

# Assessment of the Factors Responsible for Building Collapse in Nigeria

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**Abstract:** Building collapse has been one of the national disasters in Nigeria as all the geo-political zones of the country have experienced the disaster in the last three decades. This menace has been a serious challenge to the government, non-governmental organisations and professional bodies.

The date, locations, possible causes of the building collapse were derived from journals and newsletters of Nigeria Building Research and Regulation Institute (NBRRI). Geo-Spatial distribution of collapsed building was done using trend analysis. GWR was used to find the coefficient of lives that may be lost over a period of fifty years, if the menace is not controlled. Spearman order of correlation and linear regression analyses were performed to show the relationship between the collapsed building and casualties involved.

The result shows that structural failure (32%) was a major factor causing building collapse in Nigeria, while 28% of cases of building collapse were not reported. Results also showed a strong correlation coefficient between building collapse and lives lost (rs of 0.8286). This also correlates with the result derived from geographically weighted regression analysis with Sigma of 0.875666 and the residual square of 0.996359.

The study, therefore, concludes that structural failures are the major factors responsible for building collapse in Nigeria. The research recommended that professional bodies and Standard Organization of Nigeria (SON) are to create awareness of the disaster and measures to control and mitigate it.

**Keywords:** Assessment, Factors, Buildings, Collapse, Nigeria

## I. INTRODUCTION

Goal eleven of Sustainable Development Goals is about sustainable cities and communities. It is well known that a city is incomplete without the proper construction of buildings which serve residential, commercial or industrial purposes. Buildings and the provision of safe and affordable homes are major contributors to sustainable development and through the centuries, these have been important aspects of the socio-economic development of humans. However, the contribution of buildings to Nigeria's development has not yielded the desired potentials because of failed projects and more recently their poor functional performance. (Abimbola et al, 2012).

Building collapse, though a common phenomenon all over the world, is more unbridled and devastating in the developing countries particularly in Nigeria (Ibrahim, 2013). Building collapse is a phenomenon experienced by the building when

the building members failed to perform its structural duties (Fagbenle, et al 2010). Fagbenle (2010) noted that "building collapse occurs when the structural frame of a building breaks up when the loads on it are beyond its carrying capacity". These loads can be live loads, wind loads or dead loads that are not being catered for during the analysis and design of such buildings.

Buildings are designed to support certain loads without deformation. The loads can be live loads which are movable loads and the dead load which is the load of the building itself. Failure in a building can be described as the inability of the building components to perform its structural capacity that is normally expected or required of those components to carry before the building finally collapsed. Building failure is an unacceptable difference between expected and observed performance in a building component when that component can no longer be relied upon to fulfil its principal functions. Limited deflection on a floor which causes a certain amount of cracking/distortions in partitions could be considered a defect but not a failure. Whereas excessive deflection resulting in serious damage to partitions, ceilings and floor finishes could be referred to as a failure, but sudden dislocation or giving away of a structure is classified as building collapse (Abimbola et al., 2012).

Though building collapse is not peculiar to Nigeria, the trend in the country is becoming quite worrisome and a source of concern to stakeholders. According to Ayedun et al (2012), the spate and frequency of occurrence have become a major source of concern not only to the governments but to all meaning Nigerians and most especially the stakeholders in the building industry as the magnitude of the incidents are becoming very unprecedented. That building collapse incidence is still regularly occurring despite the fact that there has been the increasing diffusion of engineering knowledge over the years have brought to question whether these stakeholders have critically examined the reasons for building failure and the roles they can play or the strategies they can articulate that would help to arrest the incidents. This seeming gap portends the reason for this study; thus, this research examines the spatial distribution of the building collapse in Nigeria with the desire to finding out the factors responsible for the building collapse, casualties involved and the possible ways of arresting the situations.

In the building industry today, building collapse has been one of the major problems faced by both private and public

developers, whether for personal use or for investment purposes. This has posed a very serious challenge to people in building industry, government and individuals who are into property development in the country. Several factors have been associated with building collapse some of which are negligence, greed, deficient foundations, inadequate steel reinforcement, hasty construction, no soil test, poor supervision and non-adherence to building codes (Ede, 2010).

