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Challenges Affecting the Development and Optimal Use of Tall Buildings in Nigeria

Anthony Nkem Ede,
Department of Civil Engineering, Covenant University, Ota- Nigeria.

----------ABSTRACT----------
Since late nineteenth century till date, major World cities have been growing in size and in height. Tall buildings have become a prominent feature in any city of economic or political importance. This has been in response to the ever pressing need for greater accommodations in vibrant economic cities and for the acute scarcity buildable land in major urban areas. USA pioneered the growth tall buildings more than one hundred years ago while the developing nations have taken the baton from the USA since the reasons that gave birth to the development of tall buildings are becoming more critical in the developing countries. This research therefore evaluates the challenges affecting the development and optimal use of tall buildings in Nigeria. Lagos the economic capital and Abuja the political capital of Nigeria are chosen for this research. Statistical methods were used to analyse the data collected and interesting results emerged from the research. A 100% absence of regulation for high rise construction and maintenance, about 90% lack of domestic expertise for high rise buildings, almost zero public supply of electricity and water were among the results obtained.

Keywords: *Emergency Preparedness, Safety Measures, Tall buildings, Urban Over-population.*

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I. INTRODUCTION

A current trend in modern cities all over the world is the development of high-rise buildings mainly to overcome the challenges of urban over population, for optimal use of scarce land resources, as status symbol, as tourist attractions and for beautiful skylines. Regardless of these advantages, the development of high-rise buildings in Nigeria has been experiencing drawbacks. The retarding growth translates to the very fewness of high-rise buildings in existence in Nigerian cities just as even most of the few in existence are poorly utilized due to some persistent factors. With the continuous increase in the population of Nigeria (which have moved from 140 million in 2006 to 170 million in 2014), leading to ever increasing surge in rural – urban drift, land scarcity and the consequent high cost of available land can only be expected to be on the increase especially in Abuja and Lagos Cosmopolitan Cities. Bearing in mind that tall, thin buildings have smaller footprints than the equivalent number of low-rise housing units, making them occupy less land area; it is a wonder that building high is not growing at some significant rate compared to the galloping growth of Nigerian population. The low rate of building tall will heighten the burdensome challenge of housing in Nigerian urban cities.

This research examines the current trend of high-rise buildings development and utilization in Nigeria, taking Abuja and Lagos, the administrative capital and the economic capitals respectively, as case studies. It is a generally accepted fact that one of the greatest challenges facing the Federal Capital Development Authority (FCDA) in Abuja and the economic capital of Nigeria in Lagos today is the provision of housing both in quantity and quality. With Nigeria being the most populous nation in Africa, there is a dire need for greater awareness on the opportunities that exist in the use of high-rise buildings and to find out what is the situation currently on the ground and what is needed for improvement.

II. GENESIS OF HIGH RISE BUILDING DEVELOPMENT AROUND THE WORLD

According to [1], the emergence of tall buildings in the United States of America began in the nineteenth century. The intense rural – urban population drift and the ensuing pressure on the limited land resources have greatly inspired modern city building development efforts. Over the years, the development of any kind of structure has always depended on the available construction materials, construction technology and the services needed for the use of the building. The socioeconomic problems that accompanied industrialization

in the nineteenth century and the increasing demand for land in urban cities were the driving forces for tall building construction. Advances in material sciences that gave birth to high strength and structurally more efficient materials such as steel and the introduction elevator greatly enhanced the development of tall buildings. The introduction of new materials permitted the development of light weight skeletal structures which when coupled with improved design methods and construction technologies empowered continuous growth in the height of tall buildings [2]. Starting from the 11- storey metal framed Home Insurance Building in Chicago in 1883, and then followed the 9-storey first all-steel framed Rand-Mcnally Building in1889, the 20-storey vertical trussed Masonic Temple in 1891, the 60-storey Woolworth Building in New York in 1913. The American tall building development got to its crowning point in 1931 with the 102-storey braced steel frame of Empire State Building that attained the height of 381m. After a period of about 40 years in 1973, this great edifice was superseded by the 442 m tall, 110-storey framed-tube World Trade Centre Twin Towers in New York and quickly followed in 1974 by the 442m tall bundled-tube Sears Tower in Chicago.

