ASSESSMENT OF FIRE PREVENTION STRATEGIES IN THE DESIGN OF HIGH-RISE CONDOMINIUM BUILDINGS IN VICTORIA ISLAND, LAGOS STATE, NIGERIA

BY

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Abstract

High-rise is generally a building that is greater than (22.5 m), and with 7 to 10 stories. They could also mean structures with improved construction activities and enriched with technology that will help in reducing land scarcity, urban density and can accommodate large families in a lesser space. Condominium on the other hand, is a building divided into several apartments or units, and each unit is occupied or managed by different individuals or people. It could also be used for residential, commercial and or industrial purposes. Despite the enormous advantages associated with high-rise buildings, there are challenges facing its development especially in Nigeria. The most notable among its risks is fire outbreak. The multiple floors in the building usually create a cumulative effect that requires many occupants to travel through vertical distances on stairs which will create escape problem during fire outbreak. Fire outbreak in high-rise buildings is always terrible as the occupants population make escape difficult or tedious. This study however, assesses fire prevention strategies available in of some high-rise condominium buildings in Lagos state, in order to suggest most suitable ones that can help in saving lives and properties. To achieve this, the researcher uses both qualitative and quantitative data collection through the use of structured observation schedule and questionnaires issued to the occupants of the selected high rise condominium buildings in Victoria Island, Lagos state. Descriptive research was adopted on selected high-rise condominium buildings. However, eleven (11) high-rise buildings were selected out of five hundred and eighty six (586) buildings using simple random and purposive sampling technique. Out of three hundred (300) close-ended questionnaires issued, two hundred and forty three (243) were returned. Data collected were analysed through descriptive statistics (frequency and percentages), pie charts and bar charts. Findings however, shows that 80% of the buildings observed makes used of active fire prevention strategies though some are not functional. In addition, 77% of the buildings have good ventilation. Many occupants of the selected high-rise buildings responded that most fire outbreaks are caused by electrical faults. Also, 52% of them however, responded not to have come across any fire safety instruction. As a result many occupants have little or no knowledge on fire safety measures and facilities within their building. This is why the researcher recommends that electrical cables and fittings should be of good quality and should be properly installed and monitored. Passive fire prevention strategies recommended are building form, shape of the roof, compartmentation of fire, intumescent coating, photo luminescent marking and fire resistance materials. More so, the occupants of such building should have requisite knowledge on fire safety instructions through awareness, education and information on the operational methods of any available fire prevention measures in the building as that will increase occupant's cautiousness on fire risks. All these should be applied in designs and constructions of high-rise condominium buildings.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

High-rise buildings are structures with improved construction activities and technology that help in reducing land scarcity, urban density and accommodate large families in lesser a space (Kavilkar & Patil, 2014). Gibbon (2018) defined condominium as a large complex (building) divided into individual units. Condominium is also seen as a building divided into several apartments or units and each unit is occupied or managed by different individuals or people. The building could be used for residential, commercial and /or industrial purposes (Paulsson, 2012). From a wider perspective, condominium is said to be a building with several stories and parcels, owned and or used by different individuals (Ariyawansa & Udayanthika, 2012). Condominium buildings help to reduce the distance residents will cover in accessing recreational and commercial centres since those centres are mostly attached to condominium complexes for easy access (Weldemariam, 2017).

On the contrary, many authors and building professionals have in several occasions criticised condominium. To substantiate this, Charlterjee (2009), reported that the occupants of high-rise buildings are faced with psychological problems such as depression, stress, anxiety, and carelessness in community affairs. Zahari *et al.* (2014) added that, fire outbreak is yet another risk associated with high-rise buildings. This is because, they are buildings with many floors and require many people to walk through vertical distances on stairs. To corroborate the above assertion, Osunsanmi *et al.* (2017),

supported that, the occurrence of stack effect (temperature difference between two areas) is always high in high-rise buildings thereby creating series of pressure between the floors which will result in natural air movement capable of moving huge volume of heat and smoke when there is a fire outbreak within the building. Similarly, Nimlyat *et al.* (2017) submitted that, most fire outbreaks in high-rise buildings are associated with construction features capable of causing extensive fire and smoke spread that will make it difficult for occupants to exit. Olagunju *et al.* (2013) opined that, fire outbreak of high-rise buildings are always terrible since there are many occupants in building which make escape difficult or tedious.

Osunsanmi *et al.* (2017) also revealed that, high-rise buildings may cause disastrous fire outbreak as panic or fear in the mind of occupants may lead to stampede or taking the wrong exit. Nevertheless, Yang (2013) stated that, many occupants of high-rise buildings are often unaware of the fire safety measures and facilities in their building. In line with that, Guo (2012) asserted that, most occupants of high-rise buildings doubt the effectiveness of the provided firefighting measures. Therefore, this research assesses fire prevention strategies in some selected high-rise buildings in Victoria Island, Lagos state.

1.2 Statement of the Research Problem

The challenges facing high rise buildings in Nigeria today include problem of heights, long vertical distance travel during exit and access to the building (Nimlyat *et al.*, 2017). Onoyan-Usina *et al.* (2017), added factors such as power surge, abrupt electrical discharge, use of defective generators, occupants carelessness, fuel adulteration, improper electrical wiring and fittings, use of substandard materials and arson as possible

causes of fire outbreak in Nigeria. However, other features of high-rise buildings that may contribute greatly to fire outbreak are its structural complexity and functional diversity (Hassanain, 2009). Ahrens (2016) suggests that, it is necessary to provide in high-rise buildings fire prevention and fire protection facilities since occupants make exit discharge longer. Olagunju *et al.* (2013), also stressed that, fire outbreak of high-rise buildings is mostly terrible as the occupants population make the escape means difficult. Osunsanmi *et al.* (2017), further added that, occupant's population and their panic during fire outbreak may lead to stamped or taking a wrong exit there by making the situation disastrous. Having said that, Yang (2013), averred that, many occupants of high-rise buildings have little or no knowledge of fire safety measures and facilities within their building.

However, the challenges created by high-rise buildings will not only affect the occupants but also the firefighting agencies. This is because, it is the duty of fire safety evaluator to prevent and respond quickly to any fire incident. (Dechamps *et al.*, 2011). However, the researcher could not find any literature that discusses fire incident of high-rise condominium buildings especially in Lagos state. In view of the above stated problems, this research suggests both passive and active fire prevention strategies as a ways of arresting fire incidents in high-rise buildings to save lives and properties.

1.3 Aim and Objectives

1.3.1 Aim

The aim of this research is to assess fire prevention strategies in some selected high-rise condominium buildings in Victoria Island, Lagos state, in order to suggest better ways of saving lives and property.

1.3.2 Objectives

i. To identify fire prevention measures in some selected high-rise condominium buildings. ii. To examine causes of fire in the selected high-rise condominium buildings in the study area. iii. To suggest methods (active and passive) of fire fighting in the selected buildings.

iv. To propose an architectural design of a high-rise condominium building with a perfect fire preventive strategies.

1.4 Justification of the Study

Population density and land scarcity are some of the factors that contributed or gave birth to the construction of high-rise and supper high-rise buildings in cities and countries of the world. In Nigeria presently, high-rise buildings are seen as modernized and multifunctional structures despite the fact that, it is very difficult to put out fire and rescue lives from them when there is fire outbreak due to high floors, complex functions and diversified devices when compared with ordinary constructions (Xiuyu *et al.*, 2012).

Nigerian government have recently concentrated on safety measures of high-rise buildings due to the perpetual fire incidences in the country. Tolofari (2010), an expert in disaster management said that, Nigeria experienced about 7000 fire outbreaks and over

1000 death persons every year. Wakili (2013), contributed to the assertion above when he states that, over ($250, 000000) worth of properties are lost to fire disaster every year in Nigeria. The high rate of fire outbreaks in the country call for urgent preventive measures. This is why Nigerian government established National Building Codes (N.B.C) and Fire Safety Codes across the country (Nimlyat *et al.,* 2017). Since high-rise buildings are taller in height, complex in structure, and serve multiple functions when compare with other buildings; their danger when it comes to fire outbreak is also higher (Hassanain, 2009). Condominium apartments however, provide better housing in the country as it can accommodates more occupants than the low-cost flats (Weldemariam, 2017).

1.5 Scope of the Study

The scope of this research is to provide optimum safety measures for the occupants of high rise buildings located within the study area. This was achieved by studying different active and passive methods of fire preventions needed to be integrated in the design of any high rise condominium building. Escape route components should include: corridors, stairs, fire door provision and the intermediate floors must also be provided. The researcher also studied and integrated fire insulation properties into the design.

1.6 Limitation to the Study

The security challenge in the country has greatly limited this research as occupants of some of the selected high-rise condominium buildings denied the researcher access to their building and from taking photographs. As such, measurement taking and photographs were very difficult in some places for security reasons.

1.7 Contribution to Study

This research provides information on ways to prevent and protect high rise condominium buildings from fire through the use of active (such as fire extinguisher, alarm system, smoke detectors, fire hydrants and sprinkler system) and passive (such as building form, compartmentation of fire, photo luminescent marking, means of egress and fire resistant materials) fire prevention strategies. The results obtained from the data analysed through critical observation and questionnaires, provides greater awareness on factors that causes fire outbreak in high rise condominium buildings (smoking, carelessness, electrical faults, and arson) and how fire outbreak can be prevented. The information shall also be useful during designing and construction of high-rise condominium buildings.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. General Overview of High Rise Buildings

Chandwani (2012) defined high-rise building as a building greater than 22.5m, and generally with 7 to 10 stories. Carrigan (2015) added that, high-rise building is a building with 75 feet (23m). Osunsanmi (2017) contributes that, high-rise building and its components such as Elisha Graves Otis safety elevator, which helped in vertical movement, and steel frames were invention of 1870, while air conditioning was invented in 1902 are proof of advancement in technology.

Ismail *et al.* (2015) assert that, development of high-rise buildings was through three generations. The first generation was from 1870 to 1920. During this period, exterior walls of buildings were stones or bricks, cast iron and floors were made from woods, the elevator shafts were closed and the only way to escape from any danger was through a single stairway. The second generation, which came to improve on the first generation, was from 1920 to 1940. During this generation, combustible construction materials were replaced better ones. The third generation began from 1940 (after World War II) to the

present. Constructions during this period are done with lightweight steel or reinforced concrete frame with exterior curtain walls.

This is why many authors described high-rise buildings as tool that ensures maximum use of land. 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. Farouk (2010) opines that, building evolution was affected by high population growth and constant pressure on the limited land area in our urban communities. Xiuyu *et al.* (2012) added that, building of high-rise and super high-rise is increasing in our cities today because land is expensive and limited to develop our urban economy and lastly, there is a population density especially in our urban centres. In the contrary, Osunsanmi *et al.* (2017) argued that, many land developers dislike erecting high-rise buildings as their designs are complex and provision of amenities such as alarms, exits, emergency lighting, and sprinkler systems in the building are expensive. Similarly, Olagunju *et al.* (2013), claims that, construction and maintenance of high-rise building needs much attention, money and time. The materials/tools that would not delayed occupants from evacuating from the building without difficulty are what mostly discourage developers.

2.1.2 Condominium building

Condominium is a building with two or more stories and consists of parcels, owned and used by different individuals (Animansa & Danimi, 2014). Linn (2016) added that, condominium is a multilevel building divided horizontally or vertically into sections or units and each unit is owned and used different individual. Condominium is a building

with two or more stories with parcels owned and managed by different individual owners (Ariyawansa & Udayanthika, 2012). Paulsson (2012), mentions that, condominium can be used to strictly subdivide a building into several apartments that could be owned by different individuals. Many countries of the world used condominium for residential and commercial purposes. In Nigeria however, condominium are often confused with apartment. Form of ownership is what generally differentiate apartment from condominium. Having said that, every unit of a condominium is owned by Homeowners‟ Association (H.O.A). Each unit of a condominium can be rented through its landlord but apartment building unit cannot be purchased. According to Gibbons (2018), apartment buildings are corporately owned by one person but leased to individual tenant and the landlord would serve as a management company.

2.1.3 High-rise development in Nigeria

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). Ede (2014), found that, most modern cities nowadays build high-rise to arrest the challenges of population density in our urban centres and manage the limited land. Although, high-rise buildings can also attract tourists and could serve as a symbol of development in the country.

Challenges facing the development of high-rise buildings in this country include: they are mostly owned by the rich or people with high social status since the facilities of such buildings are expensive (Weldemariam, 2017). Presently there is an 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 in Lagos after that includes: Dangote apartment, Folwiyo Tower, Rose of Sharon Tower, Eko Pearl

Tower, Niger Tower and many are still under construction.

2.2 Assessment of Fire Prevention Strategies in High Rise Condominium Building

Fire prevention strategies are methods of preventing the spread of fire in a building using active or passive method. Kurniawan *et al.* (2018), states that, fire prevention strategies must be considered first when assessing the safety of the occupants in any building. The duration occupants can take to escape before any fire hazard occurs should also be put into cognizance.

2.2.1 Definition of fire

Raichur (2012) defines 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 (combustion) that manufactured energy in form of heat. Combustion occurs when fuel or its related material respond to oxygen, heat, and produce flame. This flame generally consists of carbon dioxide, water vapour, oxygen, and nitrogen. The gaseous part of fire is produced at the point of ignition and during combustion. Raalte (2010) corroborates the above assertion when he says that, fire feeds on air, moisture, and any earthy material such as oxygen, heat, combustible material, and exothermic reaction (fire). All these must be present simultaneously for fire

to be produced. Adekunle (2018) also added that, fire(s) is produced when combustible material is mixed with enough oxidizer such as oxygen and are exposed to a heat source.

2.2.2 Fire problems in Nigeria

Many high-rise buildings in Nigeria have recently witnessed fire outbreaks which demanded for immediate response from the government to avoid such disastrous incidences. A disaster management expert Tolofari (2010) estimated annual fire outbreaks in Nigeria at about 7000 and claiming over 1000 lives. Wakili (2013) said that, fire disasters in Nigeria consumed every year over Two hundred and fifty million dollar worth of properties. The increase of fire outbreaks in Nigeria has called for it preventive measures through technology advancement. Onoyan-usina *et al.* (2017), mentions power surge, abrupt electrical discharge, use of defective generators, occupants carelessness, fuel adulteration, improper electrical wiring and fittings, use of substandard materials and arson as factors responsible for fire outbreaks in Nigeria

2.2.3 Nature of fire

Fire could be defined as the chemical reaction (combustion) that produced energy in form of heat. Combustion happens when fuel or its related material quickly respond to oxygen, heat, and produce flame. A flame is the gaseous part of fire produced during ignition (Reflex, 2011). Having said that, fire could generally said to be a chemical reaction. This reaction depends on the material used to produce heat and flame. Before the invention of fire extinguishers, fire was said to be in triangular shape (three sides) which are heat, fuel, and oxygen. If any of the three sides is to be removed there would be no fire (Voelkert,

2015).

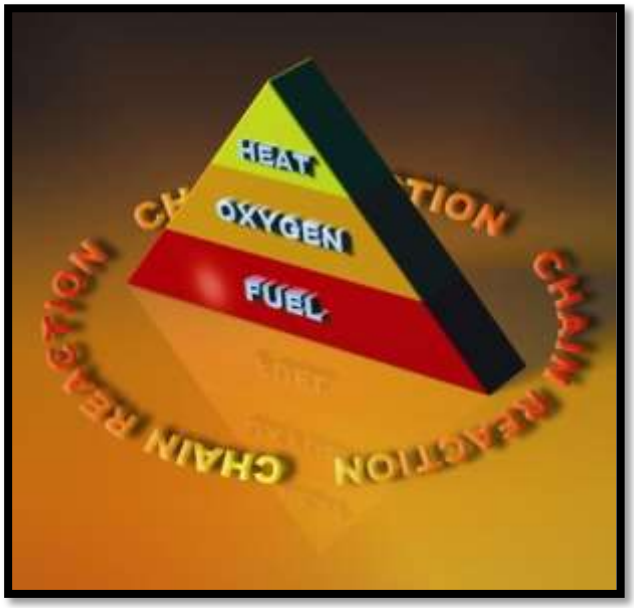

Plate I: Fire triangle. Source: Fire and Emergency Service (2014).

2.2.4 Classification of fire and their extinguishers

According to Fire and Emergency Service (2014), there are five classes of fire:

(i) Class "A" Fire: Here, the fire is caused by combustible materials such as wood, cloth, paper, trash, and plastics. The extinguisher for this fire class is water.

Plate II: Class "A" Fire. Source: Fire and Emergency Service (2014).

(ii) Class "B" Fire: This is a fire caused by any inflammable liquid or gas such as gasoline, oil, propane, solvent, alcohol and natural gas. Any fires extinguishing agents could be used to terminate the fire in this class. Although, the circumstance will determined or dictate the extinguishing agent to be used. Voelkert (2015) asserts that, it is the vapours generated from flammable liquids that ignite fire as a flammable liquid cannot start fire in their liquid form. All extinguishers in this class of fire should be labelled with a letter "B" in a square and painted red when colour coded.

Plate III: Class B Fire. Source: Fire and Emergency Service (2014).

(iii) Class "C" Fire: These are fires that occur on strong electrical equipment. It is advisable not to use water or solution to extinguish this class of fires. The best to use here are non-conductivity extinguishing agents. They can be identified with a circle letter "C" and painted blue when colour coded.

Plate IV: Class C Fire. Source: Fire and Emergency Service (2014).

(iv) Class "D" Fire: These are fires associated with exotic metals like titanium, zirconium, magnesium, and sodium. Fire in this class required unique extinguishing agents such as dry powders and other special methods to be extinguished. Every fire class has its unique extinguishing agents or techniques that can work for it as discussed above. Thus, extinguishing agents of a particular fire class cannot work on another. In this fire class for instance, water can only react on burning metals but will violently increase the intensity of fire (Voelkert, 2015). Extinguishers for this fire class carried a star with letter a "D" in it but when colour coded the star should be painted yellow.

Plate V: Class D Fire. Source: Fire and Emergency Service (2014).

(v) Class "K" Fire: These are fires that occur in kitchen appliances with combustible ingredients like vegetable or animal fats and oil. The only extinguisher for this fire class is

WET CHEMICAL and can be recognised by the letter K.

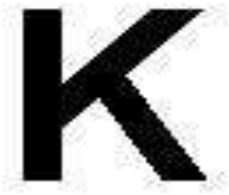

Plate VI: Class K Fire. Source: Fire and Emergency Service (2014).

2.2.5 Stages of fire

Fire stages according to Boynowsi (2012) are as follows:

(i) Incipient stage: The invisible aerosols are generated here, as there is a small but visible smoke.

(ii) Smouldering stage: This is when there is a visible or partly dense smoke. Here, much toxic are produced as a result of inadequate combustion. Fire in this stage can be terminated using fire extinguishers or its related extinguishing agents.

(iii) Flaming stage: An open fire is experienced in this stage for that, there is need to engage fire brigade. Here, combustion process is complete and that result into a high production of carbon dioxide.

(iv) Heat Stage/ Flashover: Explosive fire occurs in this stage. The gases and aerosols move the fire to the rooms already occupied by the smoke gases.

Phases 5 to 7 were added by Champneys *et al.* (2013), as follows:

(v) Full development: This stage of fire is spread through the total surface of fuel and room and that weaken the ability to communicate with the exterior.

(vi) Structure fire: At this stage, there is a communication between the fire and other rooms through windows, doors, pipes or other means available.

