Mitigating building collapse in Nigeria

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ARTICLE INFO	ABSTRACT
  *Corresponding author: Williams Barnabas Qurix Department of Architecture, Faculty of Environmental Sciences Abu Zaria/Bingham University, Nigeria Email: qurexs@yahoo.com ORCID: 0000-0003-2741-5786	*The past ten years (2010- 2020), an overwhelming number of buildings (forty-eight) have collapsed in Nigerian urban cities, with about 77% rise from the previous decade. To address this menace, the study aimed at exploring major causes of building collapse in Nigeria as perceived by building industry professionals, policy makers and the public; with a view of establishing effective ways for mitigation. The primary data were obtained from Questionnaires and field observations while secondary data were obtained from textbooks, Journal articles and newspapers. The results revealed that factors such as change of use for building without following professional protocols is a major cause of building collapse. Poor supervision or lack of supervision by qualified professionals; substandard materials, structural failure; government controlling agency not monitoring projects and standards are compromised, a significant amount (27.7%) of collapse cases recorded during constructions. Other factors include faulty architectural and engineering designs; clients not ready to pay for quality jobs and contractors cut corners for profit. The study recommends use of Building Information Modelling to predict behaviour of buildings under various loading and environmental conditions. Also, only certified professionals should carry out design and supervision of projects. Further research should evaluate the role of technology on existing buildings to check the level of safety for occupants' in such buildings.*

Introduction

Building collapse is arguably the most ponderous issue that has been discussed in Nigerian construction industry especially the last 10 years (Ede 2010). This is due to the increased spade of building collapse witnessed in many urban areas. Generally speaking, building collapse is said to occur when the structural components or other significant components of a building physically gives way from their designed positions that cover deformation, disfiguration or fall of the building (Oseghale, Ikpo, and Ajayi 2015; O., Giwa, and Abdulwahab 2019). Factors such as design errors and poor construction details are the main causes of building collapse; sudden geotechnical changes, earthquakes and flooding (Olagunju, Aremu, and Ogundele 2013). Often a building collapse is preceded by failure, which may or may not be obvious that could occur overtime (Fakere, Fadairo, and Fakere 2012). A failure could be in the form of building over use beyond its design capacity, breakdown of building services leading to underground seepages, construction materials weakness overtime, maintenance negligence and flood (Olabosipo I. and Adedamola O. 2010).

Generally, the discourse on building collapse has tended to be centred on the roles of

professionals' and Regulatory Agencies'. It is important to explore the specific options available to Professionals, policy makers and the public in tackling this menace, which appears to be a global phenomenon (Fakere, Fadairo, and Fakere 2012). This research centres on technology as a basis for mitigation in Nigeria. Under certain circumstances, buildings are designed to behave in a pre-determined pattern in the event of collapse, which may be due to a terrorist attack, earthquake or fire (Islam, Khan, and Sharman 2012). Therefore, the professionals' responsibility in addition to mitigating these building collapses, anticipate the possible nature of collateral damage.

The aim of this study is to explore the major causes of building collapse in Nigeria with a view of proffering effective solutions for mitigation. The objectives are:
i. To identify the major causes of building collapse in Abuja, Lagos and Kaduna.
ii. To explore the roles of professionals, policy makers and public for mitigating building collapse.
iii. To identify the use of technology for mitigating building collapse.

The study is significant to professionals, policy makers and the public in identifying major causes of building collapse and the stakeholders' roles in mitigation. It is also significant to policy makers in terms of special courts formed that handle construction errors counts. Establishment of Building Materials Standard Agency (BMSA) as substitutes to the existing institutions, which control building activities. Lastly stakeholders will ensure that only certified professionals carry out design and supervision of projects. The study is significant for professionals to ensure the use of modern technology in designs.

Understanding building collapse
Building collapse is a global phenomenon contrary to the commonly held beliefs that is mostly a Nigeria phenomenon. Different building types are affected just as a wide range of reasons is adduced. It has also caused huge losses in terms of human life, material and collateral damage (Omenihu, Onundi, and Alkali 2016). Therefore, it has remained a matter of concern for Professionals and Regulatory Agencies.

Zanzan (2014) categorized building collapse in Nigeria according to building types and causes (Zanzan 2014). Based on type, residential and commercial buildings both have 38%, followed by educational 15% and religious buildings 9%. The author identifies unspecified reasons as the main cause with 65% followed by faulty construction 25% and faulty structural design as 10%. More recently, Lagos is leading with 24%, Abuja 19%, Kaduna 8% and Ibadan 6%.

In late 20th Century theatres, churches and stadiums are affected. The trend appears to be shifting to multi-storey residential buildings. Buildings undergoing construction collapse more in developing countries compared with developed countries (Windapo and Rotimi 2012; Ayeni and Adedeji 2015).