In the early part of tall building development, most tall buildings of significance were then built in the U.S.A. Other countries across Europe and later Asian countries like Hong-Kong, China, Japan, Korea, and Malaysia followed suit. From data published in the 1980s, about 49% of the world's tall buildings were built in North America. This has now changed drastically as Asia now has the largest share (32%) against North America's 24% (Table 1). The data highlights the speedy growth of High-rise construction in Asia recently, and the decline in growth of High-rise construction in North America.

Table 1: Tall Buildings per Regions. Source: Most functional cities in the regions reported in www.emporis.com (2006)

REGION	NOS. COUNTRIES	PERCENT (%)	NOS. BUILDINGS
Asia	20	32.2	35,016
North America	18	23.9	26,053
Europe	20	23.7	25,809
South America	10	16.6	18,129
Oceania	7	2.6	2,839
Africa	20	1.0	1,078
TOTAL	95		108,924

Traditionally, the principle drive to construct tall buildings has always been the desire to cope with pressing demand of housing units and the need to expand national economies. Hong Kong, for example is known to be one of the most significant financial capitals in Asia, and as a result has a long history in the use of high-rises for offices and residential purposes. According to [3], the embargo placed on trading with China by the United Nations paved way for the emergence of the economic growth of Hong Kong. Attractive tax policy spurred the influx of foreign investors thereby turning Hong Kong to an economic hub. From [4], Britain and Europe witnessed an intense housing deficiency as a result of bomb damage from the World War II. Thus, large-scale housing projects mostly made of tall buildings were considered to be a modern and effective way of meeting the demand. The Middle East region has witnessed rapid development in terms of economic and infrastructural development in recent years. As a result, many high-rises have been built. Based on [5], the principal reason for the huge development of the region was the recognition of the need to expand their economy so as to make it less reliant on oil revenue. Therefore, tourism, enhanced by the presence of world-class high-rises has been used as an alternate source of revenue. Some of the most remarkable structures include: The Burj Dubai, Burj Al Arab (built on a man-made island in 1999), Burj Khalifa (the tallest building in the world) among others.

Without doubt, the high-rise building is viewed as a wealth-generating instrument for an urban economy. In most cases, tall buildings are built largely because they can generate a lot of real estate out of a relatively small piece of land. With the increasing rural-urban drift especially in the developing nations leading to higher demand for real estate and the ever growing availability of new technology, tall buildings are seen as the most suitable solution for any city faced with the challenge of space and the need to comfortably accommodate its inhabitants. Thus, cities with limited amount of space have employed the concept of building higher as a means of providing better living conditions for the inhabitants.

[6] opined high-rise buildings provide the advantages of tall slim buildings accommodating many people while occupying less land in the land-scarcity prone urban canter locations, offering great views to the upper level occupant and better security with the efficient controlled entrance systems which reduce crime and dissipates the fear of crime. Despite the many advantages that High-rise buildings, the disadvantages include absence of community life, as it is always a situation of "every man for himself", lack of children's play area, causing a possibility of children having hindered development, being prime targets for terrorist attacks (for example the case of Twin towers of New York in 2001), inadequate number of lifts and parking spaces, high risk of spread of communicable diseases, heighted traffic problems and great burden on services and infrastructure.

2.1 Tall building development in Africa

In 2009, the UN population fund opined that the population of Africa had reached 1,022,234,000, thus making Africa the second most populous continent on earth just behind Asia. At this rate, the continent's population is expected to reach 1.9 billion by the year 2050 and this will definitely spur developmental challenges especially in the urban cities. At the onset, very few African cities characterized by the presence of major financial and commercial activities possessed large skylines. Some of these cities are Cape Town (South Africa), Lagos (Nigeria), Abidjan (Cote d'Ivoire), Harare (Zimbabwe), Nairobi (Kenya), and Johannesburg (South Africa).

Table 2: List of High-rise buildings in Africa. Source: [7]

S/N	BUILDING'S NAME	HEIGHT	FLOORS	COUNTRY	YEAR
1.	Carlton centre	223m	50	South Africa	1973
2.	Ponte city Apartments	173m	54	South Africa	1975
3.	Bahia centre	161m	31	Algeria	2008
4.	NITEL building	160m	32	Nigeria	1979
5.	Marble towers	152m	32	South Africa	1973
6.	Pearl Dawn	152m	31	South Africa	2010
7.	SA Reserve Bank Building	150m	38	South Africa	1988
8.	Villagio Vista	150m	35	Ghana	2011
9.	Metlife Centre	150m	28	South Africa	1993
10.	88 on field	147m	26	South Africa	1985

Starting from the mid-2000s, more tall buildings have been built in some other cities in Africa. They are: Kampala (Uganda), Port Louis (Mauritius), Addis Ababa (Ethiopia), Maputo (Mozambique), Dar es Salaam (Tanzania) and Abuja (Nigeria). Table 2 presents the African top high-rise buildings.