(vii) Collapse: Since most valuable areas of the room has already been consumed by fire, the level of heat released will begin to diminish until they are properly extinguished.

2.2.5 Mode of fire spread in the compartment and building

The act of dividing a buildings into compartments and fenced it with a fire resisting construction help to protect the building from fire passively and control the spread of fire within the building. To obey the local building regulations, there is need to limit the size of every compartment. The overall building size is what determined the size of the compartment, number of storey, and the need to provide automatic sprinkler (Barker, 2015). Galaja (2016) added that, the origin of fire in any building usually find it cause from a single room. The start of fire of any building begins from a room. Smoke layers are later formed to radiate heat and on getting to flammable materials in the room, the fire escalates and combustion occurs. This means that, smoke layer and the room temperature are what determined the speed of the fire in a room. A situation where single furniture in a room causes simultaneous combustion that is, burning other materials in the room is called Flashover. This normally takes few minutes and may last for about ten minutes from the time the fire begins. To buttress this, Dheri (2009), states that, fire can be spread from compartment to compartment, floor to floor, unsealed service shafts, ceiling voids, A.C. Ducts, windows and door(s) failure.

2.2.6 Heat transfer mechanism

Champneys *et al.* (2013), states that, there are three mode of heat transfer and they are:

i. Convection: This is the common type of heat transfer in liquids and gasses. The transfer occurs when there is a movement of liquid from one place to another. During the fire incident, the hot gasses will move upwards and that will quickly cause the spread of fire up to stairwells and lift shafts.

ii. Conduction: This is common in solids. It is a heat transfer that occurs when particles or quasi-particles collide as a result of temperature gradient. This explains that, if a room within a building is on fire, heat can be transfer to the closer rooms even if there are no cracks for it to travel through.

iii. Thermal radiation: This is a process of transferring thermal energy through waves, air or empty space. If the thermal energy get to objects, they transfer the energy to the objects and that make them warm. Any matter with a temperature above zero is capable of emitting thermal radiation. This clarifies that, heat energy from the fire will be pass to the surrounding area having come into contact with smoke or the flames.

2.2.7 Causes of fire in buildings

Baker (2015), itemizes the following causes of fire in building:

a. 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.

b. To avert fire in a building one should ensure good housekeeping practices. This means that, there should be routine removal and disposal of waste.

c. Fire is also caused when out-of-hours inspection and security procedures are not established and maintained in a building. There should be regular inspection and maintenance of all heat generating equipment as they are capable of causing fire outbreak.

d. Fire incident can be minimized through regular supervision of contractors and subcontractors construction of the building.

e. Gas and dust explosion must be avoided through the provision of adequate ventilation and communication system.

2.3. Fire Prevention Strategies in High Rise Condominium

There are measures of preventing fire from happening in buildings especially high-rise buildings. Guo (2012), states that, Architects for over 100 years have considered fire safety in high-rise buildings working of deliberation. They as well ensured awareness was created worldwide after the 1970 regarding fire prevention or hazard problems and most important was attached to the provision of fire safety system in every building to handle fire related issues. To corroborate this Kurniawan *et al.* (2018), states that, fire prevention strategies must be considered first when assessing the safety of occupants in every building and the duration occupants can take to escape before any fire hazard occur should also be put into cognizance. Generally speaking, there are two types of fire fighting protection and they are:

2.3.1 Active fire prevention strategies

Sujatmiko *et al.* (2014) defined Active Fire Protection as the systematic arrangement to perfectly put out fire in a building using manual or automatic instruments. Fire extinguisher is for example operated manually while sprinkler and fire or smoke alarm are automatic instruments as they alert occupants once there is fire or smoke in the building. Furthermore, the active fire protection systems help to end or slow down the

fire before the coming of the fire fighters to the location. On the arrival at the location, the fire fighters will apply or carry with them fire extinguishers, fire hoses and others tools that will help to put out the fire (Hees & Wahlqvist, 2016). Some active fire fighting system examples can be explained as follows:

i. Sprinkler system

This is an automatic fire protection system in which water pipes are connected to the sprinkler. The moment the room temperature is beyond normal, the plug enclosed to the sprinkler nozzle will melt and releases the water to the fire source (Kalidasan, 2018). Some of the components of any sprinkler system as shown in Figure one (1), which include piping, sprinkle, retard chamber, fire alarm check valve, water motor gong, cut off valves and inspector's test valve. Provision of fire alarm and detector in the building is also important as it helps in alerting the occupants once there is fire (Abdulgani *et al.*, 2016).

Plate VII: Automatic sprinkler system. Source: www.amazon.com (2019)

Figure I: Automatic sprinkler system. Source: www.regencyfire.com. (2020)

ii. Fire hydrant system

This is one of the most active fire prevention system which help in reducing fire rapidly. It is a joint that allow connection with the water supply system. This fire fighter will help in controlling the water supply system when there is a fire incident. The component of the fire hydrant system is a large water reservoir (Groner, 2016).

Plate VIII: Fire Hydrant. Source: www.amazon .com (2019)

iii. Fire hose system

This system is mostly used in commercial or residential buildings. It is a process where by large vertical pipes attached to the building are connected to a hose where water is kept at a high pressure. When there is a fire incident, the hose releases the water at a greater speed to terminate the fire immediately. A situation where hose pipe is filled with water is called a wet riser system (Lou *et al.* 2014). A dry riser system on the other hand, is a situation where the hose pipe is connected to the water supply source but not filled with water (Daeid, 2014). In this system however, the sprinkler head is connected to the dry riser system. Most pipe branches are connected to the head of the sprinkler and compressed to the water tank system (Yamano, 2015). When there is any fire incident, the sprinkler head releases and spread out the distributed water accurately and quickly (Yan-bo *et al.*, 2011).

Plate IX: Fire Hose System. Source: www.firehosedirect.com (2019)

iv. Fire extinguishers

Fire extinguishers are also known as "first attack" fire fighting measure. Occupants use fire extinguishers in the building before the arrival of fire fighters. As such, there is a need for the occupants to be knowledgeable on the typology of extinguishers and their uses. Most large fires originate from small fire (Galaja *et al.,* 2013). Massive fire can only be removed when adequate fire resisting agents are used. The latest fire extinguisher types include the following:

Fire Classes	**Fire Causes/Principle(s) to be Used/Adopted**	**Extinguishing Agent**
A	These are wood and paper fires and not electrical fires.	Water
B	They are not electrical fires but flammable liquids fires	Foam
C	These are electrical Fires	Carbon dioxide
D	These are electrical and flammable liquids fires	Dry Chemical
K	These are fat fires or grease fire in kitchen	Wet chemical

Table 2.1: Fire extinguishers types and the extinguishing agents.

Source: www.billah.com (2019)

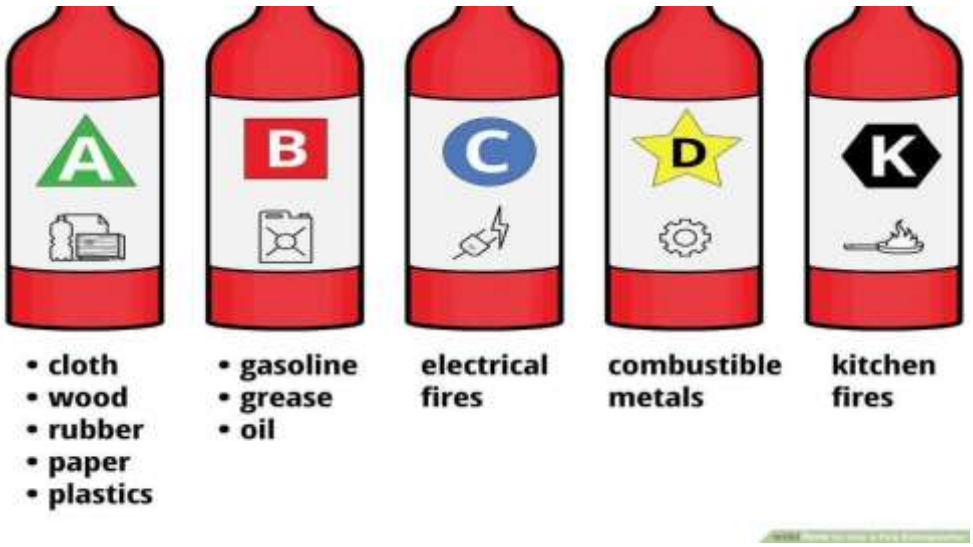

Plate X: Fire extinguishers. Source: www.wikihowlife.com (2019)

v. Travel distance

When planning for every building there is need to make the distance travel to the exit closer to allow the occupants easy access to outside in case there is a fire incident. The closer the exit distance travel to the exit, the safer the building (Peng *et al.,* 2013).

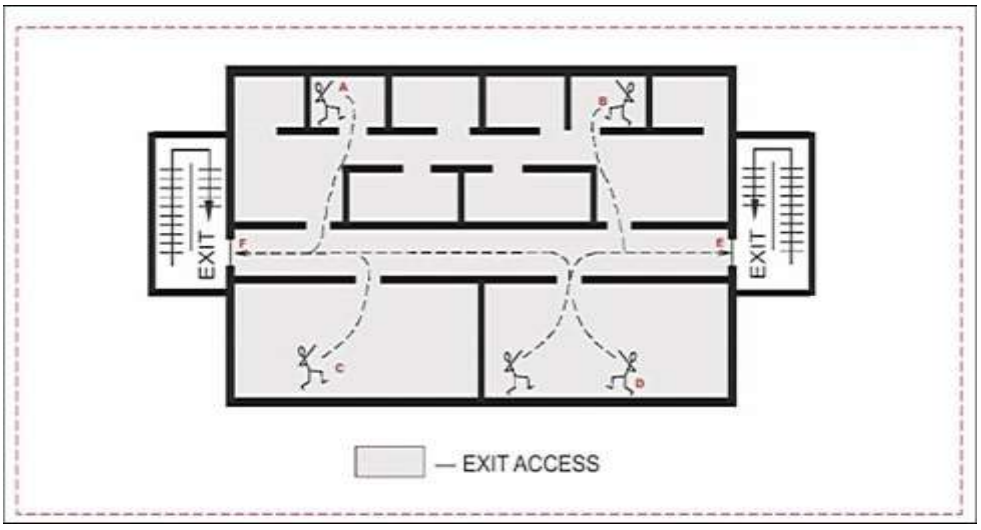

Figure II: Short safe travel distance for fire safety. Source: www.zheng.com (2019)

vi. Escape chute system

This is a system that allows every occupant in a building to exit safely with the aid of a strong synthetic fabric tube hanged at the roof or upper floor of tall buildings to permit exit easily in case there is a massive fire. The use of this system will allow many occupants to escape easily. Kevler is known to be the major component of this fabric system (Xiuyu, 2012). This synthetic fabric tubes are also made from good and non-flammable properties and can help in preventing criminal attack (Kolaitis *et al.*, 2017).

Plate XI: Escape chute system.

Source: www.escapeescue.com (2019)

Plate XII: Escape chute system.

Source: www.alamy.com (2021)

vii. Heat detectors

This device helps in detecting fire automatically. It can also function as fire system activator especially when smoke is detected in the building. The moment this device detects heat from fire, occupants would be immediately alerted of the need to evacuate especially when it is activated (Ismail, 2014).

Plate XIII: Heat Detector. Source: www.indiamart.com (2019)

viii. Smoke detectors

The device could be used typically to detects smoke and indicate fire. When certain amount of smoke is detected, it can serve as fire alarm system activator. The essence of Automatic Smoke Vents is to serve as escape means to the occupants when there is fire. If the smoke vents gather at the top of the building, the occupants can escape safely from the building under the smoke layer. Manual Smoke Vents are provided to serve as smoke clearance and allow fire fighters access to the building once the fire is extinguished (Barker, 2015).

Plate XIV: Smoke Detector. Source: www.wach.com (2019)

2.3.2 Passive fire prevention strategies

These are regarded as very important fire protection components of structural system and fire safety in a building. They are methods of delaying fire from spreading quickly with the help of 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 floor 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:

i. Building form

The nature of the building affects the spread of fire. Complex building forms for instance, are structurally complex and their surface area contribute to fire spread. Simple building forms on another hand are regarded as one of the fire prevention strategies as they make it easier to protect the building from wild fires. The exterior surface of this building type is simple, less expensive and helps to protect the building from fire. In addition, the surface area of a complex building form is structured in shapes that can trap heat of the fire

(Bueche, 2012).

ii. Shape of the roof

This is another way of preventing fire passively. A simple roofs form is considered the best as it helps in preventing fire. In other words, embers greatly influenced roof in a fire controlled by wind (Bueche, 2012).

iii. Fire compartmentation

This is yet another passive fire prevention strategy. Barker (2015), states that, when a buildings is structured into compartments and supported with fire resistant materials, it will protect the occupants and the building passively from fire spread. This is why local building regulation suggests the need to limit the size of every building in compartments. The size of the building, number of storey, and position of the automatic sprinkler system are what determined the compartment size of every building.

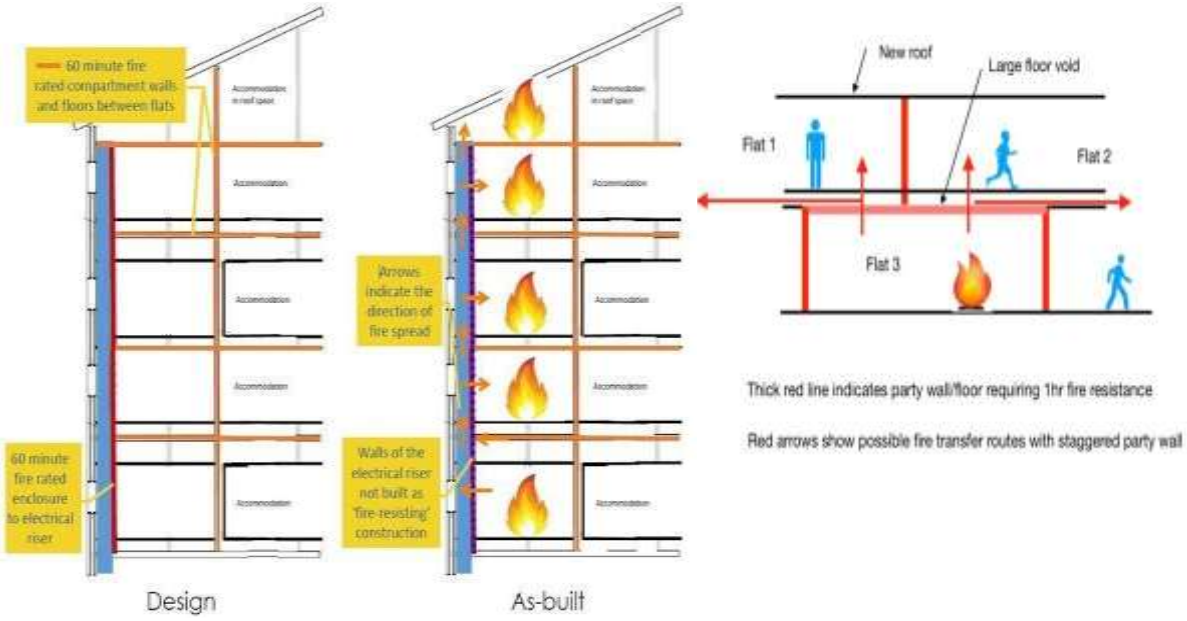

Figure III: Compartmentation of fire. Source: www.cookeonfire.com (2019)

iv. Fire resistant materials

They are also among passive fire prevention strategies and some of them can be discussed as follows:

a. Cementitious products

These are considered the best fire resistant materials as substantiated several times by some petrochemical industries years back. The industries concluded that, concrete or granite material gives convincing protection to buildings especially those made from steel. Steel structures are protected by cementitious materials in two ways, firstly the trapped moisture in them help to boil the steel and when there is fire outbreak, it temperature remain 100 °C until water completely disappeared. The thermal conductivity of concrete help to reduce heat input to the underlying structure (Zuccaro, 2012).

b. Gypsum

This is also known as Calcium Sulphate Dehydrate. Gypsum is naturally crystalline and it is the mineral got from sedimentary rock. There is natural and synthetic gypsum. Natural gypsum is mined from the earth and ground into powder while synthetic gypsum is a thermal power station that burns coal to generate electricity. It is also capable of removing sulphur dioxide from flue gas. Gypsum board(s) can effectively protect the building from fire passively. They are entirely incombustible materials even after the evaporation of whole water, they remain as a thermal insulation barrier (Mróz *et al.*, 2016).

c. Polypropylene fibers

They are known as effective technique of preventing and reducing Portland cement and concrete spalling.

d. Intumescent coatings

Intumescent coatings are used commonly to serve as passive fire protection. They are light coatings but weight 5-25 kg/m2. When they are exposed to heat, they increase in volume and decrease in density. They also go beyond other complex coating materials in terms of function (Zuccaro, 2012).

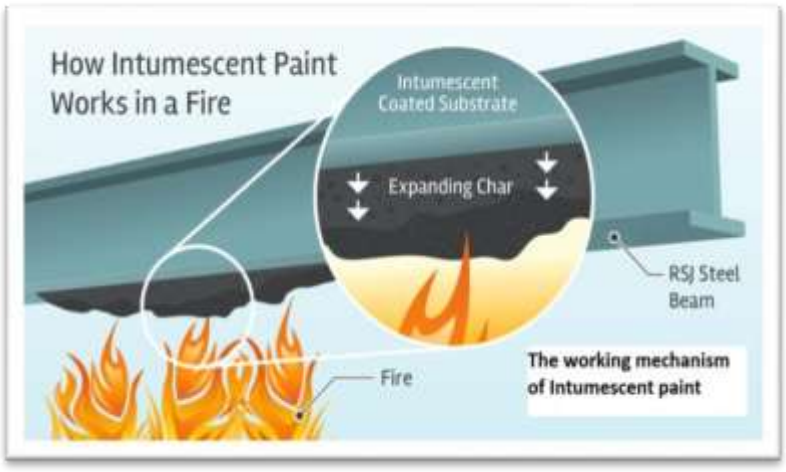

Plate XV: Mechanism of Intumescent Paint.www.ddcoatings.co.uk (2019)

e. Thermal insulation as fireproofing

This fireproofing material provides double functions. It is a passive fire protection and a thermal insulation. It insulate the steel and substrate it from the heat of a fire (Zuccaro, 2012). Mineral wool is one of the oldest insulation made from a non-combustible material that can serve as a natural fire resistant material. It is also capable of withstanding 1000°C temperature without burning and serves as thermal and fire insulation. Other mineral wool materials include mudstone shale, slate and mud rock (Mróz *et al.*, 2016).

f. Structural fire protection

These are methods brought into building designs and constructions. Structural fire protections help in maintaining structural integrity of a building and prevent it from fire for a very long time. All building types (commercial, residential and industrial) need Structural fire protection to prevent fire and smoke from spreading. This help to contain the damage to just an area and presents to the occupants opportunity to vacate the premises safely.

g. Fire resistant glass

The use of a better intumescent coating on a glass surface will increase the temperature, density and viscosity of the glass and that will hindered the spread of fire (Kobes *et al.*, 2010). However, mechanism used in applying intumescent coating can also be used on steel girders or columns and would immediately turn bigger and help in protecting the steel structure from fire (Y. E and Zhou, 2016).

