

Assessment of Design Method on Fire Prevention Strategies for High Rise Buildings in Lagos, Nigeria

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Abstract:

High rise buildings are popular structures with improved construction activities and technology that help in reducing land scarcity, urban density and accommodate large families in lesser space. Fire outbreak is one of the risks associated with high rise buildings because the buildings consist of multiple floors which create a cumulative effect that require many people to travel through vertical distances. Fire outbreak in high rise buildings is always terrible as population of occupants in building make escape difficult or tedious. This study, therefore, assessed the design methods used to prevent the spread of fire in High Rise buildings in Lagos State. Qualitative research method was used with purposeful sampling technique employed; the researcher analysed 11 high rise buildings in Victoria island Lagos the findings show a high percentage of high-rise buildings in Lagos state adopt fire prevention strategies, however there is a clear lack of fire escape in most of the buildings. In conclusion, the paper suggests design ways of preventing the spread of fire in high rise buildings to avoid of loss of life and properties.

Keywords: high rise building, life and properties, fire prevention strategies, fire outbreak, Nigeria.

BACKGROUND OF THE STUDY

High population density and scarcity of land in urban centres contribute to the increase of high-rise and super high-rise buildings in most cities. In most modern cities presently, high-rise structure is built to curtail over population, land scarcity and to also serve as symbol of status and tourist attraction as a result of its aesthetics (Ede, 2014). Chandwani (2012), added that, high rise building is a building greater than 75ft (23m), and generally with 7 to 10 stories. Despite the advantages of high-rise buildings stated above, there are numerous challenges facing high-rise buildings in Nigeria. Zahari *et al.* (2014), added that, fire outbreak is one of the many risks high rise buildings. As the buildings consist of multiple floors which create cumulative effect that require the occupants to travel through vertical distances on the stairs. To corroborate the assertion above, Abdullah (2011), states that, stack effect (temperature difference between two areas) is one of the negative effect of high-rise buildings as it creates series of pressure between the floors which would result to the movement of natural air capable of moving huge volume of heat and smoke when there is fire outbreak within the building. Onoyan-usina *et al.* (2017), added that, in Nigeria, factors such as power outages, power surge, illegal connections of electricity, improper electrical fittings, substandard materials, indoor use of generators, arson, and negligence of household are some of the causes of fire outbreak in Nigeria, Lantz and Skroder (2013), submitted that, most fire outbreaks in high rise buildings are associated with construction features capable of causing extensive fire and smoke spread which make it difficult for occupants to exit. In the same vein, Olagunju *et al.* (2013), opined that, fire outbreak in high rise buildings is always terrible as population of occupants in building make escape difficult or tedious. However, some of the features of high-rise buildings such as great height, structural complex, diverse function, and many others contribute greatly to many fire outbreaks in high rise condominium (Hassanain, 2009).

This research is aimed at identifying design methods on fire prevention strategies in high rise buildings in Nigeria. This method helps in protecting components of structural system and also delay the spread of fire through the use of fire-resistant materials, use of simple building forms, simple roof forms such as hip roof, and fire compartmentation.

General overview of high rise buildings

Al-Kodmany (2018), sees high rise building as a structure higher than 22m (72ft) with room to accommodate people permanently. Carrigan (2015), contributes that, high rise building can be defined as a building with 75 feet (23m) and above the lowest level of fire department vehicle access. Osunsanmi (2017), posits that, high rise building and other building components such as Elisha Graves Otis safety elevator which helped in vertical movement, steel frames invention of 1870, and invention of air conditioning in 1902 are proof of advancement in technology. Ismail *et al.* (2015) assert that, high rise buildings developed through three generations. The first was from 1870 to 1920. During those years, the exterior walls of the building were made of stones or bricks, cast iron and floors were made of woods, the elevator shafts were closed and the only escape route was through a single stairway. The second generation was from 1920 to 1940 which came to improve the first generation. The development in this second generation includes replacement of combustible construction materials. The third generation of high rise buildings began after the World War II (from 1940 to 2019). During this period, constructions were done using lightweight steel, reinforced concrete frame and exterior curtain walls (Ismail *et al.*, 2015). Kavilkar *et al.* (2014), states that, high rise building is now popular worldwide due to the improved in construction activities, technology and its ability to reduce land scarcity, urban density and accommodate more population in small space. Xiuyu *et al.* (2012), added that, development in our urban economy, high population density and land cost have made high rise buildings and super high rise buildings to increase.