Shifting attention from Africa to Nigeria, the focus of this research, it is important to know that the population of Africa's most populous nation is estimated to be about 170 million in 2014 and is also the seventh most populous country in the world and is blessed to be one of the most economically developed nations on the African continent, occupying a land area estimated at about 923,768 sq. km. However, despite its size, advanced development is significantly localized around two cities: Lagos and Abuja. Beyond these two mega centres, development is marginal. Their dominance can largely be attributed to the fact that most of the major financial and governmental activities are conducted in these two cities. This poor developmental plan has put so much pressure on the provision of buildings, infrastructure and urbanization of these two cosmopolitans. Coping with the massive influx of citizens from the rural areas in search of greener pasture has been an austere task. Table 3 shows the top 10 tall buildings in Nigeria.

Table 3: List of Tall buildings in Nigeria

S/N	NAME OF BUILDING	LOCATION	HEIGHT	FLOORS	YEAR
1.	NITEL/NECOM house	Lagos	160m	32	1979
2.	Union Bank Headquarters	Lagos	124m	28	N/A
3.	Cocoa house	Ibadan	105m	26	1965
4.	Independence house	Lagos	103m	23	1960
5.	CBN Building	Lagos	100m	19	U/C
6.	Great Nigeria house	Lagos	95m	22	N/A

7.	National Oil Headquarters	Lagos	83m	23	1984
8.	Stock Exchange house	Lagos	83m	22	N/A
9.	UBA house	Lagos	80m	20	N/A
10.	Eagle house	Lagos	78m	20	1985

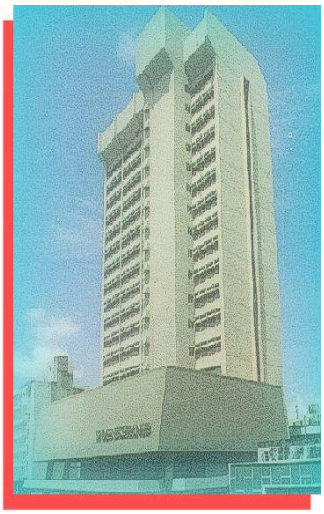
NOTE: N/A means Not Available; U/C means Under Construction;

Presently, the development of high-rises in Nigeria has been influenced by urban needs, constraints, and a host of other commercial reasons that task the Engineer's ingenuity [8]. Lagos, the former capital of Nigeria and the major economic hob in the West African sub-region has the highest number of tall buildings in Nigeria. The transference of the nation's capital to Abuja in the late 1980's has led to the degrade state of major tall buildings in Lagos. Three major high rise buildings in Lagos are shown in Fig. 1.

The Abuja skyline is made up of mostly mid-range buildings, with just few tall buildings. Only recently have tall buildings begun to appear. Most of the buildings are modern, thereby reflecting that it is a new city. The Millennium Tower, the Nigerian Cultural Centre, and the municipal building (all part of the proposed Nigerian National Complex, shown in Fig. 2) are part of the many projects in the Central District of Nigeria's capital city of Abuja. At 170 meters, the Millennium tower would be the tallest building in Nigeria, going beyond the 160m high NITEL building.

NITEL BUILDING

INDEPENDENCE HOUSE



STOCK EXCHANGE HOUSE

Figure1: Major high rise building in Lagos, Nigeria.

Figure 2: The proposed World Trade Centre in Abuja; Source: www.churchgate.com (2013).

2.2 Problems associated with high-rise buildings

Like any other structure, high-rise buildings are faced with several problems and experience accidents that endanger the lives of its occupants, destroy facilities and equipment within them, and affect other neighboring structures. The most feared hazards of tall buildings around the world are fire, terroristic attaches and building collapse.