Plate XVI: Fire Resistant Glass. Source: www.tongxiaofiredoor.en.made-in-china.com (2019)

iv. Fire-resistance-rated wall

This is a wall with protected openings that help to limit fire spread and hindered its extension from the foundation to the roof fire (Zuccaro, 2012).

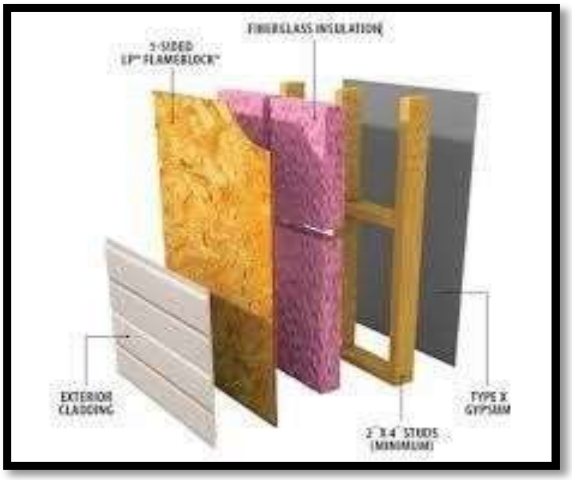

Plate XVII: Fire-Resistance-Rated Wall. Source: www.bimobject.com (2019)

v. Fire door

This is a fire resistance door used to passively protect the building from fire and reduce fire spread and smoke from a building or between different structures or compartments (Kalidasan, 2017).

2.4. Egress Strategies for Fire Safety

According to Sun (2013), egress strategy is defined as an evacuation process which is basically a plan to get out of a situation. The population can either begin evacuation simultaneously or systematic. Egress strategies can be grouped into the population of evacuees.

2.4.1 Means of egress

This is a regular and free movement from any part of the building or structure to exit stairs or elevators. Spearpoint and MacLennan (2012) opines that, the essence of providing means of egress to make sure that occupants are safely evacuated from the building within a short period. Nilsson and Johnson (2011) added that, the fire egress is affected by occupant‟s behaviour, demographic, advancement in technology and subsequent increase in the building height should be considered. Egress components include stairs, escape elevators, area of refuge.

a. Simultaneous evacuation

This is an evacuation strategy aimed at taking out all the people at the same. Egress process begins generally with alarm sound and activation of fire warning system simultaneously on every floor. Although, evacuation of the whole building is still considered easiest to implement (Sun, 2013).

b. Phased evacuation

Phased evacuation is mostly associated with high-rise buildings. In the evacuation of this kind, occupants from where fire begins should be moved to an area of the building that is considered fire free zone. Multiple notifications such as horn/speakers, voice alarms, combined with strobe devices are used to initiate or notify the occupants of a phased building evacuation. Occupants on the floor where the fire begins and on the floor above and below are given a signal and message to evacuate and to enter floors below their originating floor (Sharma *et al.*, 2014).

c. Total evacuation

In this strategy, all occupants in the building must be evacuated to the specified area of safety (Hassanain 2009).

d. Defend-in-place

This strategy is often used when there is fire in high-rise buildings and occupants close to the doors of their rooms would have to wait for rescuers. This strategy has been used in the past to help people with disabilities as they may be faced with mobility impairments which may hinder their self-rescue activities (Ronchi and Nilsson, 2014).

2.4.2 Egress strategies for high-rise condominium buildings

Evacuation of high rise buildings has always been hindered by the vertical nature of egress. For this reason, modern designs should be free from variables that may hindered occupants escape from the building when there is fire incident (Spearpoint and MacLennan 2012). According to Nilsson and Jönsson (2011), Occupants ignorance, technology advancement and the height of the building should also be considered

2.4.3 Egress components

The design of the egress components is considered as the first step in achieving adequate safety in high-rise building. The egress components are:

i. Stairs

Stairs are the oldest means of evacuation in high-rise buildings. Stair should be wide enough to accommodate many occupants in a floor. In other words, Stairs should be wide enough to allow two persons walk side by side during evacuation process (Ronchi and Nilsson, 2014).

ii. Core arrangement

A Core is the center and the major area of any high rise building that brought together functions and service needed in the building. The area includes toilet facilities, elevator banks, utilities, smoke shafts and stair, and mechanical facilities. In other words, it is the building part that is regarded as servicing facilities within the building, largely for the purpose of vertical transportation as in the case of lift and stair (Sanya, 2018).

ii. Fire service access elevators

This has an important impact on occupants egress especially in tall buildings but is not among the means of egress. The egress of any tall building most be completed before the fire services can begin operations so as to avoid conflict between occupants and firefighters as a result of counter flow in the stairs (Bukowski, 2009).

iv. Refuge floors

High-rise buildings of more than 20 floors must be provided with refuge or mechanical floors. The space in these floors cannot accommodate all occupants, equipment and fuel but should be at 0.3m square or 3fts per person. In other words, refuge floor are provided just to rest or await assistance (Bukowski, 2009).

2.4.4 Fire resistance construction

Fire Resisting Construction helps in preventing fire spread within and outside the building since the building is divided into compartments stabilized and provided with adequate resistance that would disallowed fire spread from the roof of one building to another (Kurniawan *et al.*, 2018).

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

A descriptive research was adopted in this study to help the researcher attain its objectives. This was used to allow collection of data directly from respondents who have different attitudes, opinions, beliefs and norms on the subject matter. The researcher also implores the use of self-observation of buildings and studying of a sample population as methods of data collection. Observation schedule was structured in the form of checklists, questionnaires were close ended to assess fire prevention strategies in different high-rise condominium buildings selected in the study area as shown in the appendices A, and B.

Primary and secondary sources of data were used to acquire data for this study.

3.2 Data Type and Sources

To attain objectives in this research, data were obtained from primary and secondary sources.

3.2.1 Primary data

The researcher generates the primary data for this research from field work through the use of observation schedule and questionnaires. The surveys was conducted on the selected high-rise buildings in the study area. The research focused on the study area and selected a total of eleven (11) high rise buildings and conducted physical measurement with the aid of a well-structured observation schedule to note down information based on the variables derived as discussed in section 3.4.1 and used it to realise some of the stated objectives of this study. Questionnaires were also administered to collect some information required for this study.

3.2.2 Secondary data

Secondary data on another hand, were obtained from the Lagos State Physical Planning Permits Authority under the Lagos State Ministry of Physical Planning and Urban Development, to ascertain the number of high rise residential buildings in Victoria Island Lagos. The researcher also used Google earth map to generate total number of streets available in Victoria Island Lagos as discussed in the next section. Data were also acquired from the different relevant published journals on sample sizes and zoning of Victoria Island, Lagos.

3.3 Sample Size and Population of the Study

Victoria Island is the research site. According to Google earth map, there are 115 streets in Victoria Island, Lagos, which were divided to six zones of population strata (Bishi, and Olajide, 2011). The six zones the Diplomatic zone (At Eleke Crescent/ Bonny Camp), Mixed zone I (At Kofo Abayomi Axis); Commercial zone I (At Adeola Odeku/ Ahmadu Bello Axis); Professional zone (At Law School/Sanusi Fafunwa); Commercial zone II (At

Ajose Adeogun/ Akin Adesola, Adetokunboh Ademola Axis); and the Mixed zone II (At 1004/ Muri Okunola Axis). According to the Lagos State Physical Planning Permits Authority, there are one hundred and two (102) high-rise residential buildings in Victoria Island, Lagos; out of which the researcher selected eleven (11) from each zone for the purpose of this research. The selection of the buildings was purposefully done with the researcher making decision based on the ability of the buildings to provide the necessary data.

Table 3.1 Lists of high rise residential buildings selected in Victoria Island, Lagos

ZONE	TOTAL NUMBER OF HIGH RISE BUILDINGS	NAME OF SELECTED BUILDINGS	LOCATION	TOTAL NUMBER OF UNITS IN THE BUILDING
Diplomatic Zone	9	Eden Height	Elsei Femi Pearse Street, Victoria Island, Lagos State.	27
Mixed Zone	21	Vita Tower	off Kofo Abayomi street, Victoria Island, Lagos State.	44
		Eko Court Tower	Kofo Abayomi street in Victoria Island, Lagos State.	155
		Olympic Tower	280, Kofo Abayomi Road, Victoria Island, Lagos State.	25
Commercial Zone	17	Bar Beach Tower	Bishop Oluwole Street, Victoria Island, Lagos State.	108
		Visage Tower	Taslim Elias close, Victoria Island, Lagos State.	21
Professional Zone	6	Nill	Law School/Sanusi Fafunwa Victoria Island, Lagos State.	Nill
Commercial Zone (II)	23	Pier Harbour	A.J Marinho Drive, Victoria Island, Lagos State.	16
		Aqua Tower	12 A.J Marinho Drive, Victoria Island, Lagos State.	30
		Genbrite Complex	Akin Adesola street, Victoria Island, Lagos State.	15
Mixed Zone (II)	26	1004 Apartment	Off Ozumba Mdadiwe Road, Victoria Island, Lagos.	126
		Grand Orchard	111 Palace Road, Victoria Island, Lagos State.	19
Total	102	11		586

Source: Author's field work (2020)

According to Singh and Masuku (2014), a population size of six hundred (600) can give a desired, confident and accurate level of 95% when the sample size is 234 (refer to the appendix 1). The population size of this research is however, five hundred and eighty six (586) which correlated with the above authors sample population of three hundred (300).

3.4. Data Collection Instruments

Data was obtained from the field through the use of observation schedule and questionnaires refer to the appendices A and B.

3.4.1 Observation schedule

The researcher used observation schedule for data collection of the selected high-rise residential buildings at the study area. Pring and Thomas (2009) present the observation schedule as a document prepared to enhance the examination of variables in the sampled population. However, the variables chosen in the study of fire prevention strategies of high-rise condominium were obtained from the review of related literature to this of study. The variables include:

(i) Number of floors in the building

(ii) Number of stairs in the building

(iii) Causes of fire in the buildings

(iv) Types of fire prevention strategies

(v) Present of alarms, smoke detectors, hydrants, types of extinguisher, sprinkler system, and hose system.

(vi) Building form, shape of the roof, compartmentation of the floor, provisions of corridors.

(vii) Application of fire resistance material

Table 3.2. The Statistical Information Showing the Selection of Study Population

NAME OF THE BUILDING	TOTAL NUMBER OF UNIT IN THE BUILDING	% OF TOTAL NUMBER OF UNIT IN THE BUILDING	NUMBER OF QUSTIONNAIRE DISTRIBUTED	NUMBER OF QUSTIONNAIRE 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 field work (2020)

3.4.2 Questionnaires

Questionnaire was designed and presented to the occupants of those selected high rise buildings in the study area and their responses were recorded against the building they represent. Out of 300 questionnaires (refer to section 3.3) distributed to the occupants, only 243 were returned.

3.5. Sampling Technique

Simple random and purposive sampling technique were adopted for this research. In the simple random sampling technique, any unit included in the sample were given the same opportunity of inclusion as other unit in the sample (Singh & Masuku, 2014). Simple random sampling technique were used in selection of the sample size from the entire population after which purposive sampling techniques was used to select buildings from each zone in Victoria Island, Lagos. Purposive sampling technique, which is also known as judgment sampling, is when a participant is chosen internationally based on the qualities the participant possesses (Ikler *et al.,* 2016). These sampling techniques helped the researcher to acquired information on the causes of fire and the prevention strategies used in selected high rise residential buildings.

3.6. Method of Data Collection

Using the required variables on passive fire prevention strategies, the researcher used observation schedule as one of the instrument of gathering data in this research. The researcher observed directly from the selected high-rise condominium buildings in Victoria Island, Lagos and assessed the effectiveness of those methods of fire prevention strategies used in those buildings. Questionnaire was prepared and distributed to the

occupants of the selected high-rise buildings in the study area and captured their responses independently in this research. The variables chosen in the study of fire prevention strategies in high-rise condominium as mentioned in section 3.4.1 were obtained from the review of literature relevant to the field of study.

3.7. Method of Data Analysis

The data collected from the field work were analysed using descriptive statistics (frequency and percentages), pie charts and bar charts. Plates were also used while computing results to give a clearer view of some elements in the study area.

3.8 Study Area

This study centres on Victoria Island, Lagos state which is regarded as an affluent area that accommodates former Island with same name. This Island is located between Lagos Island and the Lekki peninsula at the Lagos lagoon. It is considered a business and financial centre of Lagos state, Nigeria. The Island shared boundaries with the Eti-Osa local government area. The researcher, however chosen Victoria Island, Lagos state because its high concentration on high rise buildings.

3.8.1. Location of Victoria Island

Victoria Island is located at the southern part of Lagos state and within Eti-Osa Local Government Area of Lagos State. It shared boundaries with Five Cowries Creek from the North, Atlantic Ocean from the South, Lagos Island Local Government Area from the West and Lekki from the East.

Plate XVIII: Victoria Island, Lagos showing the major axis. Source: Author‟s field work (2020)

3.8.2. History of Victoria Island

Victoria- Island was formally known as “Iru-land” has its traditional ruler till date. The old plan of this area was designed by Lagos State Development Property Corporation in 1973, while the plan of its extension was done by the New Town Development Authority, having demolished and evacuated Maroko in the mid 1980‟s. Eti-Osa local government area where Victoria Island is located was created in 1989 and is regarded as one of the oldest local government area in Lagos state. “Eti-Osa” in Yoruba Language means located along a stretch of water bodies at three of its edges.

3.8.3. The people of Victoria Island

Victoria Island is a home for individual and families that have a taste for a lifestyle characterized by comfort, affluence and luxury. It is a home for many celebrities, socialites, embassies, business people and government officials.

3.8.4. Justification to the choice of study area

Victoria Island is regarded as the largest commercial area in Lagos State as it covers about 772 Hectares or 7.72 sq. km. it is also known to be the fastest growing commercial area when compared with other Islands in Lagos state. It provides comfort and security to the people. It comprises of both residential and commercial high-rise buildings with an extensive road and water transport network. The researcher concentrates on Victoria Island, as it has the highest number of high-rise buildings in Nigeria.

3.9 Summary of Data Collection

The descriptive survey method was adopted for this research while observation schedule and questionnaire were used as research instruments to serve as primary source of data. Secondary data were however gathered from the Lagos State Physical Planning Permits Authority under the Lagos State Ministry of Physical Planning and Urban Development, google earth map and relevant published journals. Eleven (11) high rise buildings were selected from a total of five hundred and eighty six (586) using simple random and purposive sampling technique. The different data obtained were analysed in the subsequent chapter.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Data Analysis

This chapter concentrates on the analysis of data collected through the administration questionnaire and observation schedule. The results obtained from the analysis are discussed and presented in this chapter in the form of Tables, Figures and Plates correlating with the stated objectives of this research which are thus:

(i) To identify fire prevention features used in the selected high rise condominium buildings.

(ii) To determine fire causes of high rise condominium buildings in the study area

(iii) To determine design methods to fight and prevent fire in the selected buildings

(iv) To propose a design of a condominium that can prevent fire through the use of passive and active design strategies.

4.2.0 Case Studies

4.2.1. Eden height tower, Victoria Island, Lagos

Eden Height Tower is located at Elsei Femi Pearse Street Victoria Island Lagos. Is has 15 floors which has 27 units of apartents, which are one (1) bedroom flat, two (2) bedroom flats, three (3) bedroom flats, four (4) bedroom flats and penthouse. The facilities include spa, salon, laundry, club lounge, swimming pool and gym.

Appraisal

Building materials used in the construction of the aforementioned tower are glass, concrete, hollow blocks and steel. Eden Height Tower also has in every floor modern active and passive fire safety measures such as sprinkler system, fire hose system, fire detectors and fire extinguishers. Also provision of fire hydrants was made. The passive fire prevention strategies available in the building are fire doors, cement product, intumescent coating and frame structures.

Plate XIX: Approach view of Eden Height Tower.
Source: Author's field work (2020)

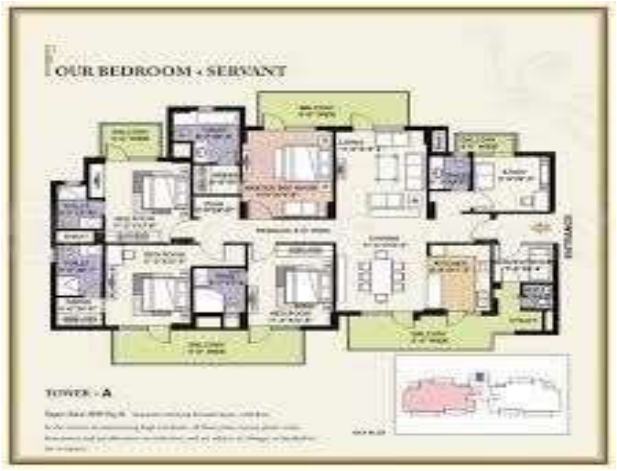

Figure V: floor plan view of Eden Height Tower at VI.
Source: Author's field work (2020)

Plate XX: Bed room of Eden Height Tower at VI.
Source: Author's field work (2020)

Plate XXI: Bed room of Eden Height Tower at VI. Source: Author's field work (2020)

4.2.2. Vita tower, Victoria Island, Lagos

This building is located at number one Anifowoshe Street, off Kofo Abayomi Street, Victoria Island Lagos. Vita Tower consists of two high rise buildings with 12 floors and modern architectural master piece of eight penthouses and 36 apartments. The apartments are three (3) bedrooms and four (4) bedrooms. Other facilities include gym, swimming pool, sky bar and lounge.

Appraisal

Materials used for construction includes; glass, reinforced concrete, hollow blocks, steel. The tower used both active and passive fire safety measures. Sprinkler system and fire extinguishers were installed but were not adequate. Also provision of fire hydrants was made. The passive fire prevention strategies used in the building are fire doors, cement product, intumescent coating and frame structures.

Plate XXII: Side view of Vita Tower.

Source: Author's field work (2020)

Plate XXIII: Approach view of Vita Tower at VI.

Source: Author's field work (2020)

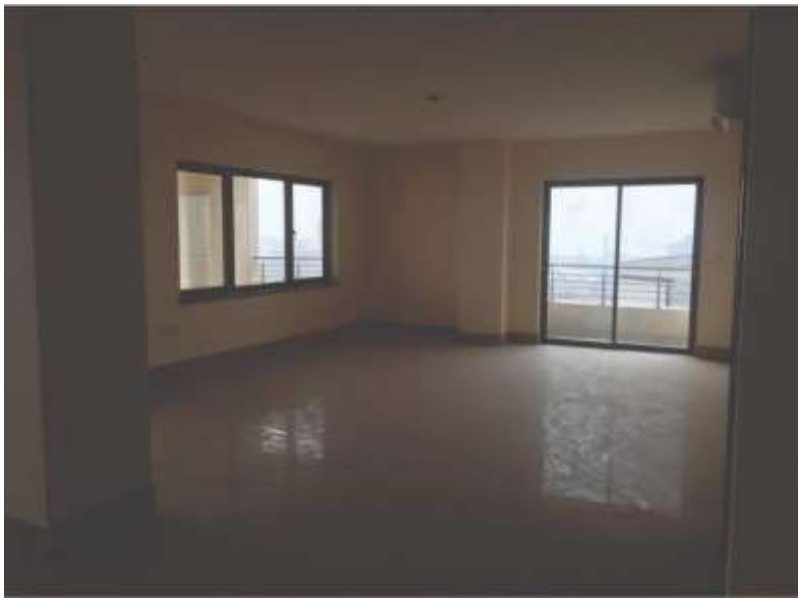

Plate XXIV: Bedroom at Vita Tower at VI. Source: Author's field work (2020)

Plate XXV: Bedroom at Vita Tower at VI. Source: Author's field work (2020)

4.2.3. Eko court tower, Victoria Island, Lagos

This tower is at located at number 174, Kofo Abayomi Street, Victoria Island, Lagos. It consists of three (3) high rise and one (1) low-rise buildings with one hundred and fifty five (155) apartments. Eko court block A and B consists of 24 floors which comprises of two (2) and three (3) bedrooms with a penthouse. Other facilities include gym, elevators, swimming pool and tennis court.