Causes of building collapse
The causes of building collapse are as follows;
a) Designer or supervisor incompetency
These include poor design and specification of materials detected by unqualified supervisor or incompetence professional (Chendo and Obi 2015; David 2020) see figure 1 and 2.

Figure 1. Poor design and specification
Source: (Agwuncha 2020)

Figure 2. Two-storey building collapses in Gbagada, Lagos
Source: (David 2020)

b) Construction errors
This manifest informs poor practice with regards to concrete work, inappropriate foundation, steel fabrication (especially of long spoons) and inability to construct fine details by

contractors. In Nigeria, many of the building collapses occur during construction with 27.7% cases (Oloyede, Omoogun, and Akinjare 2010).

c) Clients undue interference

These include clients not ready to pay for quality jobs, serious changes and variation are made at an advanced construction stage without consultants' advice see figure 3 and 4 (Biniyat 2013; Odunisi 2019).

Figure 3. Change of use at construction stage
Source: (Odunisi 2019)

Figure 4. Building collapse in Kaduna
Source: (Biniyat 2013)

d) Commercial dishonesty

Contractors cut corners for profit. The quality of materials is not up to standard, the investor also may be aware of this but deliberately used these materials. Another angle to this is that the professional might have been "settled" to test a new material and if the test "fails" this could lead to collapse see figure 5 and 6 (Adeniran 2013).

Figure 5. Poor quality of materials
Source: (Olukoya and Oyekanmi 2019)

Figure 6. Poor standard of materials
Source: (Usman, Akoni, and Olowoopejo 2011)

e) Natural Causes

These include earthquake, force majeure, wildfires and earth tremor. These may occur without any warning but sometimes show the signs, which are not adequately addressed at the design and supervision stage (Olagunju, Aremu, and Ogundele 2013).

f) Man-made Reasons

These include terrorist activities, Arson, Riots and Wars. The World Trade Centre collapsed as a result of a terrorist activity; many buildings in Allepo Syria were demolished by bombs (Oke 2011).

g) Wear and tear

This is as a result of additional floors constructed on existing buildings, which were not designed or have suffered enough wear and tear as not to be able to carry additional loads. The collapse of Synagogue church building in Lagos was said to have been designed for two floors only but additional four floors were being constructed illegally as seen in figure 7. However, the claim was disputed by the church. Wear and tear could take the form of gradual weakening of structure overtime due to weathering. Weakness could

occur if there is a broken pipe or flooding. Barnawa housing estate collapse in Kaduna was said to be as a result of broken pipe leakage (Oke 2011).

Figure 7. Synagogue building collapse
Source: (Olaiya 2016)

Possible nature of collateral damage
a) Designing against natural causes
Architects must anticipate the effect of natural causes such as flooding and earthquake as well as Earth tremor, Arson or riots which are all prevalent in Nigeria.
b) Deliberate demolition
Buildings which are adjudged to be structurally defective or "tired" are deliberately demolished (Fagbenle and Oluwunmi 2010). Demolition Science is a new field that studies the pattern, nature and analysed control of collateral damage. The World Trade Centre and five-storey residential building in Mumbai India were said to have collapsed in a "pancake" manner to minimize collateral damage. It is difficult to predict the nature of an earthquake's collapse hence an "all out" precaution is required. Another form of collapse is "segment collapse" in which the building is demolished in segments to reduce casualties and collateral damage.

Technology and building collapse
Building Design information Modelling (BIM) and computer Aided Design (CAD) brings more predictability to the design process and better ideas. It is possible to visualize a building's behaviour under different loading conditions over time and even predict the possible nature of collapse with the use of BIM. BIM displays disputed data in digital layout throughout the building life cycle (Oduyemi and Okoroh 2016). The Architect oversees aesthetic articulation, semiology, overall building layout and distributes all technical details (Schumacher 2016). Programming is an important component of technology that takes centre stage in order to reduce collapse. Ingels (2016) argued on the emergence of new materials through new technology that totally transform architecture and building. New technology now produces materials with almost magical properties such as grapheme, which is 200 times more conductive than copper and 100 times stronger than steel. Furthermore, when 3D printing becomes commercialized it will eliminate shortcuts, increase precision and reduce the use of ineffective materials.

Method

The research adopted an extensive case study strategy for primary data to generate elaborate explanations on general theoretical constructs. Typical case and quota purposeful sampling techniques were used for data collection due to large concentration of professionals and building collapse rate at the selected study area. Heterogeneous purposive sampling technique was adopted for selection of participants through electronic media chat because the unit of research exhibits a wide range of attributes, and incidents Data collection used questionnaire and survey mapping, through electronic media and archival document, which lasted for (3) three weeks. 50 questionnaires were sent to building team professionals and policy makers 'through electronic media group charts. 27 responses were returned after several phone calls were sent as reminders. The responses from the public were obtained through the newspapers. The data acquired were analysed using content and thematic analysis. The secondary data were obtained from published literature as well as unpublished articles.

