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Sustainable constructions and cases of high-rise buildings collapse in Nigeria

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ABSTRACT: High-rise residential and commercial development in developing countries like Nigeria has been spurred by both the rapid growth of the population and the pressing need to protect the country's limited land supply in areas of commercial development. However, recent years have seen an increase in the number of building collapses in Nigeria, which is a cause for concern. This study uses statistical method on historical data to highlight the scenarios of the collapse of high-rise buildings in Nigeria and drawing a relationship with it to sustainable construction. According to this study, Nigerian high rises have a low rate of collapse despite the country's high rate of collapse, but the number of fatalities in the collapse of these structures is alarming. The high death toll associated with these collapses is a negative indicator for achieving the Sustainable Development Goals of the United Nations (SDGs).

Keywords: Building Collapse, High-rise Buildings, Casualty Rate, Failure Rate, SDGs

1 INTRODUCTION

Sustainability, as a concept has gained increased importance in the construction industry over the past few decades. A large contributor to this is the United Nations World Commission on Environment and Development who facilitated an awareness concerning the urgency to lessen the detrimental effect of development and urbanization activities on the society and environment, having particular emphasis and focus on raising developing countries (Dania, 2016; WCED, 1987). In general, sustainability in construction refers to the implementation of sustainability concepts in construction practices or techniques (Esezobor, 2016). Sustainable construction (SC) can be termed to be the act of creating and managing a healthy built environment by the efficient utilization of ecological principles and resources (Kibert, 2012).

Every construction activity basically entails combustion of fossil fuels, release of CO_2, methane, & other by-products which causes pollution to the environment as well as the loss of natural ecosystems (Toriola-Coker et al., 2021). The construction sector has been demonstrated to have negative environmental consequences attributed to waste creation, depletion of energy and water, and a variety of other factors (Aigbavboa et al., 2017). Construction operations have a huge impact on global climate change and pose several additional environmental risks. According to the United Nations Environment Programme, the construction sector accounts for the release of around one-third of global greenhouse gas and consumes considerable amounts of non-renewable natural resources

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(Esezobor, 2016). In addition, construction activity is said to consume half of the resources utilized by man, of which 50% of the world's fossil fuel has been utilized to serve buildings, 37% of the world's total energy is used in construction works, and roughly 6500 hectares of rural area has been converted to urban territory (He, 2019).

The quest to assuage the negative and detrimental effects of human activities on the environment brought about the concept of sustainability (Akinshipe et al., 2019). According to (Anigbogu & Kolawole, 2005), the best approach to ensure that the ecosystem is preserved is to avoid any type of building activity, which is nearly impossible. The only rational thing to do is to engage in activities that counteract the negative environmental impacts of development (Dahiru et al., 2014). As a result, the notion of sustainable construction has emerged, which incorporates the construction, design, operation, maintenance, and management of a structure (Akinshipe et al., 2019). Conservation of land, conservation of energy, conservation of material, reducing pollution, and stormwater retention, as described by Nwokoro, are five essential strategies that may be used to accomplish sustainable construction (Nwokoro & Onukwube, 2011).

Many countries' pushes for sustainable building have been fuelled by population growth and excessive demand for buildings and infrastructure. High-rise buildings are becoming a noticeable feature in major cities of economic or political importance due to the ever-increasing need for accommodations and gradual disappearance of buildable land in major urban areas of the world (Ede, 2014).

Populations are moving to densely populated metropolitan areas because of global urbanization. As a result, there is an increased adoption of high-rise buildings that might have disproportionately negative effects from exposure to extreme weather. These slender structures are extremely vulnerable to wind-induced motion. In designing high-rise buildings, structural engineers are faced with the problem of working toward the most effective and cost-effective design solutions while guaranteeing structural safety, serviceability for intended use, and liveability for inhabitants during its design lifetime (Ding & Kareem, 2020).