High rise development in Nigeria

The growth in population and increased urbanization has led to a great increase in demand for housing. In the advent of technology and limited supply of land for development, the idea of high rise development evolved to cater for more people. (Olanrele *et al.*, 2014) Despite these advantages, there are challenges facing the development of high-rise buildings in Nigeria

High rise in this country are spared for the rich or people with high social status as the facilities of such buildings must be manage and deliver efficiently (Weldemariam, 2017). Presently there is increase of high rise residential buildings especially in Lagos where One Thousand and Four Tour (1004) Estate and Eric Moore Tower are located. The two towers were developed by Lagos State Development and property corporation (LSDPC). Other high rise buildings built in Lagos after that includes: Dangote apartment, Folwiyo Tower, Rose of Sharon Tower, Eko Pearl Tower, Niger Tower and many others are still under construction. Urban centres of most developed and developing countries are faced with a common problem of homelessness which is made worse through rural-urban migration (Ingwani *et al.*, 2010). Presently there is increase of high rise residential buildings especially in Lagos where One Thousand and Four Tour (1004) Estate and Eric Moore Tower are located. The two towers were developed by Lagos State Development and property corporation (LSDPC). Other high rise buildings built in Lagos after that includes: Dangote apartment, Folwiyo Tower, Rose of Sharon Tower, Eko Pearl Tower, Niger Tower and many others are still under construction.

Nature of Fire

Raichur (2012), define burning or fire as a reaction of chemical substances and oxygen mixed with heat and accompanied by visual flame or incandescence. Reflex (2011), similarly opines that, Fire is a chemical reaction in which energy in the form of heat is made. The chemical

reaction is known as combustion which happens when fuel or other material reacts constantly with oxygen, giving off light, heat, and flame. Flame generally consists of carbon dioxide, water vapour, oxygen, and nitrogen. A flame that is produced during the ignition point and in the combustion reaction is said to be the visible and gaseous part of a fire. To corroborate this assertion, Adekunle (2018), also added that, fires is produced when a flammable and/or combustible material is combined with a enough quantity of an oxidizer such as oxygen gas when exposed to a source of heat.

Baker (2015), states that, one of the greatest fire risks is smoking as such it should be prevented in buildings and workplace. If not legally prevented, it should be done only in specified areas with bins provided. Hossain and Islam (2018), assert that fire outbreak is cause due to electrical short circuit, cooking/ stove, careless disposal of burning cigarette and match stick, chemical reaction, explosion, mosquito coil, machine/ engine, sabotage, leaked electric wire, necked lamp, thunder and unawareness of the occupants. Smokers' materials such as cigarettes, matches and lighters also caused fire outbreak in buildings (Omahanna *et al.*, 2016). Onoyanusina *et al.* (2017), states that, fire can be cause as a result of arson which is a deliberate form of protest or revenge which may be against others individuals or a group of people or against government. It can also result from kitchen appliances like gas cookers, ovens, electric stove, and gas cylinders.

Design method on Fire Prevention Strategies in High Rise Building

Fire prevention strategies are methods of preventing the spray of fire in a building which includes both active and passive methods. Kurniawan (2018), states that, fire prevention strategies must be considered first when assessing the safety of the occupants in every building and the duration occupants can take to escape before any fire hazard occur should also be put into cognizance.

While passive fire prevention strategies are regarded as very important fire protection components of structural system and fire safety in a building, it is an attempt to delay the spread of fire(s) using fire-resistant walls, floors and fire rated doors. These building materials are expected to be present and readily available within the building and should be evenly located in every floors of the building .having said that, no mechanical device is required in the operation or application of these materials (Kalidasan, 2017). Some of the passive fire prevention strategies include the following:

Table 1 shows the various suggestions by multiple authors on the design principles that can be adopted to prevent the spread of fire in buildings.

Therefore, the researcher used the following established variables to access the high-rise buildings in Lagos Nigeria to determine their level of fire prevention design principles adopted.

1. Fire egress: This is an act of exiting from the building during a fire to ensure safe evacuation of occupants from the building.
2. Form of the building: Form of the building determined the spread of fire. Simple building is easier to protect from wild fire and those not trap fire's heat while Complex building form in the contrary increase the surface area of the structure and create shapes that trap the fire's heat.
3. Shape of the roof: Roofs are significantly influenced by embers in a wind-controlled fire. A simple roof form such as a hip or straight gable is the best in preventing fire while a complex roof traps the fire's heat.
4. Building structural fabrics: Building structural fabric is required to continue to support its load during a fire.
5. Fire prevention strategies: Fire prevention strategies are measures of preventing fire from spraying in buildings especially high rise buildings.