Appraisal

Materials used for construction includes; glass, reinforced concrete, hollow blocks, steel. The tower used both active and passive fire safety measures. Sprinkler system, fire hose system and fire extinguishers were installed in each floor. The passive fire prevention strategies used in the building are cement product and frame structures.

Plate XXVI: Approach view of Eko Tower at VI. Source: Author's field work (2020)

Plate XXVII: Aerial view of Eko Tower Source: Author's field work (2020)

.

Plate XXVIII: Interior view of Eko Court Tower at VI. Source: Author's field work (2020)

4.2.4. Olympic tower, Victoria Island, Lagos

Olympic Tower is at number 280, Kofo Abayomi Street, Victoria Island Lagos. It comprises of 25 apartments in which the apartment are three (3) and four bedrooms with a penthouse and has twelve floors. Other facilities include swimming pool, gym, club house, crèche and laundry.

Appraisal

Materials used to constructs this tower includes: glass, reinforced concrete, hollow blocks and steel. The tower used both active and passive fire safety measures. Sprinkler system, fire hose system and fire extinguishers were installed in each floor. The passive fire prevention strategies used in the building are cement product, intumescent coating and frame structures.

Plate XXIX: Surrounding of Olympic Tower at VI. Source: Author's field work (2020)

Plate XXX: 3D view of Olympic Tower at VI. Source: Author's field work (2020)

Plate XXXI: Interior view of Olympic Tower at VI. Source: Author's field work (2020)

4.2.5. Bar Beach tower, Victoria Island, Lagos

Bar Brach Tower is located at Bishop Oluwole Street, Victoria Island Lagos. It is situated near the popular bar beach. Bar beach tower thirteen (13) floors which have comprises of 108 units and consists of one (1), two (2), three (3) bedrooms and penthouse.

Appraisal

Materials used for construction includes; glass, reinforced concrete, hollow blocks, steel. The tower used both active and passive fire safety measures. Sprinkler system, fire hose system and fire extinguishers were installed in each floor. The passive fire prevention strategies used in the building are cement product and frame structures.

Plate XXXII: Surrounding of Bar Brach Tower at VI.

Source: Author's field work (2020)

Plate XXXIII: Surrounding of Bar Brach Tower during fire
Source: Author's field work (2020)

Plate XXXV: Interior of Bar Brach Tower.

Source: Author's field work (2020)

Plate XXXIV: 3D view of Bar Brach Tower

Source: Author's field work (2020)

4.2.6. Visage apartment, Victoria Island, Lagos

Visage apartment is located at Taslim Elias close, Victoria Island, Lagos. Visage apartment consists of seven floors and 21 units apartments which comprises of two (2), three (3) and four (4) bedrooms with penthouse. Other facilities available are: bar, swimming pool, children play area, club house and gym.

Appraisal

Materials used for construction includes; glass, reinforced concrete, hollow blocks, steel. The tower used both active and passive fire safety measures. Sprinkler system, fire hose system and fire extinguishers were installed. The passive fire prevention strategies used in the building are cement product and frame structures.

Plate XXXVI: Surrounding of Visage apartment at VI. Source: Author's field work (2020)

Plate XXXVII: Front view of Visage apartment at VI. Source: Author's field work (2020)

Plate XXXVIII: Children play area. Source: Author's field work (2020)

Plate XXXIX: Two bedrooms in Visage apartment. Source: Author's field work (2020)

4.2.7. Pier Harbour, Victoria Island, Lagos

Pier harbour is located at A.J Marinho Drive, Victoria Island Lagos. It consists of nine (9) floors with 16 units apartments. There are two units of two bedrooms, twelve units of three bedrooms and one unit of four bedrooms. Other facilities include gym, swimming pool, squash court, massage room, games room, club house and children play area.

Appraisal

Materials used for construction includes: glass, reinforced concrete, hollow blocks, steel. The tower used both active and passive fire safety measures. Sprinkler system, fire hose system and fire extinguishers were installed in each floor. The passive fire prevention strategies used in the building are cement product and frame structures.

Plate XL: 3D view of Pier harbour at VI. Source: Author's field work (2020)

Plate XLI: Children play room at Pier harbour. Source: Author's field work (2020)

Plate XLII: Game room in Pier harbour. Source: Author's field work (2020)

Plate XLIII: Game room in Pier harbour. Source: Author's field work (2020)

4.2.8. Genbrite Complex, Victoria Island, Lagos

The location of this complex is at Akin Adesola street, Victoria Island Lagos. It has 15 floors with 15 units apartments that comprises of one (1) beddroom, three (3) bedrooms and penthouse. Other facilities include gym, and children play area.

Appraisal

Materials used for construction includes; glass, reinforced concrete, hollow blocks, steel. The tower used both active and passive fire safety measures. Sprinkler system, fire hose system and

fire extinguishers were installed in each floor. The passive fire prevention strategies used in the building are cement product and frame structures.

Plate XLIV Approach view of Genbrite complex at VI. Source: Author's field work (2020)

Plate XLV: Staircase and elevator in Genbrite complex at VI.

Source: Author's field work (2020)

Plate XLVI: Three bedrooms in Genbrite complex at VI.

Source: Author's field work (2020)

Plate XLVII: Kitchen in Genbrite complex.

Source: Author's field work (2020)

4.2.9. Aqua tower, Victoria Island, Lagos

Aqua Tower is located at number 12A.J Marinho street, Victoria Island, Lagos. It consists of 10 floors which comprises of 30 apartments units which are of t and three (3) bedrooms apartment. Other facilities include swimming pool, gym and sauna.

Appraisal

Materials used for construction includes; glass, reinforced concrete, hollow blocks, steel. The tower used both active and passive fire safety measures. Sprinkler system, fire hose system and fire extinguishers were installed in each floor. The passive fire prevention strategies used in the building are cement product and frame structures.

Plate XLVIII: Aqua Tower and its surrounding at VI. Source: Author's field work (2020)

Plate XLIX: Dining area in Aqua Tower.
Source: Author's field work (2020)

Plate L: Gym in Aqua Tower.
Source: Author's field work (2020)

4.2.10. 1004 apartment, Victoria Island, Lagos

The location is fantastic for the feel of city living with Estate entrance and exit streets that lead onto roads directly off Ozumba Mdadiwe Road, a main street in Victoria Island. Block A1, a high-rise 14-floor-block of 7 Maisonette flats in „Cluster A" of the estate is located facing Federal Housing Estate Road which is directly overlooks the grand riverside „Civic Centre" on one side and has a clear view of the Atlantic Ocean and other parts of Victoria Island on the other side. The 1004 flats comprises of two (2) bedroom flats, three (3) bedroom flats and four (4) bedroom flats.1004 is also located a short walk from several hotels, Beaches, shops, grocery stores, hospitals, banks, restaurants, bars and other trappings of city

life.

Appraisal

Materials used for construction includes; glass, reinforced concrete, hollow blocks, steel. The tower used active and passive fire safety measures. Sprinkler system, fire hose sytem and fire extinguishers were installed in each floor. The passive fire prevention strategies used in the building are cement product and frame structures.

Plate LI: Approach view of 1004 Apartment. Source: Author's field work(2020)

Plate LIII: Passage area in 1004 Apartment.
Source: Author's field work (2020)

Plate LII: 1004 Apartments surrounding at VI.
Source: Author's field work (2020)

Plate LIV: Living room and staircase to bedrooms at 1004 Apartments in VI.

Source: Author's field work (2020)

4.2.11. Grand Orchard, Victoria Island, Lagos

Grand orchard is located at number Palace Road, opposite Ihuntayi street Oniru, Victoria Island, Lagos. The building consist of two blocks apartments and each have 10 floors which comprises of 19 apartment units which comprises of three (3) bedrooms apartment. Other facilities include swimming pool and gym.

Appraisal

Materials used for construction includes; glass, reinforced concrete, hollow blocks, steel. The tower used both active and passive fire safety measures. Sprinkler system, fire hose system and fire extinguishers were installed in each floor. The passive fire prevention strategies used in the building are cement product and frame structures.

Plate LV: Approach view of Grand orchard at VI.

Source: Author's field work (2020)

Plate LVI: The two blocks in Grand orchard

Source: Author's field work (2020)

Plate LVIII: Living room and the stair case leading to bedrooms in Grand orchard at VI.

Source: Author's field work (2020)

Plate LVII: Elevator and stair case in Grand orchard at VI.

Source: Author's field work (2020)

4.2. Fire Prevention Features Adopted in Some of the Selected High Rise Condominium Buildings.

The researcher collected data on fire prevention measures used in the selected high rise residential buildings through critical environmental observation of the buildings. The availability of fire safety features and their functionality as shown in Table 4.1 below.

Tables 4.1 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: Author's field work (2020)

The table 4.1 above indicates the availability of fire safety measures either active or passive measures, their functionality and whether the building experienced fire outbreak or not.

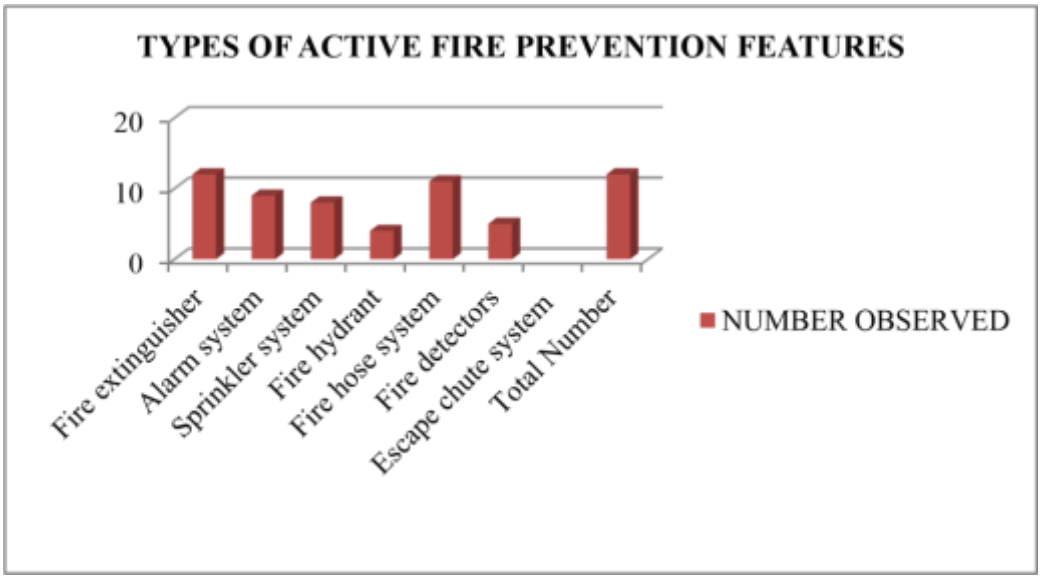

Figure 4.1 Active fire safety measures in selected buildings Source: Authors field work (2020)

Figure 4.1 shows different active fire prevention strategies used in selected buildings. Although some of the equipment are does not function well while some are not adequate.

4.2.2 Passive Fire Prevention Features in Selected Buildings

Table 4.2 Passive Fire Prevention Features in Selected Buildings

S/N	Name of the building	Form of Building	Shape of Roof	fire resistance materials applied/used	Wall materials	Roof materials	Floor finishes materials
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 board	Hollow block	Aluminium and gypsum	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: Author's field work (2020)

The table 4.2 above shows different passive fire prevention features used in some of the selected high-rise buildings. It exposes that most buildings selected used hollow blocks and cementitious product for construction.

Figure 4.2 Fire safety features in selected buildings Source: Authors field work (2020)

4.2.3 Mode of Application of Fire Prevention Features

Both active and passive fire prevention feature were observed in buildings selected

Table 4.3 Mode of Application of Fire Prevention Features

CASE STUDIES	WOFB	IIBC	ICOS	TDAE	FAFQ
Eden Height Tower	Excellently applied	Averagely applied	Excellently applied	Averagely applied	Excellently applied
Vita Tower	Averagely applied	Averagely applied	Excellently applied	Averagely applied	Averagely applied
Eko court Tower	Averagely applied	Applied poorly	Averagely applied	Excellently applied	Averagely applied
Olympic Tower,	Averagely applied	Averagely applied	Averagely	Excellently applied	Averagely applied
Bar Beach Tower	Averagely applied	Averagely applied	Averagely applied	Excellently applied	Poorly applied
Visage Apartment	Averagely applied	Averagely applied	Excellently applied	Averagely applied	Averagely applied
Pier Harbour	Averagely applied	Averagely applied	Averagely applied	Averagely applied	Excellently applied
Genbrite Complex	Excellently applied	Averagely applied	Averagely applied	Averagely applied	Excellently applied
Aqua Tower	Averagely applied	Averagely applied	Excellently applied	Averagely applied	Poorly applied
1004 Apartment	Averagely applied	Excellently applied	Averagely applied	Excellently applied	Averagely applied
Grand Orchard	Averagely applied	Excellently applied	Excellently applied	Averagely applied	Averagely applied

Key

WOFB=wide openings of fenestration in the buildings; IIBC=Improper insulation of the building components; ICOS=Inadequate compactmentation of the spaces; TDAE=Travel distances from apartment to the nearest escape route; FAFQ=Functionality of the active fire safety equipment Source: Author's field work (2020)

4.3. Causes of Fire in High Rise Condominium Buildings

From the analyses of studies (Baker, 2015 and Onoyan-Usina *et al.,* 2017) states the causes of fire in buildings includes Arson = AS; Bad housekeeping habit = BD; Carelessness =CA; Electrical faults = EF; Storage of adulterated fuel =SF; Keeping children at home without proper supervision = KS; Indoor use of generator = IG; Smoking = SK; Power surge = PS.

When respondents were asked about causes of fire in high rise buildings, their responses were given in Figure 4.3

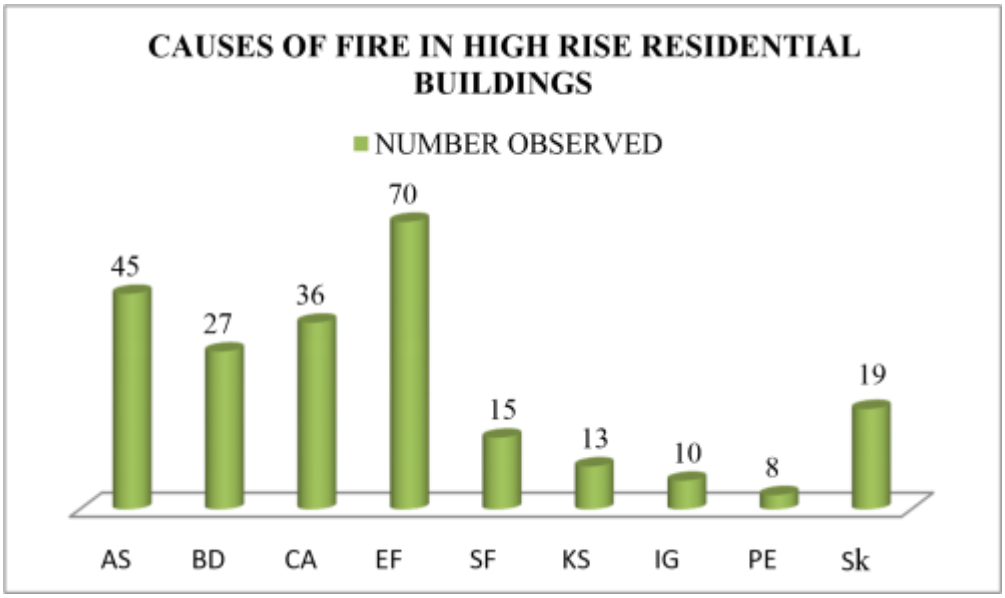

Figure 4.3 Shows causes of fire in high-rise residential buildings Source: Author's field work (2020)

Figure 4.3, shows that fire in the building are mostly caused due to electrical faults as such, proper electrical installation should be made and good electrical wires should be use during wiring of the buildings.

4.4. Occupants Responses on Design Methods to Prevent Fire in High Rise Condominium Buildings

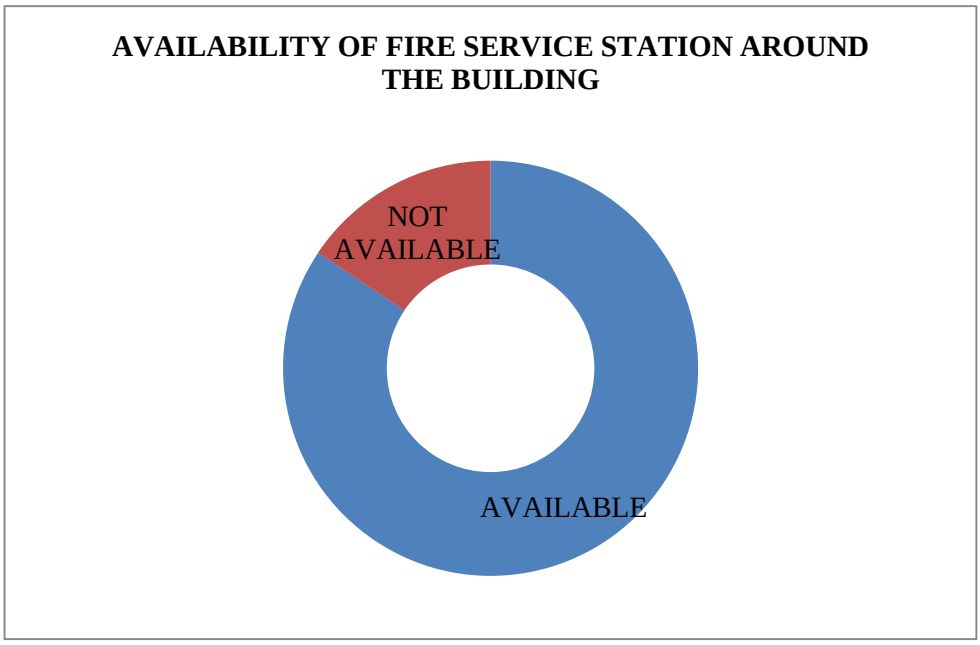

Figure 4.4 Availability of fire service station around the building. Source**:** Author's field work (2020)

The figure 4.4 shows that there is no much fire service station around the buildings and some that has it were not very functional. The absent of fire safety station around the buildings may leads to delay in extinguishing fire and can results into loss of properties and lives.