Result and discussion

Nigeria is considered by exploring the case study area (Lagos, Abuja and Kaduna); also, the roles of professionals, policy makers and the public; and the use of technology in mitigating building collapse.

Table 1. Questionnaire distribution and response rate

s/n	State	No	Professionals	Policy maker	Public	No	Professionals	Policy maker	Public	no
			Questionnaire distribution				**Response rate**			
1	Lagos	21	15	6	0	21	9	4	0	13
2	Abuja	17	10	4	3	17	6	3	2	11
3	Kaduna	12	5	2	5	12	3	2	1	6
Total		50	30	12	8	50	18	9	3	30

Table 1 shows the 50-questionnaire distributed to professionals, policy makers and the public in a ratio of 3:2:1; based on the rate of collapse in the study area. The response rate was 30% which was 60%. The members of public responses were through the newspapers.

Table 2. Demographic data

1	Profession		Response rate	Percentage
	(a)	Architects	7	26%
	(b)	Engineers	5	19%
	(c)	Quantity surveyors	2	7%
	(d)	Builders	2	7%
	(e)	Others	11	41%
2	Gender		Response rate	
	(a)	Male	22	81%
	(b)	Female	5	19%
3	Years of experience		Response rate	
	(a)	0-10 years	8	30%
	(b)	11-20 years	6	22%
	(c)	21-30 years	7	26%
	(d)	31-40 years	4	15%
	(e)	40 years and above	2	7%

The demographic data values in table 2 indicated others, to include policy makers and regulatory agencies with 41% as highest followed by architects 26% and engineers 19%. The responses tend to suggest that policy makers and regulatory agencies may play a part in minimizing the menace. Next are architects and engineers. Response rate for male is 81% while female is 19%. Perhaps the issue of gender equality may tend to reduce the incidence when there are more females in the building industries. 0-10 years of experience has 30% as the highest while 40 year and above as the lowest with 7%. These responses suggest that stakeholders with long years of experience may not be well exposed to the use of technology, since the survey was done online.

Causes of building collapse

Table 3. Causes of building collapse

The main causes	Frequency (f)	Rank (x)	fx
Cost of getting building approval is too high	10	8	80
Contractors cut corners for profit	14	6	84
Inappropriate foundation	15	5	75
Client not ready to pay for quality job	17	4	68
Government controlling agency not monitory projects and standard are compromised	18	3	54
Faulty architectural and engineering designs	18	3	54
Structural failure	20	2	40
Change of use for building without following professional protocols	25	1	25
Used of substandard materials for construction	20	2	40
Poor supervision or lack of supervision by qualified professionals.	25	1	25
	N=$\sum f$ =169		$\sum fx = 604$

$$\underline{x} = \frac{\sum fx}{N} = \frac{604}{169} = 3.5$$

The result shown on table 3 identified the actual causes of building collapse in Nigeria. Poor supervision or lack of supervision by qualified professionals ranked 1. Change of use for building without following professional protocols also ranked 1 as the leading causes. Next is used of substandard materials and structural failure, which both ranked 2. The group mean shows 3.5, which fall within the range of clients not ready to pay for quality job, Government controlling agency not monitory projects. Standards are compromised, faulty architectural and engineering designs are the major causes. Inappropriate foundation ranked 5. Contractors cut corners for profit ranked 6. Cost of getting building approval is too high ranked 8, which is the least cause. This result suggests the need to establish a special body known as Construction Materials Standard Agency (COMSA), which would pay attention to only construction materials. This would eliminate "fake" building materials which may escape the general scrutiny of the existing bodies currently in charge of standards generally.

Role of stakeholders in mitigating building collapse

Several ways have already been suggested in this write up inter alia however, a more systematic presentation is made below on some of the ways in mitigating building collapse.