More high-rise structures with unusual designs have been steadily constructed because of advancements in construction techniques, materials, and technology. Due to the increased susceptibility of high-rise structures to wind excitations, optimizing the shape of the cross-section is proposed to increase wind resistance (Zheng et al., 2018). When a building component cannot support the loads that it was intended to support, the structure collapses. When one or more components of a structure are unable to effectively carry out its original purpose due to the dysfunction of the constituent materials, the building is considered to have failed and collapsed (Odeyemi et al., 2019).

Most often in developing nations, construction of buildings results in life, health, and resource losses. These losses start with construction health and safety on site and extend to the post construction phase (Al-Khaburi & Amoudi, 2018). In future growth, vertical building construction has benefits for space use, plant space preservation, etc., but these benefits also have a cost for various developing nations like Nigeria. The collapse of multi-storey buildings has become a persistent problem for the Nigerian construction sector which has had a substantial effect over many years (Sutherland, 2017). In Nigeria, about 170 buildings are estimated to have collapsed between 1971 and 2016, resulting in the deaths of over 1500 people (Hamma-adama et al., 2020).

Over the years, the quality of life has improved, resulting in significant technical improvements. Improved methods, more resilient materials, improved construction equipment, and more sophisticated construction expertise are available today. Despite all the technological advancements, there are still instances of building collapse in many nations, but they are more common in developing nations like Nigeria. Natural disasters or man-made events such as bomb explosion like the one at World Trade Centre are the main causes of collapse in affluent nations. However, poor supervision, poor quality or substandard materials, a disregard for standards and regulations, a lack of qualified professionals, overloading, a lack of geotechnical or subsoil investigations, poor construction practices, unlawful approval, incorrect demolition procedures, a lack of maintenance, among many other factors, are frequently to blame for collapse in developing nations (Ajufoh, Gumau, & Inusa, 2014; Akpabot, Ede, Olofinnade, & Bamigboye, 2018; Ede, 2010; Ede, Olofinnade, & Awoyera, 2018; Adetunji, Oyeleye, & Akindele, 2018; Odeyemi et al., 2019; Oyegbile, Nguyen Tat, & Olutoge, 2012; Windapo & Rotimi, 2012). This paper aims to explore the cases of the collapse of high-rise buildings in Nigeria and seek a relationship with sustainable construction practices.

2 OVERVIEW OF HIGH-RISE BUILDINGS

The classification of high-rise buildings varies depending on the environment in question. It will be simple to categorize a four-story structure surrounded by bungalows as a high-rise building in the neighbourhood, and this claim won't be challenged (Ubani, 2021). Bungale contends that high-rise buildings can't be categorised in terms of a certain number of floors or storey height; rather, the line separating them should be where the structure's design crosses over from the statics to structural dynamics fields (Bungale & Taranath, 2010; Taranath, 1988). A building is a high rise if it is much high-riseer than the nearby structures or if its proportions are thin enough to create the impression of a high-rise building, according to the Council on High-rise Buildings and Urban Habitat (CTBUH, 2022). Town planning departments of municipalities, regulatory agencies, standards organizations, and communities frequently develop definitions and rules for what counts as a high rise building within their respective jurisdictions. For instance, according to the Milton Town's High-rise Building Guidelines, a high-rise building is one whose height exceeds the neighbouring street's right-of-way or is broader than two streets if it is situated at a junction. High-rise structures in Milton will begin at around 11 storeys due to the right of way lengths, which in Milton are 35 m for arterials and 47 m for regional roads. However, the standards document recognises that a structure with nine storeys would be seen as reasonably high-rise; as a result, the criteria for high-rise buildings should be implemented wherever the structure seems high-rise in proportion to its surroundings (Milton, 2018). High-rise structures in Russia are those that stand at least 75 meters high-rise (Generalov et al., 2018).

The National Building Code of Nigeria (2006) lacks a definition or guidelines for high-rise or high-rise buildings. According to the Lagos State Urban and Regional Planning Development Law, a high-rise structure is one that has more than five storeys (including the ground floor) and/or is high-riseer than 12 meters above the ground (LSURPD, 2019). As far as structural engineering is concerned, a building can be categorized as a high-rise building whenever lateral pressures begin to have a noticeable impact on the behaviour and stability of the building (Islam & Islam, 2013).