Table 1 Observed variables

S/N	VARIABLES	AUTHORS AND YEAR	CITATIONS	REMARKS
1	Fire egress	Spearpoint and MacLennan (2012)	Fire egress is an act of exiting from the building during a fire. The essence of providing a means of egress is to ensure safe evacuation of all occupants to a place of safety within a reasonable period. Evacuation process of high-rise building is always affected by the features of the vertical egress components, this includes exits, exits discharge, exit chute system, exits access and access means of egress	The statement indicates that fire egress is essential for safe evacuation
2	Fire Egress	Nilsson (2014)	Modern egress design should take into cognizance variables such as the change of occupant demographics. Occupant behaviours, the technology advancement and subsequent increase in the building height should be considered. Egress components include stairs, escape elevators, area of refuge.	The fire egress is affected by occupant's behaviour, demographic, building heights and advancement in technology
3	Form of Building	Bueche (2012)	Simple forms of building. Complex building forms as name implies are structurally complex but have more surface area relative to volume. Simple building forms on other hand, is regarded as one of the fire prevention strategies as it is easier to protect from wildfire(s), the surface of it exterior is simple to protect and less expensive to build. Complex building form in the contrary increase the surface area of the structure and create shapes that trap the fire's heat (heat traps).	Form of building also affect the spread of fire
4	Shape of the Roof	Bueche (2012)	Roofs are greatly influenced by embers in a wind-controlled fire. A simple roof form such as a hip or straight gable is the best in preventing fire. The use of complicated roofs will further highlight the importance of a truly ignition-resistant roof.	This indicates that the shape of the roof affects the spread of fire in the building
5	Design and Structural Integrity	Omahanna <i>et al.</i> (2016)	Building structural fabric is required to continue to support its load during a fire. However, fire has an adverse effect on the performance of the structural elements. Fire proofing, inbuilt fire ratings and proper interconnection of the structural elements help to increase building structural integrity.	The statements show that the design and structural integrity affects the time the building can withstand fire
6	Fire Prevention strategies	Guo (2012)	Fire prevention strategies are measures of preventing fire from happening in buildings especially high-rise buildings.	This indicates that fire prevention is very significant in assessing the safety of the occupants
7	Fire Prevention Strategies	Kurniawan (2018),	fire prevention strategies must be considered first when assessing the safety of the occupants in every building and the duration occupants can take to escape before any fire hazard occur should also be put into cognizance.	These are things to put into consideration while designing and construction
8	Compartmentation of Fire	Barker (2015)	When buildings are divided into compartments and enclosed in fire-resisting construction, it will provide passive fire protection by inhibiting the spread of fire within the building. In addition, to obey the local building regulations, there is need to limit the size of individual compartments	What determined the compartment size is the overall size of the building, the number of storeys, and the position of

				automatic sprinkler system.
9	Fire resistant materials	Kalidasan, (2017)	And Fire-resistant materials are attempt to delay the spread of fire(s) through the use of fire-resistant walls, floors, materials and fire rated doors. These building materials are expected to be present and readily available within the building and should be evenly located in every floors of the building. having said that, no mechanical device is required in the operation or application of these materials	These are materials that resists fire
10	Fire resistant materials	Outinen (2012)	There are various fire protective cladding materials that are used to join steel girder and column together in order to protect them from fire. Such materials include concrete, gypsum or masonry fire-rated floors, walls or ceilings work as fire barricades.	There are materials that can withstand fire

Source: Researcher's field work (2019)

6. Compartmentation of fire: compartmentation of fire is a way of dividing building into compartments and enclosed in fire-resisting construction.

7. Fire resistant materials: These are building materials that are used to resists fire from the building.

METHODOLOGY

Qualitative research method was used for this research because of the aim of the research which is to access the current levels of design principles adopted in high rise building design in Lagos state, Nigeria, the aim of his research calls for an observation of current practices and trends and using the data collected to make inferences, which is the sole purpose of qualitative research method.