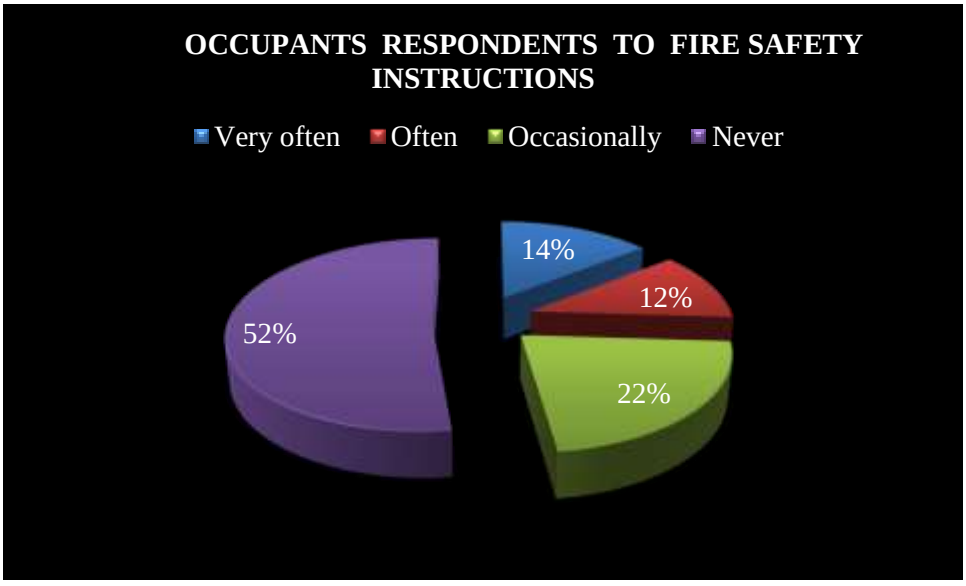

Figure 4.5 Response of the respondents to the fire safety instructions. Source: Authors field work (2020)

Figure 4.5 above reveals responses of the respondents on fire safety instructions. It explicitly shows that 52% of the respondents have not come across any fire safety instructions, 22% only occasionally respond to them, 12% often respond to the instructions and 14% respond to the instructions very well.

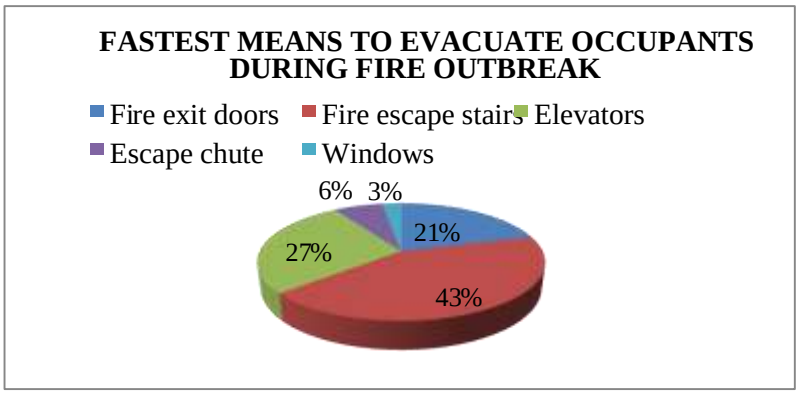

Figure 4.6 Fastest means to evacuate occupants from the building. Source: Author's field work (2020)

The figure 4.6 shows above that most occupants think that the fastest means of escape from any building during fire outbreak is through the staircase even though some still considered elevators than the staircase.

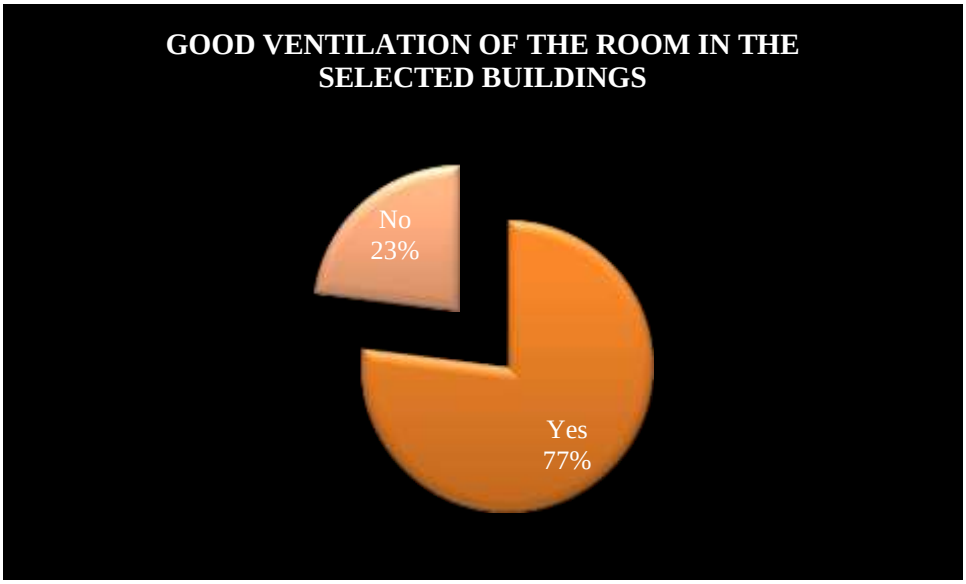

Figure 4.7 Ventilation of the rooms. Source: Author's field work (2020)

Figure 4.7, show that 77% of the buildings have good ventilation which will help to reduce accumulation of smoke in the rooms.

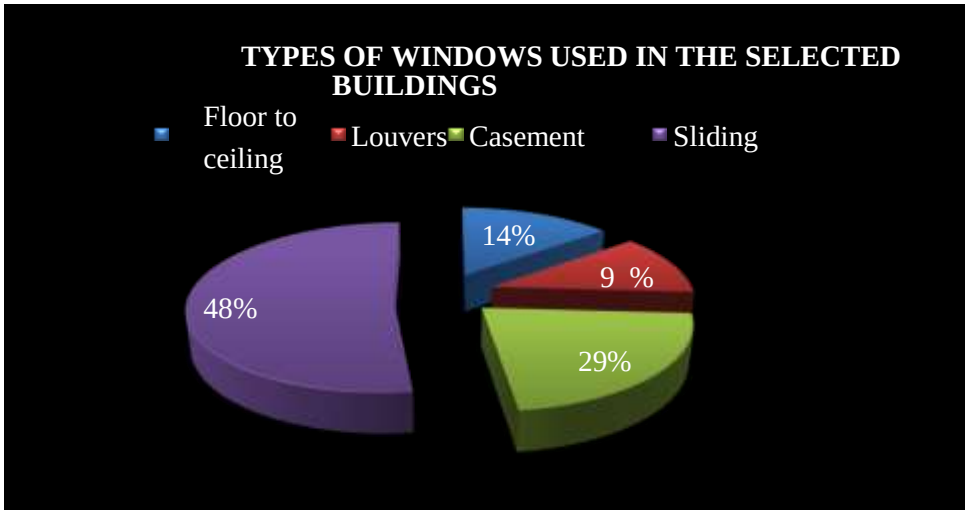

Figure 4.8 Types of windows used in selected buildings. Source: Authors field work (2020)

Figure 4.8 above reveals that, floor to ceiling window is mostly used in the buildings because of its height and wideness which help to give good ventilation to the rooms and prevent trapping of smoke in the rooms.

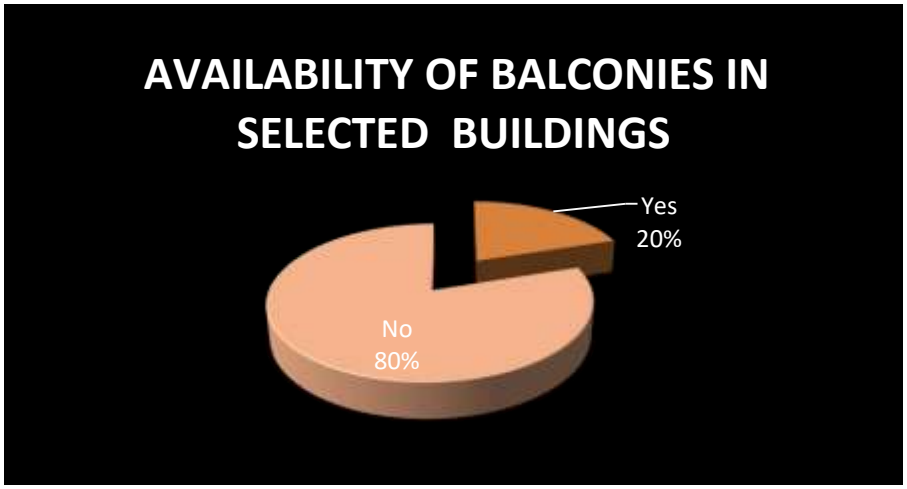

Figure 4.9 Availability of balconies in selected buildings. Source: Authors field work (2020)

Figure 4.9 above shows that there are no many balconies in some of the selected buildings. Balconies help in providing airflow movement to the building.

4.5. Design Proposal of a Condominium that Can Prevent Fire Through the Use of Passive and Active Design Strategies.

A design proposal of a high-rise condominium in Victoria Island Lagos is made putting in mind all the ideas and information gathered from objectives one to three in order to incorporate effective fire prevention strategies in the proposed building. Fire prevention strategies apart from being a pre-requisite in high-rise designs it can also save life and properties of the residents in

the building. As summary, the design features from this research, which were applied to the design, are the following:

1. Building form: the building form and exterior of the design were simple in order to prevent trap of fire heat and permits easier protection from fire as shown in the appendices K.
2. Compartmentation of fire: the building units were divided into compartments to allow maximum protection as it will help to inhibits fire spread within the building (refer to appendices F).
3. Shape of the roof: the roof was made simple because complex roof enhance the spread of fire (refer to appendices F).
4. Cementitious product: cementitious product used for the concrete were also used for slabs, beams, columns and plaster because they protect the steel members by trapping moisture that boils the steel and keep it temperature below the value at which it will fail when there is fire incident until the water disappear. It also help to reduce heat input to the underlying structure.
5. Polypropylene fibres: polypropylene fibres will be added to the cement during mixture as it help to prevent concrete spalling.
6. Intumescent coating: intumescent coating will be applied on the steel members. It work by quickly swelling to four times their original thickness when exposed to fire thus, insulating the structure that they are protecting.
7. Fire resistant wall: some of interior walls are fire resistance with opening that limit fire spread and prevent its extension.
8. Fire resistance doors: fire resistance doors were used to reduce the spread of the fire and smoke between different structural compartments and enable safe egress from the building.
9. Fire resistance glass: Fire resistance glass were used in the building to hinder the spread of fire.

10. Photoluminescent marking: photoluminescent marking are light installed on the stairs and corridors leading to the exits to serve as a guide and sign information that identify the egress path.

The design of the high rise condominium will be explained under the following headings:

i. Site location and selection criteria ii. Site analysis and inventory iii. Design concept

iv. Design planning v. Construction.

4.5.1 Site location and selection

The proposed site is located along Prince Yomi Daramola road and water corporation Dr. in Victoria Island, Lagos state. This site is selected because it provides comfort and security to the people leaving there, it is also a well mix of a quiet residential neighbourhood, a growing business hub, and also provides extensive road and water transport network. There is also growing population of high-rise buildings in the area. Plate xxvi below illustrates the site location map.

Plate LVII: Proposed site location Source: Google earth map (2019)

4.5.2 Site analysis and inventory

The site can be accessible through Prince Yomi Daramola road and water corporation Dr. in Victoria Island, Lagos state. The site has very sparse vegetation with shrubs and grasses. The site's soil is loamy which will assists in plant growth and permits pile and pad. Power cables and other utilities are present at this site and that will allow the building to access power easily. Figure 4.22 illustrates the site analysis of the proposed area while figure 4.5.2 shows an inventory of the existing features on the proposed site.

4.5.2: Site analysis

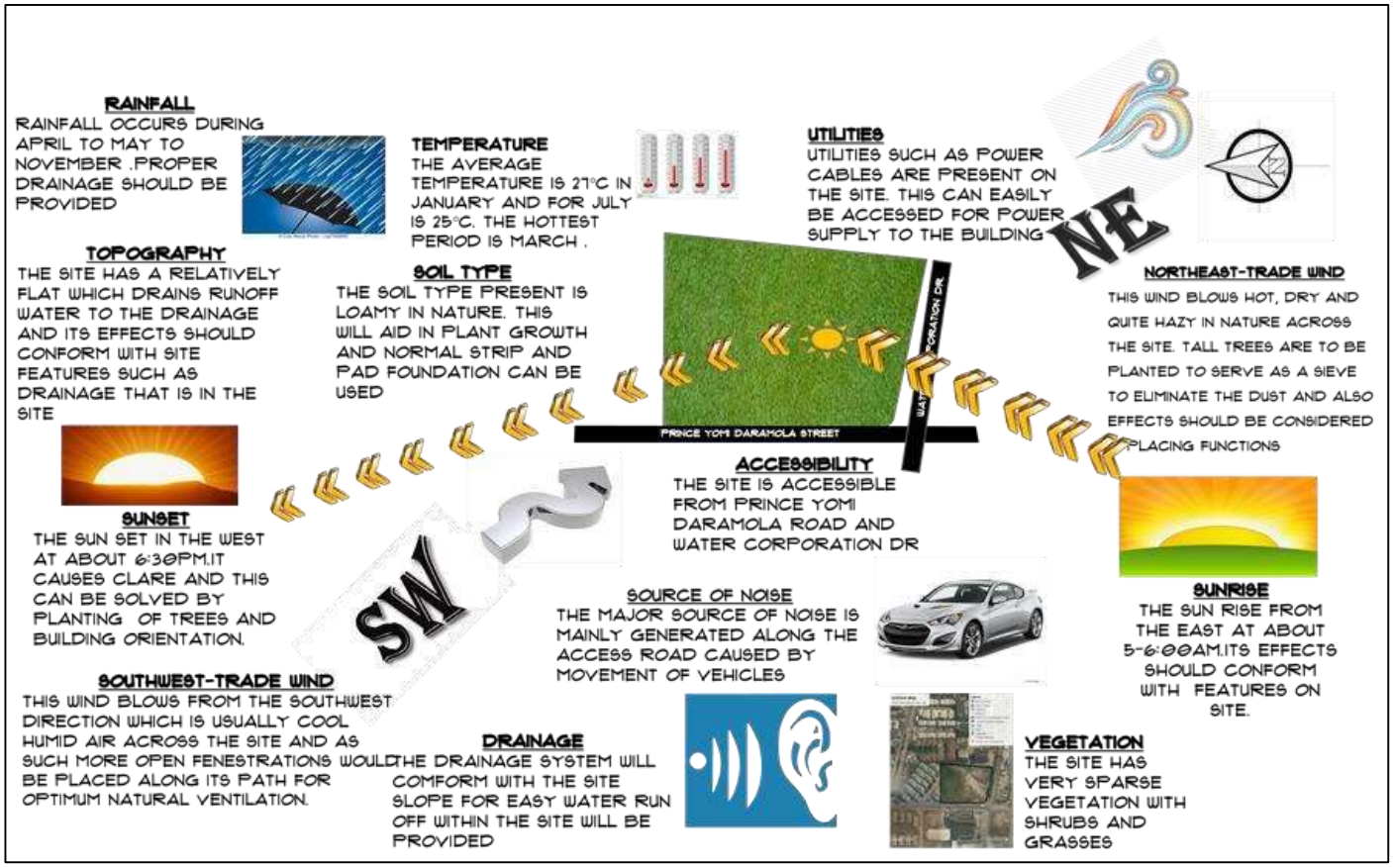

Figure 4.10 Site Analysis. Source: Author"s Design work (2019)

4.5.2. Site Inventory

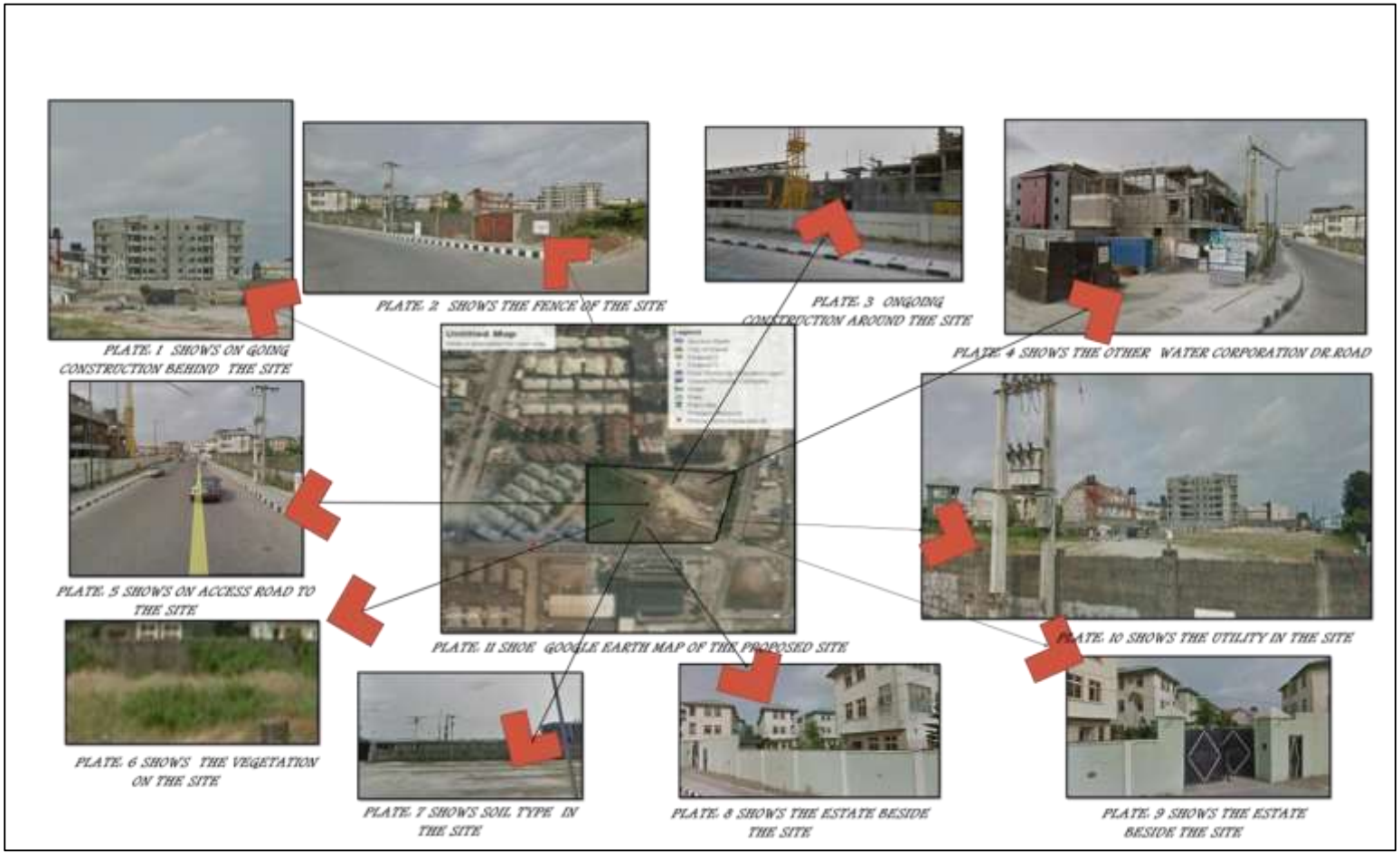

Figure 4.11: Site Inventory

Source: Author‟s Design work (2019)

4.5.3 Design concept

The concept was derived from both passive and active fire prevention strategies coming together to reduce the spread of fire and to extinguish it in the high rise condominium in order to save life and properties of the occupants/residents. Figure 4.24 below illustrates the design concept.