3 BUILDING COLLAPSE IN THE WORLD

Building collapse happens to be a phenomenon which spreads round the globe. This implies that it is an occurrence not restricted to just underdeveloped and developing nations but is also found in developed nations (Anosike, 2021). Many individuals have been made homeless due to recurring building collapses, and many have been devastated by the death of loved ones. The frequency and reasons for occurrence, however, vary from one climate to another because the causes of these collapse in advanced nations most times are due to natural forces/ disasters such as flood, earthquake, tsunami, etc.

The issue of building collapse is not strange in Nigeria, as it has become a frequent happening. Over the last 20 years, Nigeria has ranked as the country with the most building collapse in Africa (Boateng, 2020). According to a study carried out by (Umo et al., 2018), about 186 buildings were estimated to have collapsed from 1974 to 2017 and over half of these collapses happened in Lagos state. Okunola also noted that about 152 buildings collapsed in Lagos between 2005 and 2020, out of which 76.6% happened to be residential, 13.0% were commercial, and institutional buildings accounted for the remaining 9.4% (Okunola, 2021). Okunola went ahead to carry out a little survey on why residential buildings were dominating the cases of building collapse. He found out that there was increased demand for accommodation due to the high influx of people into the state. Due to this, developers try to play smart by building big structures in areas that can accommodate minimal load, thereby trying to save cost. He also noted that most of these buildings were owned by individuals who try to save cost by engaging quacks, instead of engaging professionals (Okunola, 2021).

Unlike natural forces which happens to be the reason of most building collapse in developed nations, the causes of building collapse in developing nation can be traced to human factors. Several reasons have been touted as the causes of these buildings collapse according to

research carried out by several persons, some of which are poor supervision, poor quality or substandard materials, a disregard for standards and regulations, a lack of qualified professionals, overloading, a lack of geotechnical or subsoil investigations, poor construction practices, unlawful approval, incorrect demolition procedures, a lack of maintenance, among many other factors (Ajufoh et al., 2014; Akpabot et al., 2018; Ede, 2010; Adetunji et al., 2018; Odeyemi et al., 2019; Oyegbile et al., 2012; Windapo & Rotimi, 2012).

4 DATA AND METHOD OF ANALYSIS

Historical data of building collapse in Nigeria in the last decade (2012-2022) were considered for this research. The scope of this research was limited to the last decade so as to work with the most recent data available and ensure that this research falls within current trend. Analysis of the data collected were performed with MS Excel statistical tools. The basic parameters considered for the research are the number of floors, the frequency of each group of floors, the casualty verified for each group of floors, monthly record of collapse, status of building prior to collapse, confirmed causes of building collapse and striking differences between collapse of high-rise buildings and others. For this research, high-rise buildings are assumed to be five story and above.

5 RESULTS AND DISCUSSIONS

The total number of cases of building collapse that was considered for this study is 66 cases over the last decade (2012-2022). Figure 1 presents the records of building collapse with respect to the heights of the buildings within the last decade. Three storey buildings are the most collapsed. It can be seen that the incidence of collapse is least for high-rise buildings and large mono-volume building. This can be attributed to the fact that developers or clients who engage in the construction of high-rise buildings are well exposed and well knowledgeable on the need to engage seasoned professionals for any form of construction work. The large mono-volume buildings refer to mega single storey buildings meant for large crowd like mega church buildings.