Table 4. Roles of professionals and policy makers/government control agency

s/n	Findings	No. of response	Percentage
	The role of professionals		
1	Everyone should do his job and be accountable for any error	20	74%
2	Quackery should be check	22	83%
3	Teamwork and professionalism as watch word in project delivery	17	63%
4	Professionals to be more assertive in their duties, refuse to cut corners or accept poor standards of work	25	93%
5	Proper project management standards must be adhered to	20	76%
	The role of policy makers/government regulatory agencies		
1	Governments should enforce standards on site through their agents	23	86%
2	Government should partner with private practitioners to deliver projects	18	67%
3	Erring government officials should be brought to book	27	100%
4	Government must ensure the right professionals are put in place	25	93%
5	Government should remove the bottlenecks in the approval process, ensure relevant professionals through their institutes to assist and ensure fast delivery of approval	20	67%
6	Pass into law the national building code (2006), and enforcement of same and other regulations	23	86%

a. Role of professionals in mitigation building collapse

All the built environment professionals must acquire the necessary competency for code of conduct and ethics is 93% as shown in table 4. Next is quackery should be checked is 83%. Proper project management standards must be adhered to is 76%. Everyone should do his job and be accountable for any error which is 74%. Teamwork and professionalism as a watch word in project delivery is the least with 63%. Professional's competency has the highest rating; which suggests the need for continuous mandatory education to ensure up to date competencies. Design and supervision of buildings to be handled by certified professionals. A professional who designs or supervises a building that collapses should be appropriately sanctioned if found to be culpable.

b. Role of policy makers/government regulatory agencies

The result in table 4 shows that erring government officials should be brought to book and have the highest response rate of 100%. This suggests that there should be specially constituted courts to handle construction matters. This would ensure that incompetency is determined and sanctioned appropriately. Next is that the government must ensure the right professionals are put in place with 93%. Government should enforce standards on site through their agents and pass into law the national building code (2006); enforcement of the same and other regulations with both 86%. Although there exist elaborate regulations concerning planning, they are not effectively enforced, and even when cases of collapse are identified, the investigation that

follows is not usually conclusive. Development control units should ensure that all those who seal drawings are officially certified. All drawings forwarded for planning approval must carry a letter of engagement for supervision from the client and undertaking from the relevant professionals in the building industry to supervise the building construction. The bureau for Public Procurement should ensure that no company

undertakes construction project if they do not have a qualified Engineer and Builder.

c. The role of the public

The roles of the public in mitigating building collapse in Nigeria as seen from the new paper played, to report any new structure being erected in such an environment to government regulatory agencies.

Table 5. The use of technology to mitigate building collapse

s/n	Ways by which building collapse can be solved in Nigeria	No. of response	Percentage
1	Adherence to qualitative building materials using technology	27	100%
2	Client and professionals to use BIM for quality workforce	23	86%
3	Professionals involved in building process from start to finish should use BIM	21	78%
4	Government to use GIS for proper planning of cities	18	67%
5	Online building approval tends to be faster	27	100%
6	The use of technology ensures the right ratio specified and thorough design details followed	27	100%
7	Government and professional bodies must insist on mandatory technology upgrade of members	25	93%

Role of technology in mitigation collapse

The result in table 5 shows that adherence to building materials that are qualitative, online building approval done tends to be faster; right ratio specified, and thorough design details followed all had 100% rating. These tend to suggest the use of technology would mitigate building collapse. This is followed by the government and professional bodies must insist on mandatory technology upgrade of members with 93%. Next is clients and professionals to use BIM for quality work force with 86% rating. This is followed by Professionals involved in the building process from start to finish should use BIM with 78%. The least is for the Government to use GIS for proper planning of cities with 67%. This result suggests that it has a low impact on mitigating building collapse.

The combination of BIM and digital fabrication would certainly widen the knowledge of the professional on building behaviour. Digital fabrication is a computer aided design process that manipulates materials through subtractive and additive methods leading to the production of a physical object using a machine known as 3D printer. The fabrication hardware tools include laser cutters, band and hand saws, 3D printers, bionic ally grown cells, routers (Chisels) and so on. Whereas the tools used in BIM include Revit, Structural mode law BIM (software) vector works Architect and 3D Max. Apart from predictability of the building behaviour in different conditions, technology would ensure building sustainability

and through simulation of environmental conditions which serve as a guide to design. It is possible to forecast the pattern of flooding over a period and this data could be used by designers to achieve design and planning objectives with technology. It would almost eliminate uncertainty in design.

Conclusion

Building collapse has a rising profile in Nigeria. The leading cause is change of use without following professional protocols. Major causes are Poor supervision; substandard materials, structural failure; government controlling agency not monitory projects. Other identified causes are faulty architectural and engineering designs; inappropriate foundation; contractors cut corners for profit. A significant amount (27.7%) of collapse cases are recorded during construction. Possible ways of mitigating building collapse are professional should be assertive in discharging their duties; erring government officials be brought to book and the right professionals' put in place. The role of technology has been examined with respect to new materials and computer aided methods in predicting building behaviour. This study recommends use of BIM to predict various loading and environmental conditions. Only certified professionals should carry out design and supervision of projects. Further research should

evaluate the role of technology on existing buildings to check the level of safety for occupants' in such buildings.

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