Survey research design was used in this research, it is a form of research where data is collected from samples to make inferences about a population, and it is used to study attitudes and opinions. The study area of this research is Lagos Nigeria, and the building type under research is High rise condominium. Purposeful sampling was used which is a procedure where researchers intentionally select individuals and sites to learn or understand the central phenomenon (Creswell 2012), this was adopted to aid the researcher in collecting relevant data from the case studies as pertains to the subject under research, the case studies were chosen based on the criteria of High-rise condominium buildings in Lagos state. 11 buildings were selected to be used as case studies for this research as sew in table 2, with at least one building from each of the 6 zones of Victoria island, Lagos, which was chosen because of the high density of high-rise buildings in that location, the selection of the buildings was purposeful with the researcher making the decision based on the ability of the buildings to provide the necessary data.

Observation schedule was used for this research because of the research design that was adopted, which requires an observation of trends of the various established variables. Primary Data was collected from the field based on the developed variables using the observation schedule developed by the researcher. The data was organized using codes that were assigned to each variable identified in the literature review. The organized data was analyzed manually via content analysis which involves a researcher quantifying and analyzing the meaning of words or text and making inferences from it (CSU 2004)

Table 2 Lists of high-rise residential buildings selected in Victoria Island Lagos

NAME OF THE BUILDING	TOTAL NUMBER OF UNIT IN THE BUILDING	TOTAL NUMBER OF UNIT IN THE BUILDING	NUMBER OF QUESTIONNAIRE DISTRIBUTED	NUMBER OF QUESTIONNAIRE RETURNED
Eden Height	27	3	14	9
Vita Tower	44	5	22	17
Eko Court Tower	155	17	79	70
Olympic Tower	25	3	13	10
Bar Beach Tower	108	12	55	47
Visage Tower	21	2	11	9
Pier Harbour	16	2	8	5
Aqua Tower	30	3	15	11
Genbrite Complex	15	2	8	5
1004 Apartment	126	14	65	54
Grand Orchard	19	2	10	6
Total	586	65	300	243

Source: Author's fieldwork (2020)

RESULTS AND DISCUSSION

Data on fire prevention measures that were used in the selected high rise residential buildings was obtained through critical environmental observation of the buildings studied. The availability of fire safety features and their functionality are as shown in Table 3 below which indicates the availability of fire safety measures either active or passive measures, their functionality and whether the building experienced fire outbreak or not. Figure 1 shows the total number of specific fire safety measures observed in all the case studies, it is evident that the fire extinguisher is the most adopted measure of safety while the escape chute system is the least adopted measure.

Tables 3 Availability of Fire Safety Features and Their Functionality

S/N	Name of the building	Availability of fire safety features in the building	Functionality of the fire safety features	Fire outbreak experienced in the building
1	Eden Height Tower	Adequate	Very functional	None
2	Vita Tower	Moderate	Functional	None
3	Eko court Tower	Moderate	Very functional	None
4	Olympic Tower,	Moderate	Not functional	None
5	Bar Beach Tower	Moderate	Not functional	Yes
6	Visage Apartment	Adequate	Functional	None
7	Pier Harbour	Adequate	Very functional	None
8	Genbrite Complex	Adequate	Functional	None
9	Aqua Tower	Moderate	Not functional	None
10	1004 Apartment	Moderate	Functional	Yes
11	Grand Orchard	Adequate	Functional	Yes

Source: Authors field work (2020)

This shows a lack of active design measures in place to aid the prevention of the spread of fire and the reliance on secondary means to achieve that goal. Table 4 shows the design principles adopted per case study to aid the spread of fire; it is evident that most of the case studies averagely applied the design principles.