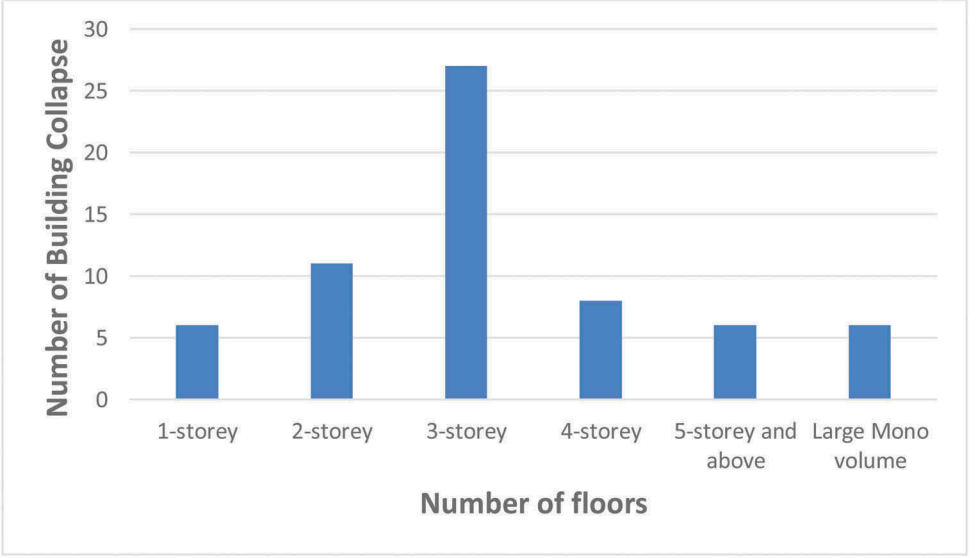

Figure 1. Record of building collapse with respect to the heights of the buildings (2012-2022).

Figure 2 shows the number of casualties associated to each group of floors. It can be seen that the casualties associated with high-rise buildings and large mono volume buildings far exceed those of other group of floors. The large mono-volume buildings refer to mega single storey buildings meant for large crowd. The high rate of casualties linked to high-rise buildings reflects the difficulties involved in realizing such buildings which only highly skilled professionals can handle.

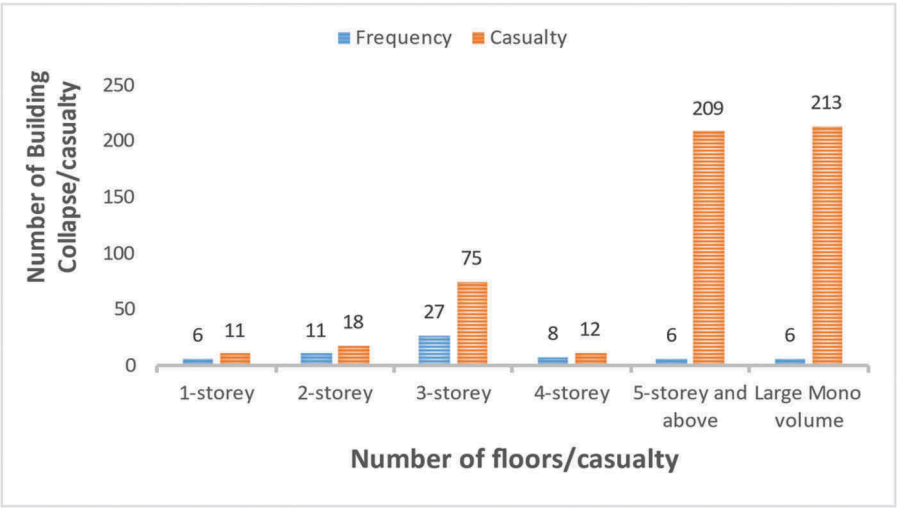

Figure 2. Record of casualties associated to the number of floors.

Figure 3 shows the monthly record of collapse of buildings in Nigeria within the period considered. The raining season is the most dangerous period for the risk of collapse, collaborating results obtained for the previous decade (Ede, 2010). The month of July is the peak month for collapse in Nigeria. From Figure 4, it can be seen that most of the building collapse occur more often for buildings under construction (64% of the cases considered).