2.3 Fire

High-rise fires pose a remarkable challenge to fire fighters. From the beginning of their existence, high-rise buildings have experienced fires of different proportions. According to [9], all (2011), an estimated 53 civilian deaths, 546 injuries to civilians, and $235 million in direct property damage was recorded between 2005 and 2009 in the USA. Further statistical data reveal that about 2.6% of structure fires that were reported between 2005 and 2009 occurred in high-rise buildings. It was the fire that resulted from the "9/11" terrorist attacks on the World Trade Centre (USA) that caused the collapse of Towers 1 and 2, killing 2749 people, including 340 fire-fighters. Therefore, it can be seen that fires constitute to a large extent the greatest form of accidents encountered by inhabitants of High-rise structures.

2.4 Terrorist attacks

Because of the number of people that high-rise buildings accommodate, they are usually prime targets for attacks by terrorists. The greatest accidents on high-rise structures are the two terrorist attacks on the World Trade Centre (USA). The first attack was a bombing on February 26, 1993 which caused 6 deaths, 1042 injuries 50,000 people evacuated. The second which is the greatest accidents ever recorded in human history on high-rise is the famous "9/11" attack of September 11, 2001 killing 2749 people, including 340 fire-fighters.

The towers were designed to resist an accidental aircraft accident involving a Boeing 707 aircraft, traveling at approximately 180 miles per hour while the attaches were executed with two Boeing 767 airplanes traveling at an estimated speed of between 470-590 miles per hour when they rammed into the towers and crumbled them.

2.5 Building Collapse

The abrupt, shocking collapse of tall buildings has produced countless tragedies throughout history, emphasizing the need for sound, safe and ethical engineering design. Structures that were outwardly rock-solid all over the world have cracked, split, and disintegrated underneath people's feet. In some instances, the collapse of towering edifices took less than ten seconds; bringing them down to the barest, turning them into debris and thereby burying people. Despite the fact that many structures are aesthetically pleasing; a lack of attention to proper safety standards, human error, and unenforced building codes potentially lead to truly terrifying catastrophes. Many tall buildings have collapsed over the years. Some of the most devastating collapses include the twin towers of New York, USA that went down as a result of the terrorist attack of September 11, 2001 killing close to 3000 persons, Sampoong Departmental Store, South Korea that crumbled under 20seconds in 1995 killing about 500 people, the Lotus Riverside Building in China that toppled over, completely intact without crumbling in 2009 and the New World Hotel, Singapore which in 1986 collapsed in less than 60 seconds, killing about 50 people. The causes of collapse of the last 3 cases of tall building collapse can be traced to poor engineering judgments and incompetence of the workers involved in the construction process.

Figure 3: The Nigerian Industrial Development Bank (NIDB) building upon collapse. Source: [11]

It is important to know that the 3 most feared hazards of tall buildings world-wide, i.e., fire, terroristic attaches and building collapse are rife in Nigeria, affecting the high rise and low rise alike. Nitel building, the Nigerian tallest building suffered a serious fire outbreak in 1983, killing 5 people. It took 72 hours to put off the fire because of lack of water hydrants and adequate water supply. The 32 storey building lacked adequate aeration and ventilation and has only two stairways provided. Nigerian Industrial Development Bank (NIDB) building shown in Fig. 3 is another example of high-rise building that suffered fires disaster in Nigeria. In its case, it experienced three fire outbreaks, the third being the last and it led to its eventual collapse in 2006 due to the weakening of the structural members.

Data obtained from [10] points out that the frequency of building collapse in Nigeria lessens with increasing height. This has been also observed through history as only a handful of high-rise buildings have been accounted to collapse. However, when they eventually occur, the effects are often of catastrophic proportions.

2.6 Special features desired of a high-rise building

There are features that plays major role for a High-Rise building to function effectively. The functionality of a high rise building is based on many provisions which are non-structural and structural and are meant to guarantee maximum safety for the occupants in cases of accidents. The structural decisions are made during design process. In combating the occurrence of accidents, especially fire, the expected non-structural features of a high-rise building as published in the Upland Municipal code (Section 8.28.180) are automatic sprinkler system, alarm and communication system, smoke detection system, smoke control, elevators and emergency exits, standby and emergency power and lighting system, fire fighting provisions, fire control center, seismic considerations, emergency helicopter facility.