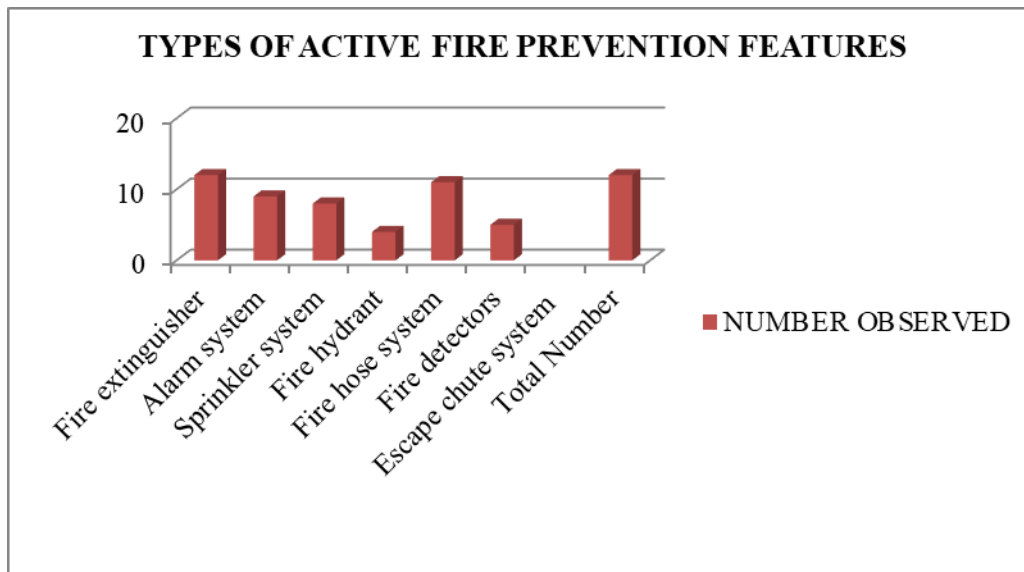


Figure 1 Active fire safety measures in selected buildings Source: Authors field work (2020)

Table 4 Passive Fire Prevention Features in Selected Buildings

S/N	Name of the building	Building form	Shape of the roof	Types of fire resistance materials applied	Types of wall materials	Types of roof materials	Types of materials used for Floor finishes
1	Eden Height Tower	Simple	Simple	Cementitious product, intumescent coating and gypsum board	Hollow block, granite, cladding and wood	Aluminium and concrete	Marble tiles, granite and wood
2	Vita Tower	Simple	Simple	Cementitious product	Hollow block	Aluminium and concrete	Marble tile and wood
3	Eko court Tower	Simple	Simple	Cementitious product	Hollow block	Concrete	Marble tiles and wood
4	Olympic Tower,	Simple	Simple	Cementitious product	Hollow block	Aluminium and concrete	Marble tiles and wood
5	Bar Beach Tower	Simple	Simple	Cementitious product	Hollow block	Aluminium	Marble tiles
6	Visage Apartment	Simple	Simple	Cementitious product	Hollow block	Aluminium and concrete	Marble tiles and wood
7	Pier Harbour	Simple	Simple	Cementitious product	Hollow block	Aluminium and concrete	Marble tiles and wood
8	Genbrite Complex	Simple	Simple	Cementitious product, and gypsum	Hollow block	Aluminium	Marble tiles and wood
9	Aqua Tower	Simple	Simple	Cementitious product	Hollow block	Aluminium	Marble tiles
10	1004 Apartment	Simple	Simple	Cementitious product and Gypsum board	Hollow block, tilling and wood	Concrete and aluminium	Marble tiles
11	Grand Orchard	Simple	Simple	Cementitious product and Gypsum board	Hollow block, tilling and wood	Concrete and aluminium	Marble tiles

Source: Authors field work (2020)

Summary of Findings

1. 3/11 (27%) of the buildings have experienced fire outbreak in the past.
2. 9/11 (81%) have functional fire prevention strategies in place.

3. The fire extinguisher is the most adopted method of fire prevention.
4. Most of the buildings adopted simple building forms, simple roofs, and the use of fire-resistant materials, which are all design strategies for fire prevention as stated in table 1.0.
5. Fire prevention strategies is achieved with combination of both active and passive means.
6. Shape of the roof and building forms affect the spread of fire in buildings so careful consideration should be taken in their design.

CONCLUSIONS

Majority of the buildings in Lagos state have functional fire safety measures in place, however there are a select few that are lacking, there is also a need to diversify in the fire prevention strategies put in place to reduce the reliance on fire extinguishers majorly. There is an apparent lack of fire escapes which could be hazardous for human lives and thus future building should be designed with this consideration while existing building scan be retrofitted to adopt it.

RECOMMENDATIONS

1. Means of egress should be provided in buildings. It should be unobstructed and clear.
2. compartmentation of fire prevents the spread of fire to another buildings.
3. The structural fabrics and elements should be able to withstand fire for a limited time frame Shape of the roof and building forms affect the spread of fire in buildings, therefore adequate testing must be done before they are allowed into the public space.
4. Manufacturers of building materials should be encouraged production of building components that are fire rated and selling them to prospective developers at affordable prices.
5. Architects should obey the building regulations and to incorporate the design methods or passive strategies to limits the spread of fire in the buildings.
6. Awareness, education, and information to increase cautiousness of occupants on fire risks and they should be train on how to use extinguisher and also on safety techniques to take during fire outbreak.

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