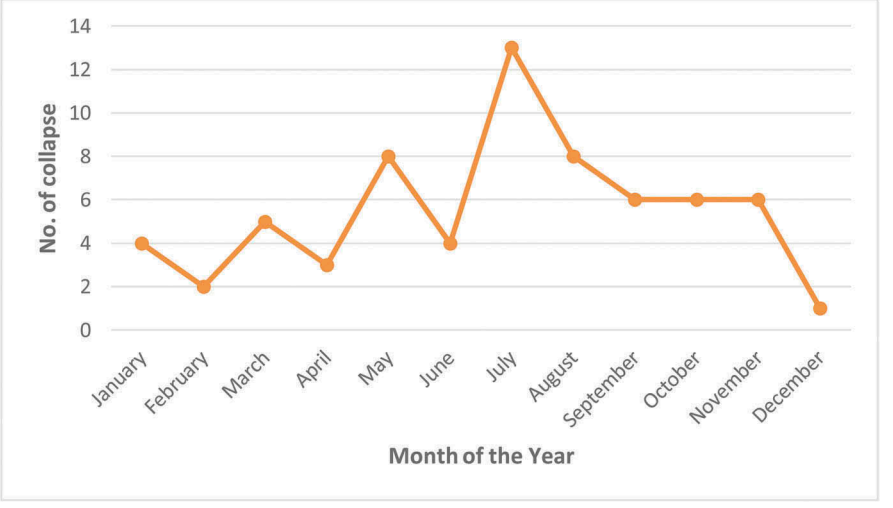

Figure 3. Monthly record of collapse of buildings in Nigeria (2012-2022).

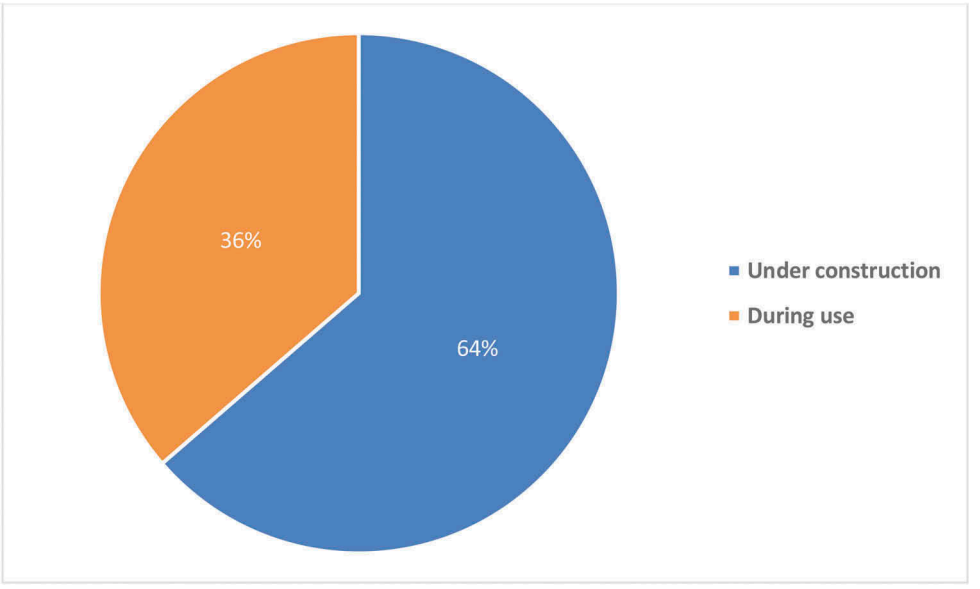

Figure 4. Status of building prior to collapse.

Figure 5 shows the common causes of building collapse in Nigeria within the last decade. It can be seen that most of the causes are difficult to ascertain (29.33%). Other prominent causes verified are substandard materials (20%), structural deficiency from poor construction (18.67%) and illegal conversion/addition of more floors (14.67%). Most of the causes of building collapses can be linked to each other. The various results gotten can be related to each other. From Figure 3, it was shown that the month with the highest collapse rate was July, which happens to coincide with the peak of the rainy season in Nigeria. As a result, it is critical to consider how changing climates will impact these investments over the design life of these structures. This requires proper planning, with an integrated design approach, construction and operation of the building infrastructures, which is very key to sustainability and resilience in building infrastructures (ASCE, 2008; Pal et al., 2022). This is also imperative as climate change is expected to increase the frequency and severity of certain types of extreme weather. It is expected that heat waves will be more severe, storm surges in coastal areas will be amplified, and precipitation will be more intense as a result of climate change. High rise buildings could all be affected by these changes, which could lead to increased delays as well as damage and failure. Hence, the need for an integrated design approach incorporating all relevant professionals required for building sustainable and resilient infrastructures.