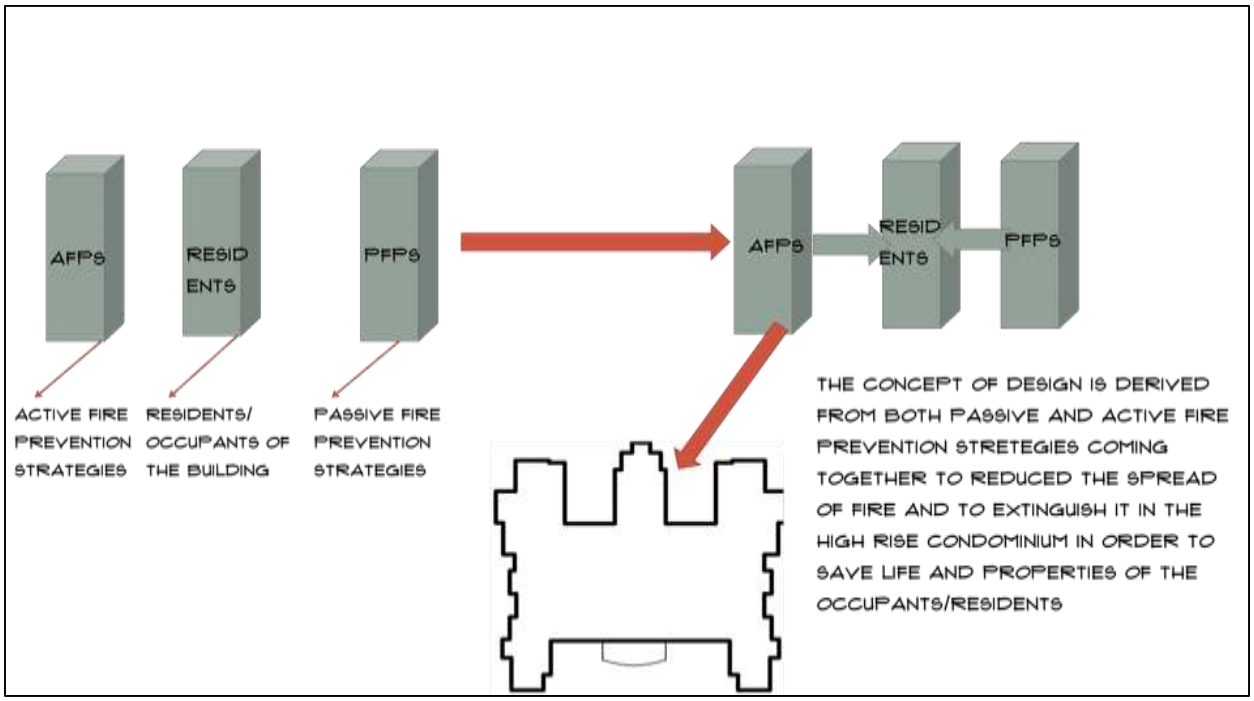

Figure 4.12: Design concept Source: Author's Design work (2019)

4.5.4 Design Planning

The proposed design was planned to meet different requirements of a high-rise condominiums setting while trying to integrate the vital facilities such as recreational spaces, parking and fire hydrant to the design. Different high-rise condominium buildings were studied to enable a better understanding of how these spaces can relate with one another.

4.5.5 Construction

This is also known as the implementation stage of a contract. This process is known to be carried out in different stages, all with the aim of accomplishing a proposed design.

i. Foundation: The foundation is a part of a building structure which is at the structural level of a building. It is responsible for carrying of loads from the super structure to the soil. Soil types mostly determine the type of foundation to be adopted as they have different load bearing capacity. For this structure, pile foundation will be used for the foundation.

ii. Walls: The walls serve as demarcations and also a part of the super structure of a building. The walls will be made of solid, hollow blocks and asphalt coating with stone cladding to resists fire and also the wall will make use of sprayed concrete containing polypropylene and intumescent coating to serve as protection, air tightness and fire resistance to the building.

iii. Floor: The floors will be design into compartment which will reduced the spray of fire and will be made of mass concrete while the suspended floors will be made of hollow clay pot floors.

The floor surface will be finished with a terrazzo, marble tiles and vinyl wood finishes.

iv. Roofing: The parapet roofing system was used with gabled roof and decked in some parts.

The roof members will be painted with intumescent to prevent the sprayed of fire in the building.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Fire outbreak and fire safety problem in Nigeria especially in high-rise buildings are currently receiving the required attention from the government. In the process of assessing fire safety measures of high rise buildings, this study sought the views of the occupants in the selected buildings in addition to the critical observation made by the researcher on the selected high rise buildings in the study area.

The observations made on those buildings include low level of occupant's awareness on fire safety measures, fire safety measures in those buildings were limited only to active fire safety features such as fire extinguishers, sprinkler systems, fire hose system with little passive fire prevention features. In addition, the occupants responded that, electrical faults are the common causes of fire outbreak in buildings. However there are instances where fire outbreak can only be reduced but cannot be completely avoided as the nature of the design and building materials determined the extend of its spread and occurrence.

5.2 Recommendations

The study recommends that occupants of the building should have requisite knowledge on fire safety instructions through awareness, education and information on the operational methods of the available fire prevention measures in the high-rise building as that will increase occupant's cautiousness on fire risks. Building form, roof shape and exterior of buildings should be made simple not complex to avoid trapping of fire heat. The floor area should be in compartment to avoid the spread of fire. Intumescent coating should be applied to steel members to serves as

insulation to the building they are protecting. Fire resistance materials such as gypsum board, fire resistance walls, doors and glass should be used in the building.

Electrical cables and fittings should be of good quality and should be properly installed and monitored. Furthermore, occupants should also be trained on how fire extinguishers are operated and on safety techniques to be adapted when there is a fire outbreak. In addition, signs and signage leading to escape staircases should be provided and well illuminated by photo luminescent marking and not blocked to ensure occupants safety. Active fire equipment should be made functional at all time.

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APPENDICES

Appendix A

AN OBSERVATION SCHEDULE ON ASSESSMENT OF FIRE PREVENTION

STRATEGIES IN THE DESIGN OF HIGH RISE CONDOMINIUM BUILDINGS IN VICTORIA ISLAND,

LAGOS STATE, NIGERIA

PART A - ABOUT THE BUILDING

1. Name of the building: ……

2. Location of the building**.....**

3. Number of floors in the building **(**a) 7-10 (b) 10-15 (c) 15-20 (d) 20 and above

4. Number of bedroom units **(**a) 20-30 (b) 30-40 (c) 40- 50 d) 50 and above

5. Types of bedrooms **(**i)One bedroom(ii) Two bedrooms (iii) Three bedrooms (d)Four bedrooms

(a) i, ii, and iii (b) i, ii and iv (c) ii, iii and iv (d) All of the above

PART (B): DESIGN METHODS TO FIGHT FIRE IN SELECETED BUILDINGS

1. Building form (a) Complex (b) Simple

2. Shape of the roof (a) Complex (b) Simple

3. Are the floor compartmentation (a) Yes ☐ (b) No

4. How many staircases are available in the building? **(**a) 1

(b) 2-3 ☐ (c) 4-5 ☐

(d) 6 and above ☐

5. How many exit staircases are available in the building? **(**a) 1 ☐ (b) 2 ☐ (c) 3

☐ (d) 4 and above ☐

6. Does each unit have its own staircase? (a) Yes ☐ (b) No ☐

7.Is there enough corridors in the building? (a) Yes ☐ (b) No

8. If yes how wide is it? **(**a) 0.9-1.2m ☐ (b) 1.5-1.8m ☐ (c) 2.1-2.4 m ☐ (d) ☐

2.4and above ☐

9. How close is the exits staircase from each apartment units? **(**a) Very close ☐ (b) Close (c)

Far ☐ (d) Very far ☐

10. Does each apartment have a balcony? (a) Yes ☐ (b) No ☐

☐ ☐

11. Does the rooms have enough ventilation? (a) Yes (b) No

12. Types of window used in the building? (a) Casement ☐ (b) Sliding ☐ (c) Awing

☐

(d) Others specify----------

13. Specify the size of windows used in the building? **(**a) 1.2-1.2m ☐ (b) 1.5-1.8m ☐

(c) 2.1-2.4 m ☐ (d) other specify----------

PART (C): FIRE PREVENTION STRATEGIES VARIABLES

1. Which type of active fire safety measures is available in the building? **(**i) sprinkler system

(ii) alarm system (iii) fire hydrant (iv) fire extinguisher (a) i, ii and iii ☐

(c) ii, iii and iv ☐ (d) Other specify----------

PART (D): FIRE RESISTANCE MATERIALS VARIABLES

1. Which type of fire resistant materials applied in the building? **(**i) Cementitious product

(ii) Intumescent coating (iii) Gypsum (a) i and ii ☐ (b) i and iii ☐ (c) ii and iii (d) Other

specify----------

2. Types of wall materials **(**a) Bricks ☐ (b) Masonry block ☐ (c) Glass ☐ (d) Other

specify----------

--

3. Types of materials for roof **(**a) Aluminum ☐ (b) Zinc ☐ (c) Concrete ☐

(d) Other specify----------

4. Floor finishes materials **(**a) Wood ☐ (b) Concrete ☐

(d) Other specify----------

Appendix B

Federal University of Technology, Minna

School of Environmental Technology

Department of Architecture

ASSESSMENT OF FIRE PREVENTION STRATEGIES IN THE DESIGN OF HIGH RISE CONDOMINIUM BUILDINGS IN VICTORIA ISLAND, LAGOS STATE, NIGERIA.

Dear respondent,

I am a student in the above named institution currently conducting a research on the topic „ASSESSMENT OF FIRE PREVENTION STRATEGIES IN HIGH RISE CONDOMINIUM BUILDINGS IN VICTORIA ISLAND, LAGOS NIGERIA". This research is being carried out among different high rise buildings selected within Victoria Island Lagos to ensure a representative picture of the residents views. Your help and assistance in completing the questionnaire will be valuable for the study. If you agree to participate, all the information you provide will be completely anonymous and confidential. This survey will provide a valuable insight on the availability and functionality of fire prevention strategies provided in high rise buildings. This research work is for purely academic purposes.

Thank you very much for your help.

Muhammad Rahmatu

(A) Personal Data

1. Kindly indicate your gender (a) Male ☐ (b) Female ☐

2. Please indicate your age bracket (a) 15-20 ☐ (b) 20-30 ☐ (c) 30-40 ☐ (d) 40 or above ☐

3. Occupation (a) Civil servant ☐ (b) Self-employed ☐ (c) Business ☐ (d) Other

specify----------

(B) Fire Prevention Measure and Features

4. Do you have any knowledge of fire safety measures? (a) Yes (b) No

5. Do you think there is need for fire safety measures in a high rise building? (a) Yes ——(b) No

6. If yes, indicate from the reasons given below;

(a) People need to feel safe in the building

(b) It is one of the criteria for designing a high rise building

(c) All of the above

(d) None of the above

7. If no, give the reason---------- 8.

Do you have any fire safety strategies in the building? (a) Yes

9. If yes, which of the following?

(a) Sprinkler system (b) Fire extinguisher (c) Smoke detector (d) other specify

---

10. How functional are the fire safety measures mention in no. 9 above (a) Very functional

(b) Functional (c) Not functional

(C) Causes of Fire Outbreak Fire in High Rise Condominium Building

11. What do you think is most common causes of fire outbreak in buildings? (a) Electrical fault (b) Arson (c) Carelessness (d) Other specify----------

12. Have you experienced any fire outbreak incidence in your building? (a) Yes (b) No

13. What were the causes? ----------

14. Was your unit affected by the fire? (a) Yes (b) No

15. If yes, what is the estimated lost? (i) Loss of property (ii) Loss of life (iii) Physical injury

(a) i and ii (b) i and iii (c) ii and iii (d) All of the above

16. Which fire safety measure was used? (i) Fire extinguisher (ii) Fire service (iii) Sprinkler system

(a) i and ii (b) i and iii (c) ii, and iii (d) Other specify----------

17. Is there any fire service station around your building? (a) Yes (b) No

18. If yes, how active is the fire service station around you? (a) Very active (b) Active

(c) Fair (d) Not active

19. How did the building respond to fire? (a) Burnt rapidly (b) Burnt slowly (c) Completely burnt (d) None of the above

(D) Design Methods to Fight and Prevents Fire in High Rise Condominium Buildings

20. Have you ever come across any fire safety instruction in a high rise building? (a) Yes (b)

No

21. If yes, how do you react to those instructions (a) Very often (b) Often

(c) Occasionally (d) Never

20. What do you think is the most suitable precautionary measure to be taken against fire outbreak……

22. What do you think is the fastest way to evacuate occupants in a high rise building?

(a) Fire exit doors (b) Fire escape stairs (c) el

---

23. Are there any signs and signage that leads to exits? (a) Yes (b) No

24. In your opinion suggest ways of preventing fire outbreak in high rise condominium buildings

---

Appendix C

APPENDIX 3: SAMPLE SIZE BASED ON DESIRED ACCURACY WITH CONFIDENCE LEVEL OF 95%

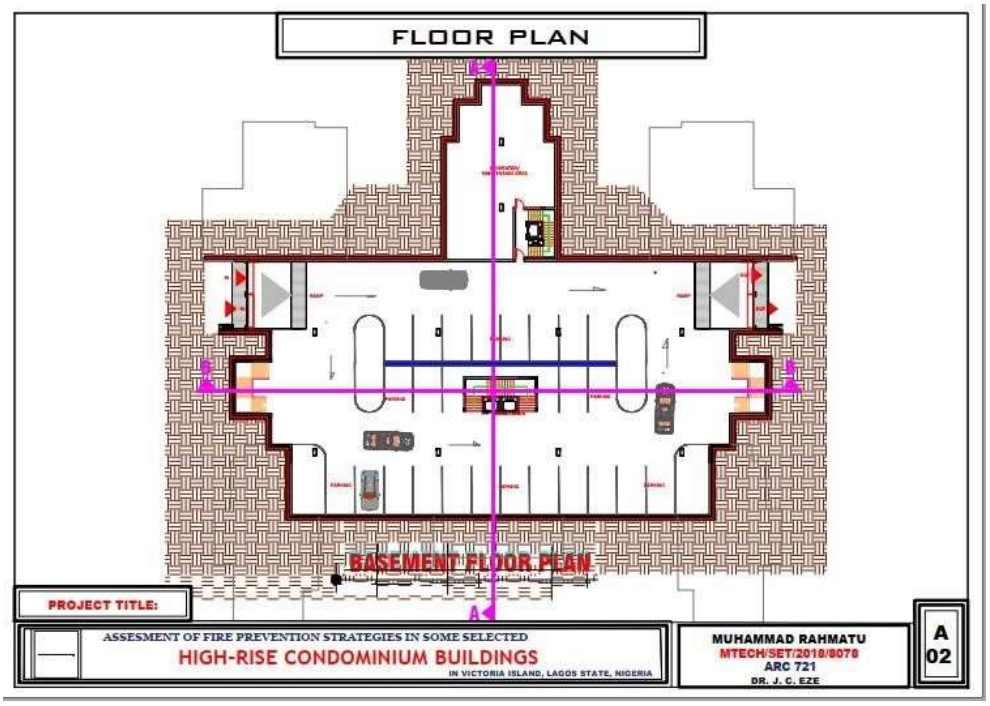
Variance of Population P = 50%

Confidence Level = 95%

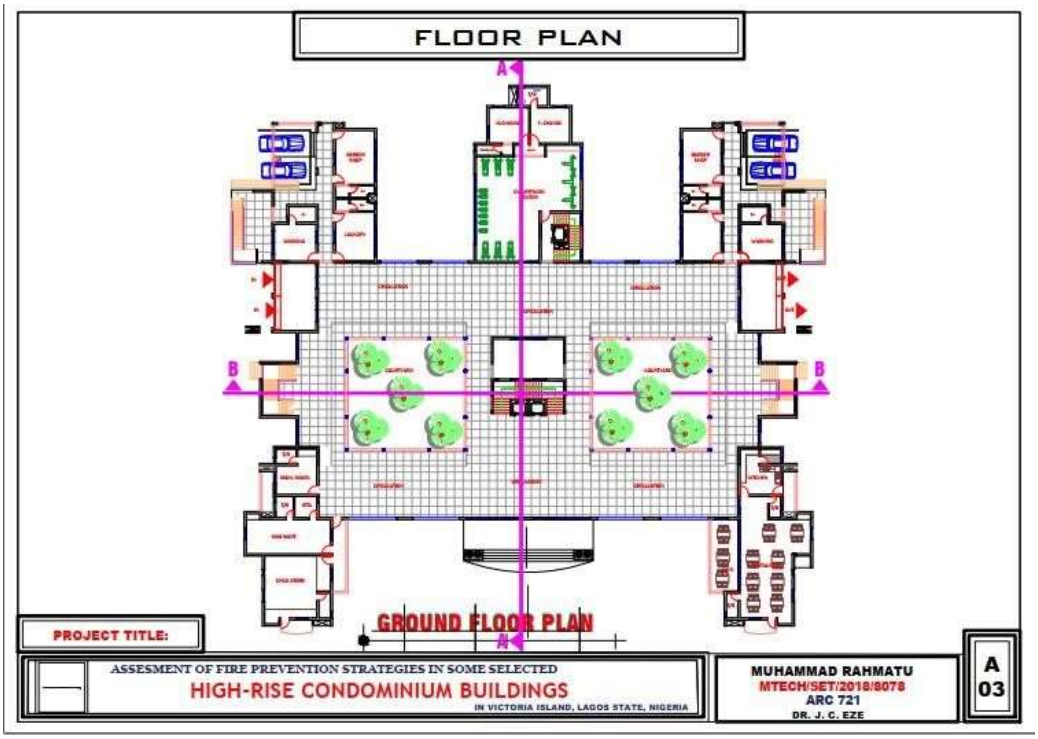
	Margin of Error		
Population Size	**5%**	**3%**	**1%**
50	44	48	50
75	63	70	74
100	79	91	99
150	108	132	148
200	132	168	196
300	168	234	291
400	196	291	384
500	217	340	475
600	234	384	565
700	248	423	652
800	260	457	738
1000	278	516	906
1500	306	624	1297
2000	322	696	1655
3000	341	787	2286
5000	357	879	3288
10000	370	964	4899
25,000	378	1023	6939
50,000	381	1045	8057
100,000	383	1056	8762
250,000	384	1063	9249
500,000	384	1065	9423
1,000,000	384	1066	9513