2.7 Structural design aspect of tall buildings

The design of any building is anchored to the three fundamental aspects of safety, economy and aesthetics. The economics of constructing tall buildings is greatly affected by wind as their height increases. To counteract wind loads and keep building motions within comfortable limits robust structural systems that drive up costs must be adopted. According to [2], the design process of high-rise building generally follows a well-defined iterative procedure. Preliminary calculations for member sizes are usually based on gravity loading augmented by an arbitrary increment to account for wind forces. A check is then made on the maximum horizontal deflection, and the forces in the major structural members, using some rapid approximate analysis technique. The procedure of preliminary analysis, checking, and adjustment is repeated until a satisfactory solution is obtained. Then, a rigorous final analysis, using a more refined analytical model will then be made to provide a final check on deflections and member strengths. This will usually include the second-order effects of gravity loads on the lateral deflections and member forces (P-Delta effects). The provision of adequate stiffness, particularly lateral stiffness, is a major consideration in the design of a tall building for several important reasons. For the ultimate limit state, the lateral deflection must be limited to prevent second-order P-Delta effects due to gravity loading being of such magnitude as to precipitate collapse. In fact, it is in the particular need of concern for the provision of lateral stiffness that the design of high-rise building largely departs from that of a low-rise building. One simple parameter that affords an estimate of the lateral stiffness of a tall building is the drift index, defined as the ratio of the maximum deflection at the top of the building to the total height. Sound engineering judgment is required when deciding on the drift index limit to be imposed.

Also, all codes require tall buildings to provide alternative means of exit from each floor in case of emergency. All these safety measures and many other not listed here contribute to the safety of the occupants of high rise buildings.

III. METHODOLOGY

This research aims at analysing the problems retarding the development and the optimal use of high-rise buildings in Nigeria, taking a look at some individual buildings. This study will involve physical investigation of selected high-rise buildings by visual inspection, personal interviews with Staffs of the organization possessing these tall buildings and physical appraisal of the structures. Surveys will be carried out to determine and analyse deficiencies in the buildings. Questionnaires shall be distributed to professionals and non-professionals on problems perceived to be associated with high-rise structures in Nigeria and how they can be remedied. The secondary data will be collected from information banks such as library (Newspapers, magazines, Internet) and also from other personnel with information concerning the tall buildings.

The study area is Lagos the economic capital of West Africa sub-region and Abuja the capital of Nigeria. These two cities were chosen since tall building development in Nigeria is significantly localized in the two cities.

Data for this research will be collected by visiting some selected high-rise structures in Abuja and Lagos to determine their current status as to compare them to international standards. Some of the problems to be investigated include maintenance, functionality, emergency preparedness, power etc. The data acquired are going to be analysed using descriptive analytical method and comparative analytical method. As the collected data were mostly qualitative data, each of the building was investigated based on global parameters outline in the previous sections of this work.

10 buildings with more than 10 floors were selected for this research. They are NNPC towers (Abuja), Churchgate (Abuja), Nicon Insurance (Abuja), Transcorp Hilton (Abuja), CBN Headquarters (Abuja), KPMG towers (Lagos), Samuel Afabia house (Lagos), Federal Secretariat Building (Abuja), NITEL Building (Lagos) and NIDB (Lagos).

Table 4: The safety measure verification of some six tall buildings

		BUILDINGS					
S/N	SAFETY MEASURES	a	b	c	d	e	f
1	Automatic Sprinkler System	✓	✓	✓	◡	⊗	⊗
2	Emergency Voice	✓	✓	✓	⊗	⊗	✓
3	Synchronized power system	✓	⊗	⊗	⊗	⊗	✓
4	Smoke Proof Stairwell	⊗	⊗	⊗	⊗	⊗	⊗
5	Modern Fire Department	✓	✓	✓	✓	⊗	⊗
6	Emergency Power	✓	✓	⊗	⊗	✓	✓
7	Fire Detector/Fire Alarm	✓	✓	✓	✓	✓	✓
8	Functional Elevator system	✓	✓	⊘	⊘	✓	✓
9	CCTV	✓	✓	⊘	⊗	⊗	⊗
10	Fire Extinguisher	✓	✓	✓	✓	✓	✓
11	Photoluminescence	⊘	⊘	⊗	⊗	⊗	⊗
12	Hose System/ Standpipe	✓	✓	✓	✓	✓	✓

The symbols adopted are defined as follows:

✓ = Available and Functioning; ◡ = Available and Deficient in Number

⊘ = Available and not Functioning; ⊗ = Not available

IV. RESULTS AND DISCUSSION

The results obtained from the study are hereby presented below. Data for this research were collected by visiting some selected high-rise structures in Abuja and Lagos ([12], [13]). The data acquired were analysed using descriptive analytical methods. Each of the building was investigated based on globally acceptable parameters for tall buildings. Some of the problems investigated include maintenance, functionality, emergency preparedness and power supply. Six of the buildings (4 from Abuja and 2 from Lagos) were selected and thoroughly checked for some basic safety and emergency measures. The result is shown in Table 4. Building (a) has a good safety and emergency record,, followed by building (b). The rest are in bad shape as far as safety measures are concerned.