In developing sustainable building infrastructures, a working knowledge of the state of the art relating to structural materials and systems coupled with their approximate carbon content is also essential in the proper utilization of locally sourced and accessible materials in building constructions for sustainable, safe, resilient, and economic building constructions (ASCE, 2008). This necessitates the further training of construction professionals to strengthen the sustainable and effective planning, execution and operation building infrastructures. This is essential to avoid future collapses due to flawed construction practices especially with the significant failures that have due to the use of substandard materials as illustrated in Figure 5.

Geotechnical studies should also be done because they provide valuable information that can be used for proper foundation design and other types of construction of civil engineering structures in order to minimize negative effects and prevent problems after construction (Nwankwoala et al., 2014).

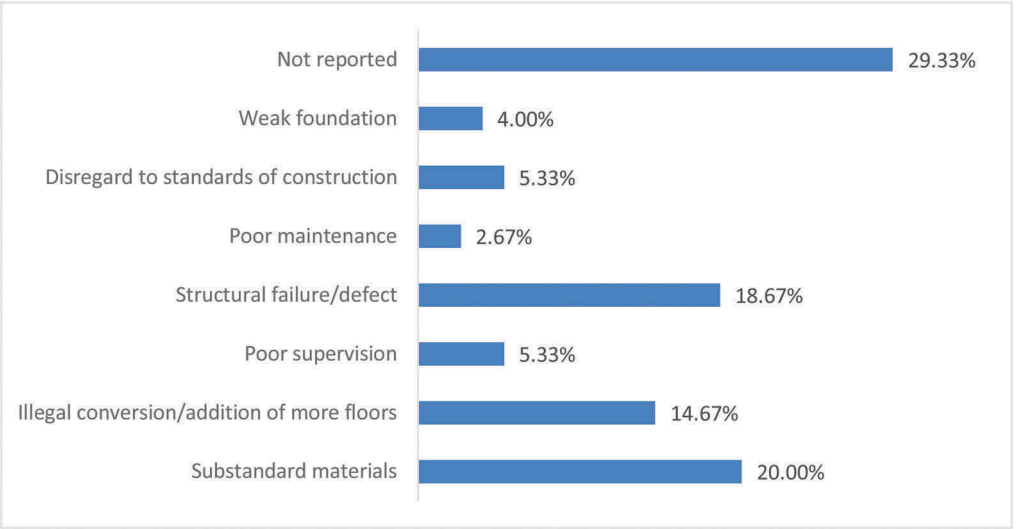

Figure 5. Causes of building collapse in Nigeria (2012-2022).

6 CONCLUSION

From the results obtained from this study as shown in Figure 1, it has been established that there are very few cases of the collapse of high-rise buildings in Nigeria when compared to the collapse of buildings of lower heights. This can be attributed to the engagement of more seasoned professionals in the construction of high-rise buildings. On the other hand, the very high rate of casualties verified for high-rise building collapse is scaring. Adequate safety measures need to be adopted to reduce to the barest minimum the risk collapse of high-rise buildings. Proper project planning and identification of probable risk with the integration of all relevant professionals is crucial in for a sustainable building construction. The development of high-rise structures has been on the rise in several parts of Nigeria, particularly in Lagos State. This is due to urbanization and a need to maximize the land space available. The very few cases of collapse of high-rise buildings shows that Nigeria as a nation can cope with the technicality and advancement that comes with the construction of these high-rise buildings. The frightening scenario of casualties linked to the collapse of high-rise buildings raises the question of how much still needs to be done in Nigeria to fully adopt and incorporate sustainable construction practices into the Nigerian construction industry processes, knowing that the environment in which we operate is changing and the conventional tools with which we use to plan projects are changing too. An understanding of these changes is also crucial to deal with the challenging future. Hence, developing new tools and focus that are required to respond to these changes is also essential.

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