Appendix D: Proposed Site Plan

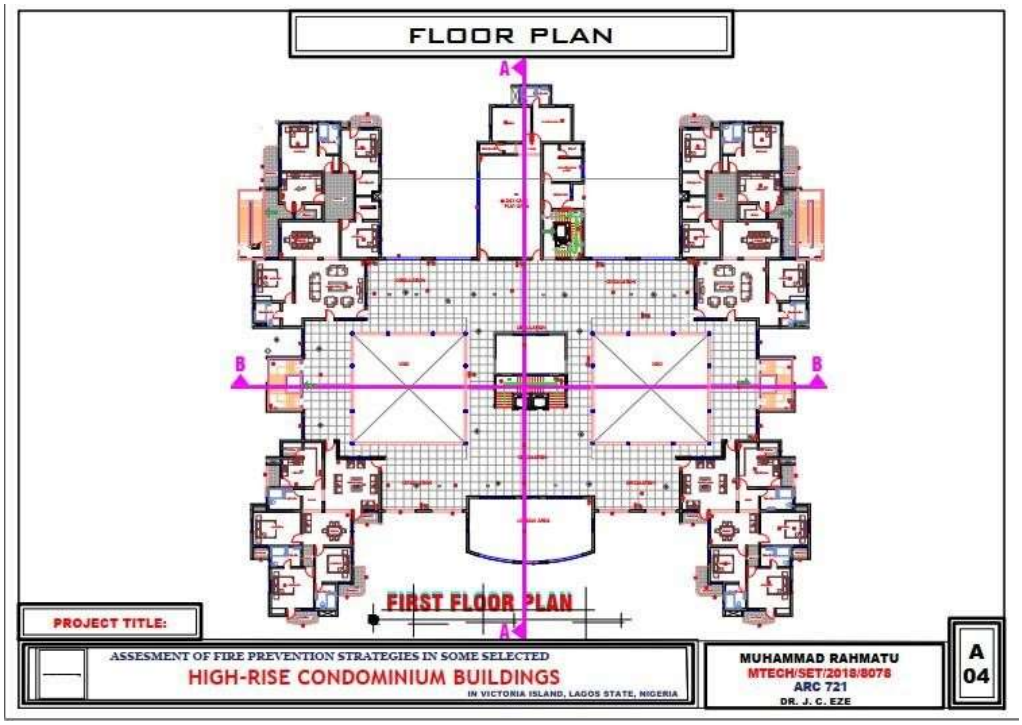
Appendix E: Basement Floor Plan



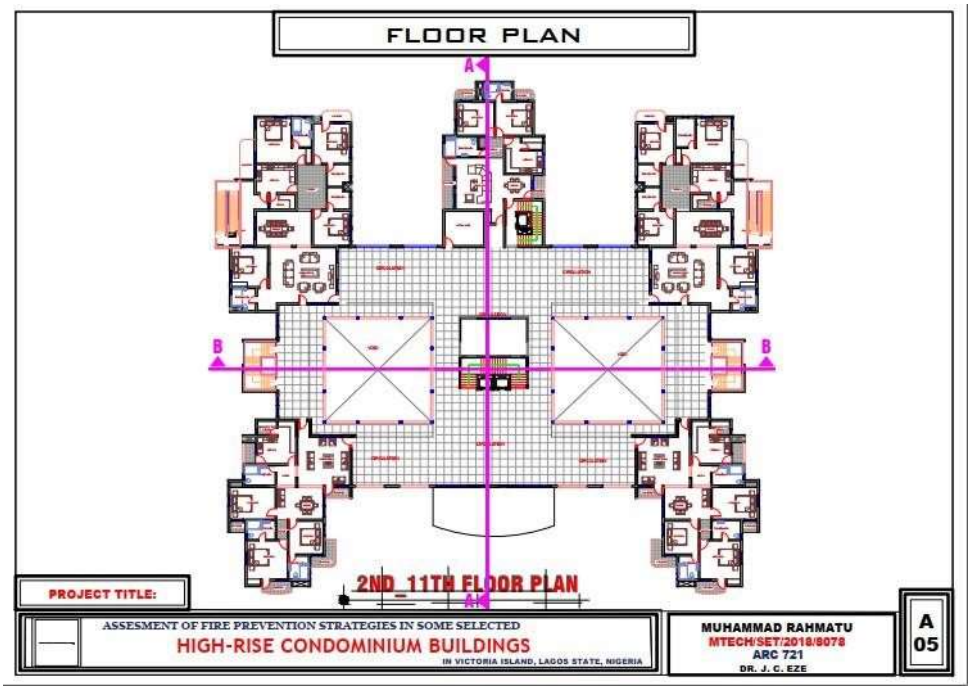
Appendix F: Ground Floor Plan



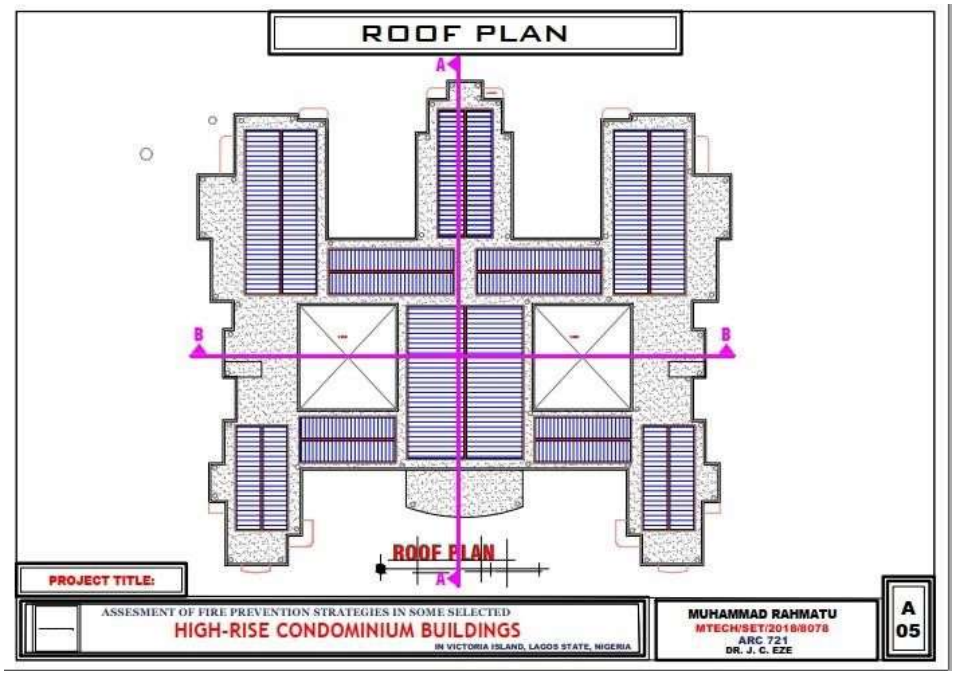
Appendix G: First Floor Plan



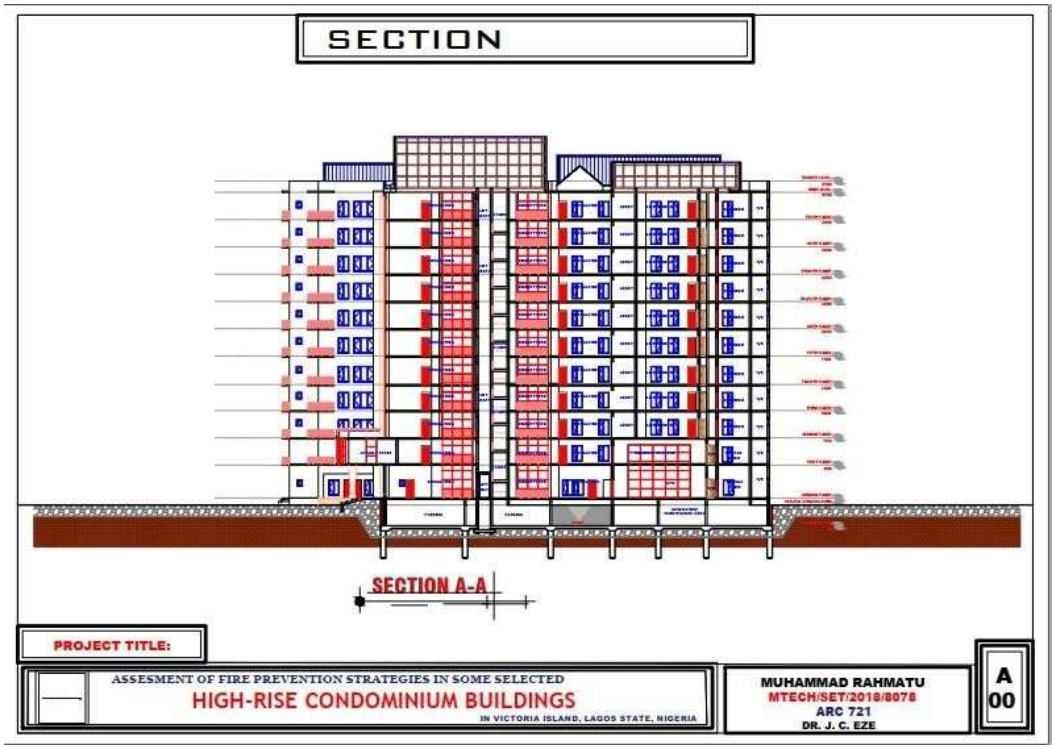
Appendix H: Second Floor Plan

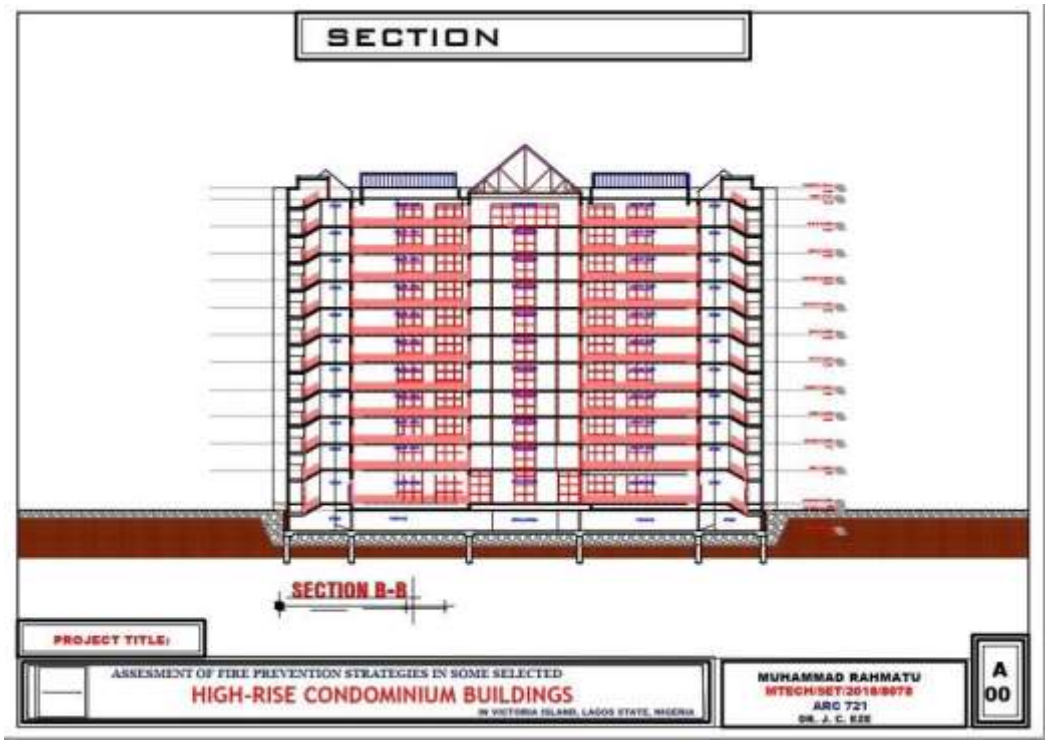


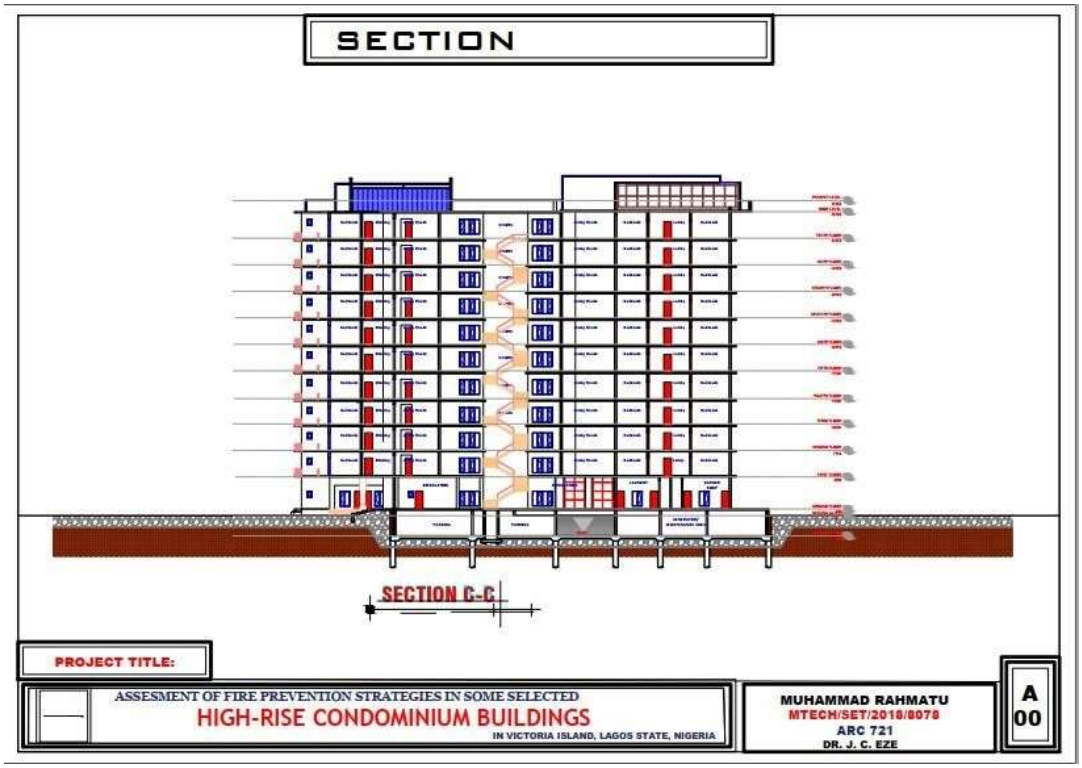
Appendix I: Roof Plan



Appendix J: Sections



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ASSESMENT OF FIRE PREVENTION STRATEGIES IN SOME SELECTED
HIGH-RISE CONDOMINIUM BUILDINGS
IN VICTORIA ISLAND, LAGOS STATE, NIGERIA
MUHAMMAD RAHMATU
MTECH/SET/2018/8078
ARC 721
DR. J. C. EZE
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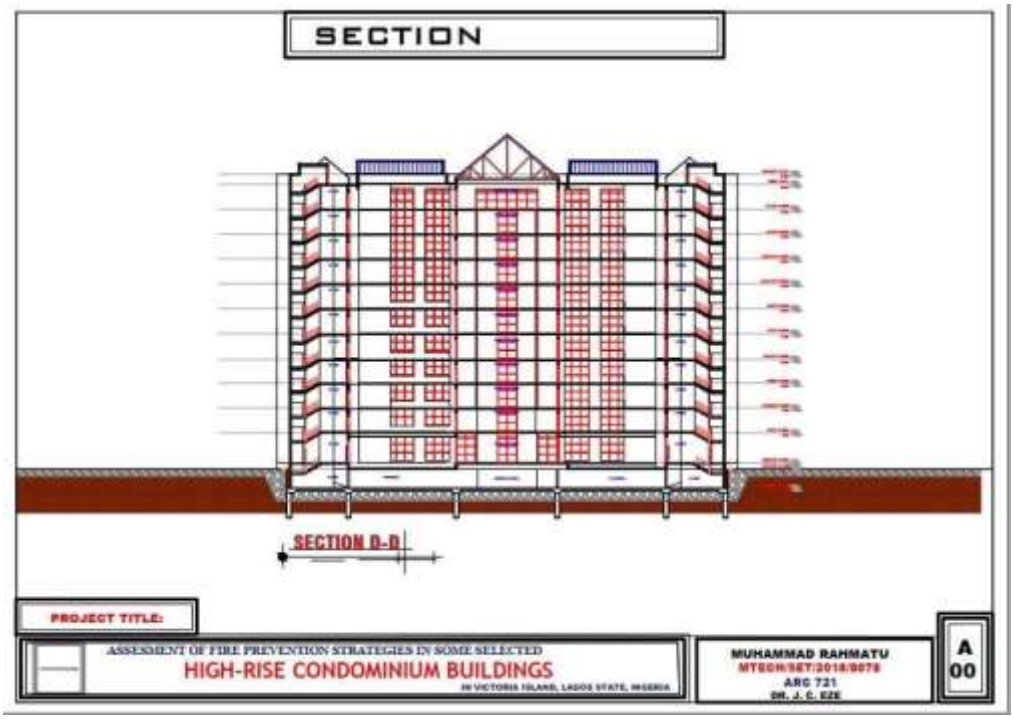
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ASSESMENT OF FIRE PREVENTION STRATEGIES IN SOME SELECTED
HIGH-RISE CONDOMINIUM BUILDINGS
IN VICTORIA ISLAND, LAGOS STATE, NIGERIA
MUHAMMAD RAHMATU
MTECH/SET/2018/8078
ARC 721
DR. J. C. EZE
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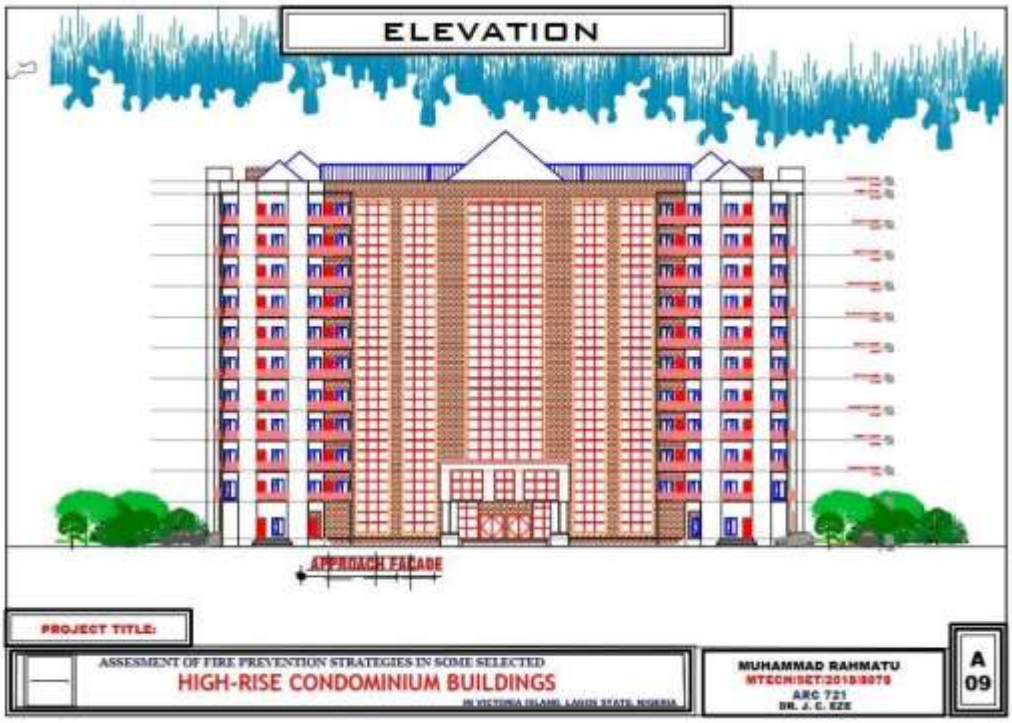
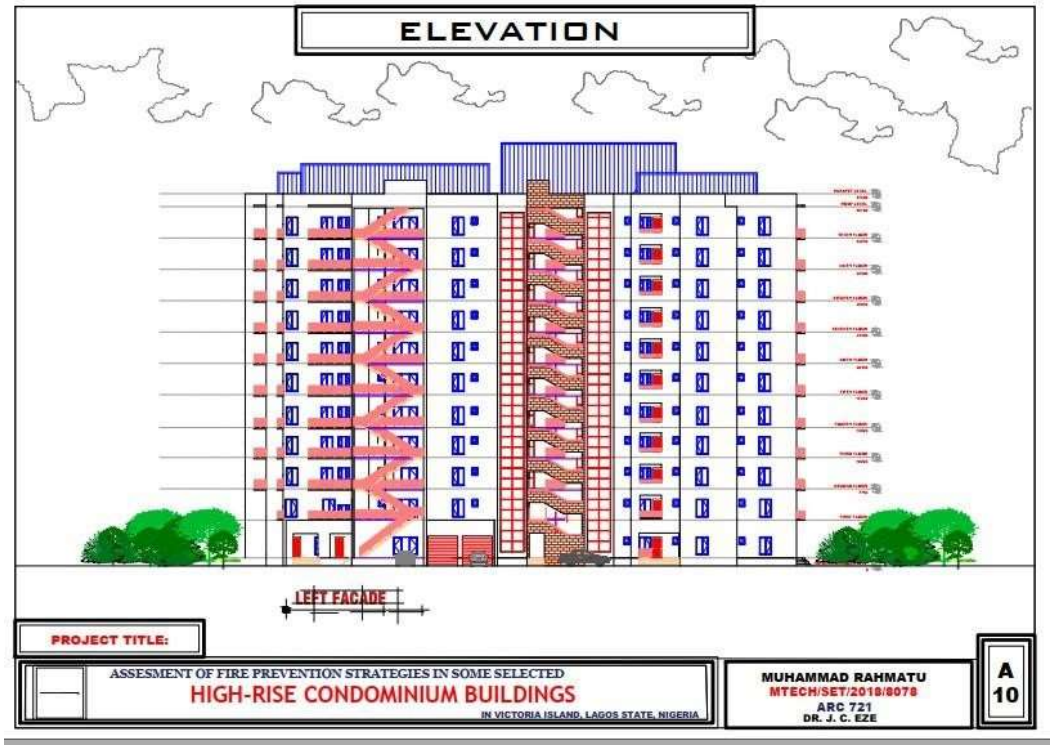
Appendix K: Elevations