Negative factors working against the development and optimal usage of tall buildings in Nigeria were looked into and analysed. Results obtained are shown in Table 5 and Fig. 4.

Table 5: shows the negative factors against the development and optimal usage of tall buildings

Negative factors	Represention in graph	%
Absence of regulation for high rise construction and maintenance	A	100
Self-generation of power	B	95
Self-procured Water	C	90.3
Lack of adequate domestic expertise for high rise buildings	D	90
External Fire fighting poor response	E	80

Non regular maintenance of structure	F	65
Non structural integrity checks on the structures	G	63
User without knowledge of emergency action to take in case of fire out break	H	56
Poor servicing of elevators	I	50
User without knowledge of the building exit protocols	J	40
Experienced Fire out break	K	40
Non Functional internal fire service	L	30
Experienced Collapse	M	10

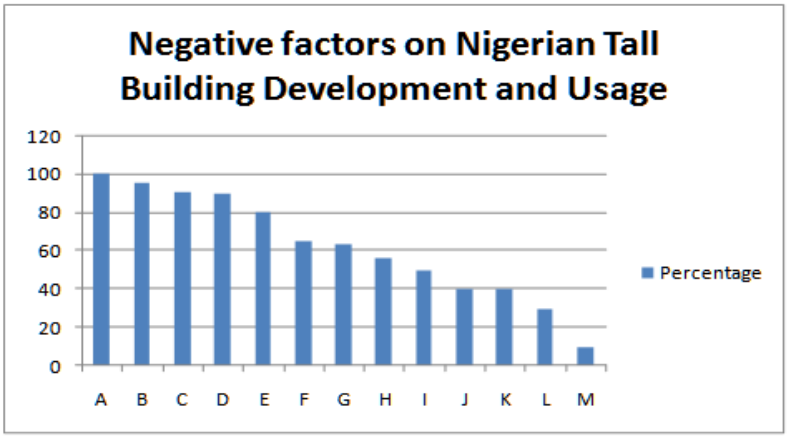


Figure 4: the negative factors militating against the development and optimal usage of tall buildings

A 100% absence of regulation for high rise construction and maintenance, almost zero public supply of electric energy and water and about 90% lack of domestic expertise for high rise buildings are grossly dangerous and cannot in any way help the advancement of tall building construction in Nigeria. Poor emergency preparedness of the nation, poor maintenance culture and poor diffusion of safety information for occupants of tall buildings are all made more evident from this result. A 40% of no knowledge of the building exit protocols is a concern because emergencies such as fire, collapse, or terrorist attacks require that all occupants are on the same level of awareness for effective evacuation of the buildings, and safety of lives. The rate of collapse of tall buildings verified in this research appeared low, but the effect of such collapse can be unimaginable. This confirms the work of [10] (2010), which pointed out that the frequency of building collapse in Nigeria lessens with increasing height. This research also shows that the high-rise buildings in Abuja are better maintained than those in Lagos. Lack of maintenance was evident in most high-rise buildings in Lagos. Investigations carried out revealed that the NIDB building had existed without functional fire- fighting system in the last twelve years before its destruction. The fire that led to its complete destruction was the third, and it proved to be fatal enough to cause the collapse of the building.

V. CONCLUSION

This research shows that most tall buildings in Nigeria largely depend on self-generated power and self-generated water. For the absence basic functional State regular services and emergency services, the risk of fire spreading fast is very high with the consequent damages to life and properties that may ensue. Also, the impact of terrorist attaches or structural failures could yet be very devastating. The poor level of maintenance verified means that drastic measures need to be taken in that direction. In order to fully harness the many advantages that high-rise buildings offer, the government and all the stake holders in the built environment must take bolder steps to combat the many problems militating against mass development and the optimal use of high-rise buildings in Nigeria. This will go a long way in providing an answer to the problem of inadequate housing in Nigeria, particularly in Abuja and Lagos where there is limited availability of buildings and usable land.

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