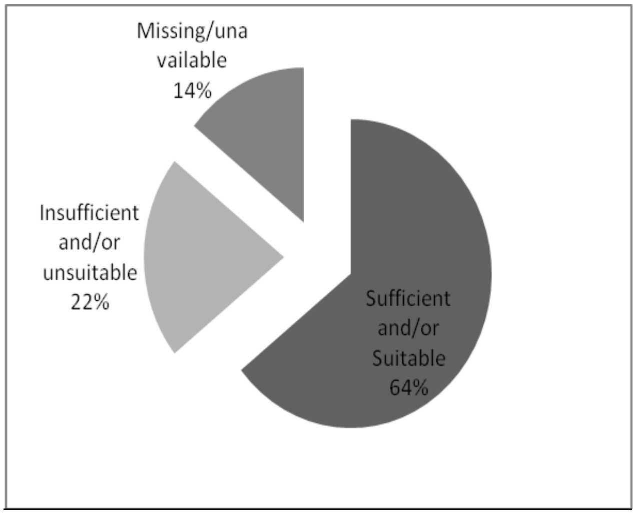

Figure 4: The proportion of buildings with or without sufficient and or/ suitable emergency lighting

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: Rule No 18 and regulation SS43 of the National Planning and Building, 2010 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 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.

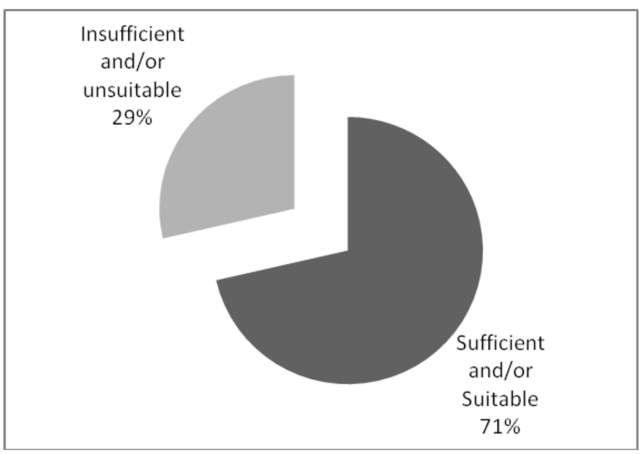

Figure 5: The proportion of buildings with or without sufficient and or/ suitable smoke control system

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 is a rigorous process that will require experts.

Riser mains, hose reels and hydrants: The Fire Risk Reduction rules, Rule No 29 (1) requires that occupiers provide means of extinguishing fire at the workplace, Section (4) 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.

Fire Extinguishers: These are first-aid fire extinguishers which are installed in the building for emergency purposes. It is a legal requirement under the Fire Risk Reduction, rule 29 (1) 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, 2007.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

In conclusion, it's noted that, although many commercial highrise buildings are provided with fire protection systems and methods such as fire detection and alarm system, portable and fixed fire extinguishers, maintenance still remains wanting. A key setback to maintenance is improper or lack of implementation of the recommendation made after inspections are performed. Further, the survey shows that all (100%) the buildings do not have critical fire protection systems such as firefighting and evacuation lifts and facilities for the disabled. In order to achieve optimal fire safety in commercial highrise buildings it's recommended that a) maintenance of fire protection systems and methods should be part of the occupier's management responsibility and should not be considered as an extra expense but rather as part of investment portfolio; b) thorough inspections, reporting, feedback and remedial actions should be undertaken with due diligence to protect the property, lives and/or the environment; c) projects undertaken for construction of commercial highrise buildings should provide for the firefighting and evacuation lifts in future. They should also consider installation of facilities for the disabled at design stage.

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