ELEVATION
RIGHT FACADE
PROJECT TITLE:
ASSESMENT OF FIRE PREVENTION STRATEGIES IN SOME SELECTED
HIGH-RISE CONDOMINIUM BUILDINGS
IN VICTORIA ISLAND, LAGOS STATE, NIGERIA
MUHAMMAD RAHMATU
MTECH/SET/2018/8078
ARC 721
DR. J. C. EZE
A
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ELEVATION
REAR FACADE
PROJECT TITLE:
ASSESMENT OF FIRE PREVENTION STRATEGIES IN SOME SELECTED
HIGH-RISE CONDOMINIUM BUILDINGS
IN VICTORIA ISLAND, LAGOS STATE, NIGERIA
MUHAMMAD RAHMATU
MTECH/SET/2018/8078
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DR. J. C. EZE
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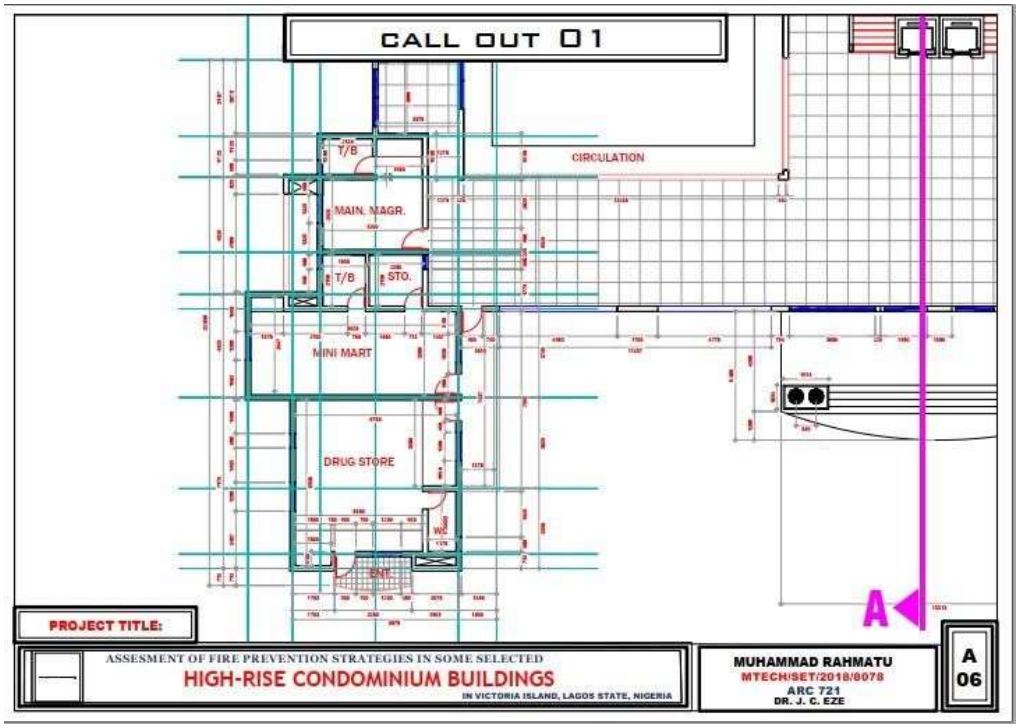
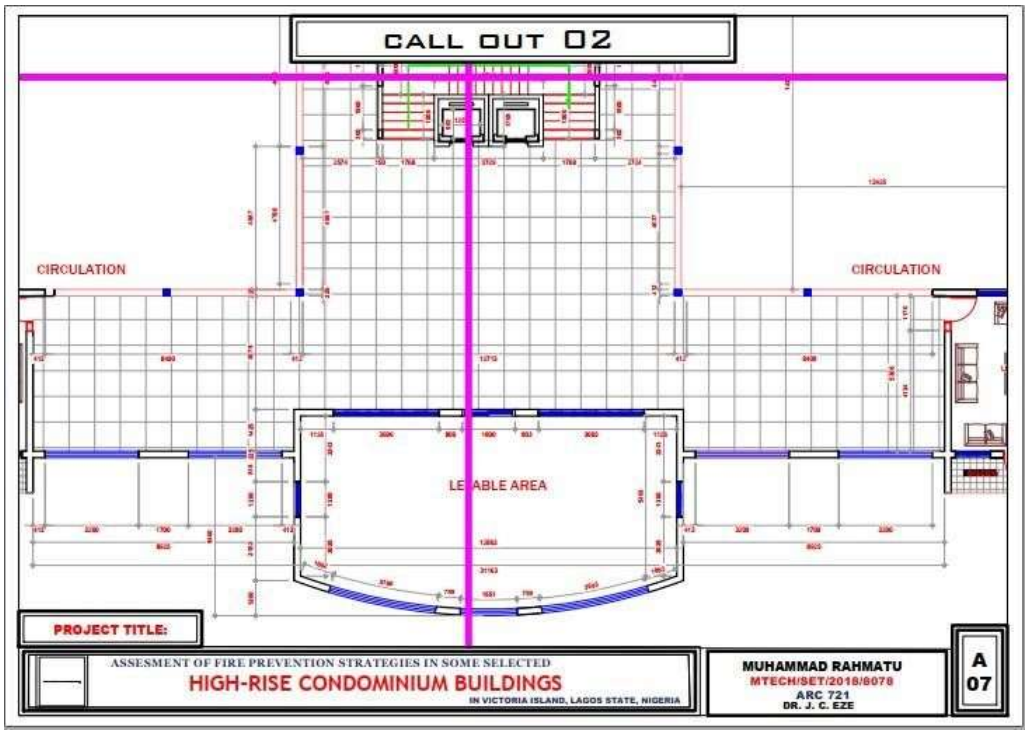
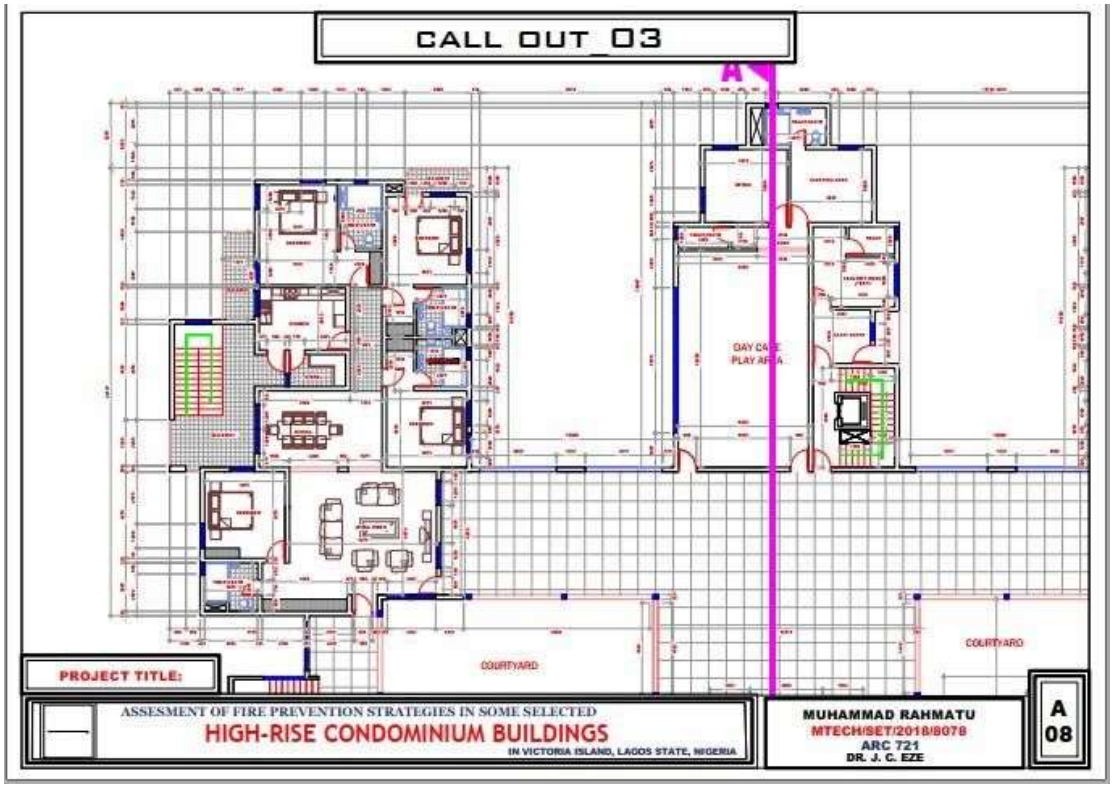
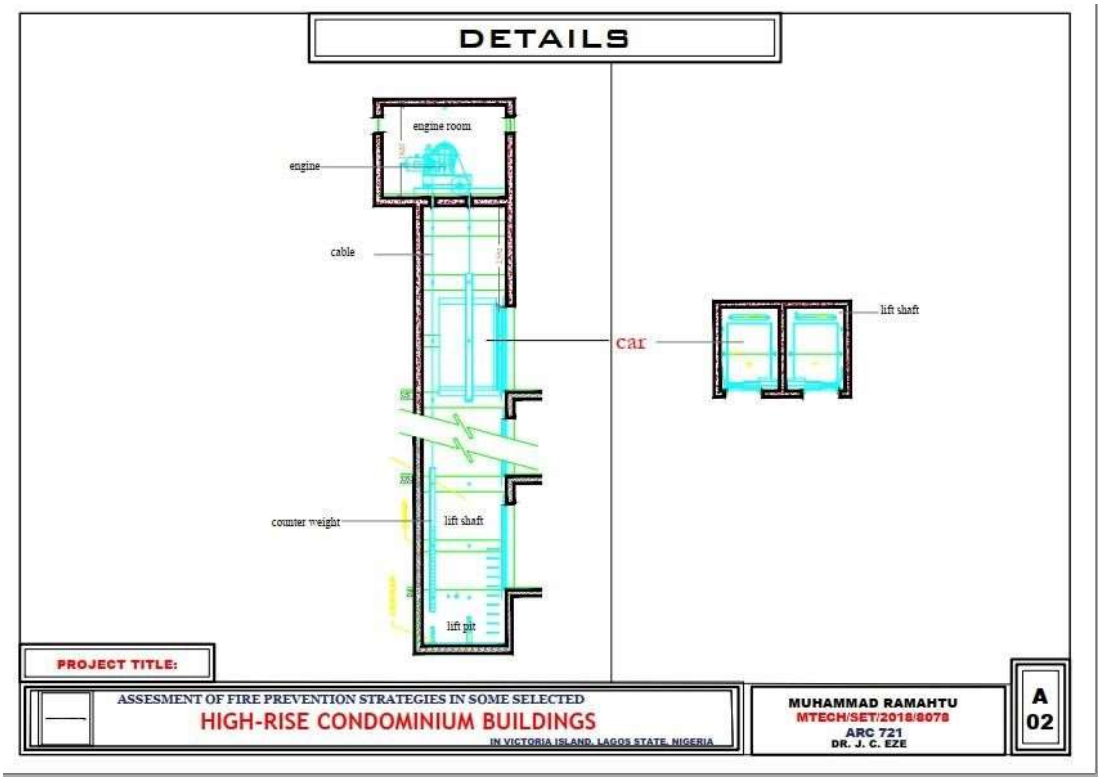
Appendix L: Blown out Working Drawing

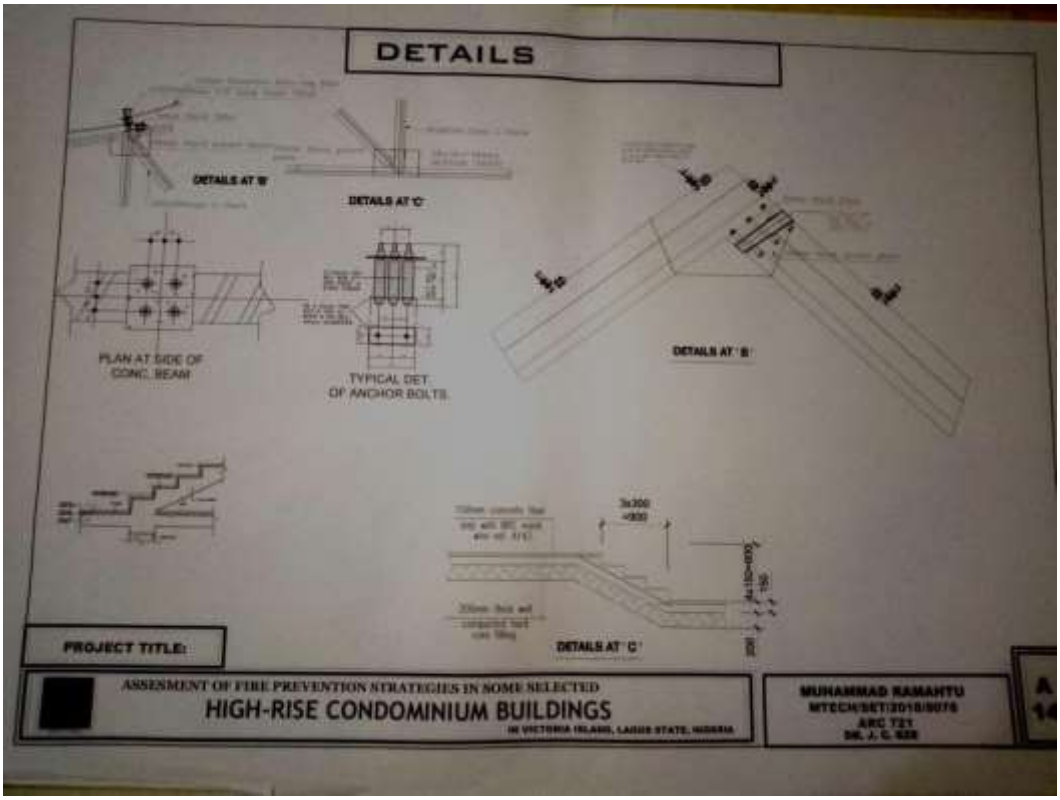


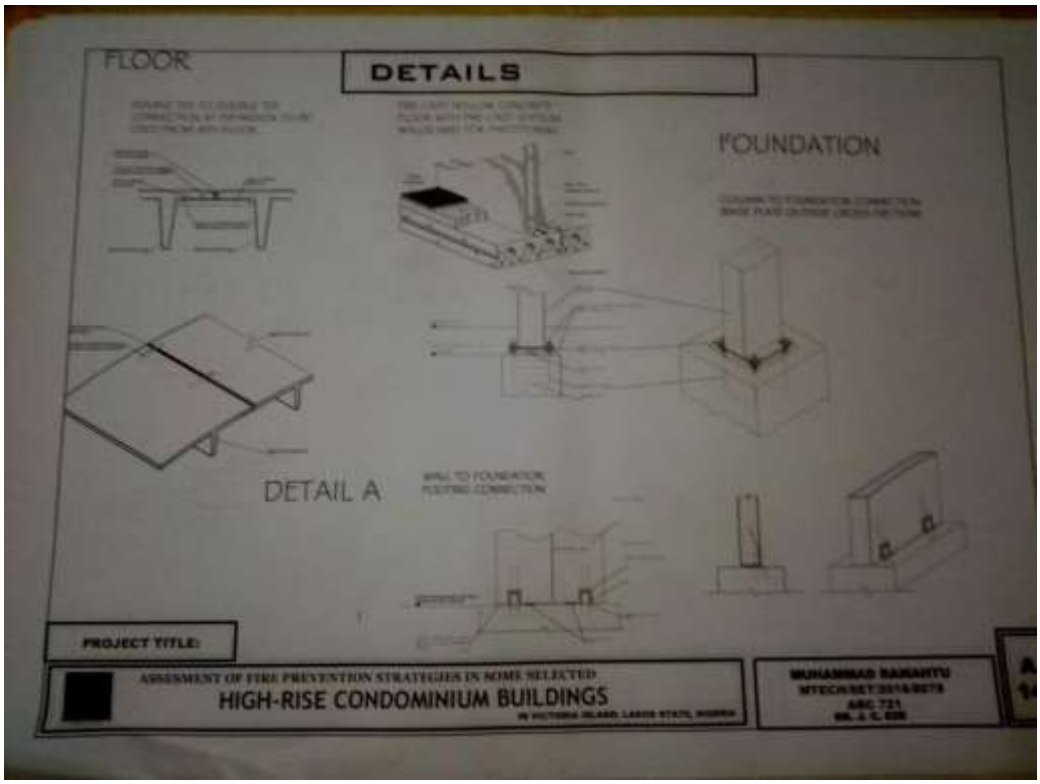




Appendix M: Details




DETAILS
DETAILS AT 'B'
DETAILS AT 'C'
PLAN AT SIDE OF CONC. BEAM
TYPICAL DET. OF ANCHOR BOLTS
DETAILS AT 'B'
DETAILS AT 'C'
PROJECT TITLE:
ASSESSMENT OF FIRE PREVENTION STRATEGIES IN SOME SELECTED
HIGH-RISE CONDOMINIUM BUILDINGS
MUHAMMAD RAMAHTU


FLOOR
DETAILS
FOUNDATION
DETAIL A
PROJECT TITLE:
ASSESSMENT OF FIRE PREVENTION STRATEGIES IN SOME SELECTED
HIGH-RISE CONDOMINIUM BUILDINGS

Appendix N: Aerial Perspective