Ayinnuola and Olalusi (2004) specifically stated that building collapse in Nigeria is attributed to 50% design fault, 40% construction fault and 10% product failure. Ede (2010) and Olagunju (2011) emphasised the importance of post-construction maintenance of a building. They also noted that lack of proper maintenance culture contributes to the crisis of building collapse in Nigeria. This was also supported by Fagbenle et al., (2010), Olagunju, Aremu and Oladele (2013) and Babalola (2015).

Many of the aforementioned studies specifically studied the major causes of building collapse without considering the number of lives that may be lost if the menace is not reduced. Building collapse has caused the loss of many lives and property. However, the relationship between loss of lives and property has not been geo-statistical and geographically established.

## AIM

The aim of this work is to assess the factors responsible for building collapse in Nigeria.

## OBJECTIVE

- i. Map building collapse in Nigeria;
- ii. Assess the factors leading to building collapse in Nigeria; and,
- iii. Determine the number of casualties involved and forecast the relationship between building collapse and lives lost.

## II. STUDY AREA

Nigeria is a sub-Saharan African country, which is located between latitude 4°N to 12°N and longitude 4°E to 14°E. It is bordered by the Niger Republic and the Chad Republic in the North and the Atlantic Ocean in the south. It is bounded by Benin Republic in the west and Cameroon in the east. Her largest city is Lagos which is the home of her industrial and commercial activities. It is divided into six geo-political zones.

Nigeria has the highest population in Africa with an estimated 190 million people. Its topography is mostly plain in the north with plateau and hills in the centre of the country. The south is mostly high and low land with tropical rain forest.

## III. METHODOGY

### A. Materials

The materials used for this research work were extracted from secondary data of building collapse in Nigeria from 1986 to 2016 (Omineru et al, (2016): An Analysis of Building Collapse in Nigeria (1971-2016): Challenges for Stakeholders; Abimbola O. W. (2012): Contemporary Issues in Building Collapse and Its Implications for Sustainable Development; NBRRI (2012). "Curbing the incidences of building collapse in Nigeria"; NBRRI Proceedings of National Technical Workshop on Building Collapse in Nigeria. NBRRI Report No. 29, Abuja. NBRRI (2012). "Federal Government Committed to

Enforcement of Building Code". NBRRI Newsletter 1(7). NBRRI (2012). "NBRRI Organizes Training for Contractors". NBRRI Newsletter 1(9)). These data contain the date, locations of the building collapse, possible causes of the building collapse and the number of casualties involved in the building collapse.

Google Earth was used to get the relative coordinate of the locations of the collapsed building. ESRI ArcGIS 10.4 was used for data analysis. Nigerian shapefile showing the Nigerian boundary and Nigerian state was gotten from Cooperative Information Network which was used to run the spatial analysis of the data.

## B. Methods

### Mapping of Building Collapse in Nigeria

The locations of the building collapsed were extracted from Google Earth as XY coordinates. The XY coordinates were tabulated in Microsoft Excel and exported into ArcGIS as a point layer and was further overlaid on the Nigeria shape file to produce the maps of building collapse.

### Factors Responsible for Building Collapse

From the data of the building collapsed, the factors that responsible for building collapsed were tabulated in relation to the frequency and percentage of occurrence and the result was tabulated.

### Casualties Involved and Determining the in the Collapse of Building

From the table extracted, the year with the highest number of casualty and number of the collapse was determined using Spearman Rank Order of correlation analysis to determine the correlation between the building collapse and the casualty.

$$r_s = 1 - \frac{6\sum d^2}{N(N^2 - 1)} \quad \dots \quad (1)$$

Where

$r_s$  is Spearman rank-order correlation coefficient

$N$  is the number of scores

$d$  is the sum of the difference in ranked squared

Likewise, linear regression analysis was used to project the possible lives that may be lost if building collapse is not being controlled.

$$Y = A + Bx$$

Where  $A = \frac{(\sum y \sum x^2 - \sum x \sum xy)}{(n \sum x^2 - (\sum x)^2)}$  and  $B = \frac{(n \sum xy - \sum x \sum y)}{(n \sum x^2 - (\sum x)^2)}$

Where

$Y$  = Projected number of lives that would be lost

$y$  = Dependent Variable = Number of lives lost

$x$  = Independent Variable = Number of collapsed buildings

$A$  = Slope and

$B$  = Intercept of the linear curve or quotient of the variable  $x$

Geographic Weighted Regression (GWR) analysis was carried out to show the geographic regression map that predicts the coefficient of lives that may become the casualty of building collapse if the occurrence is not being corrected.

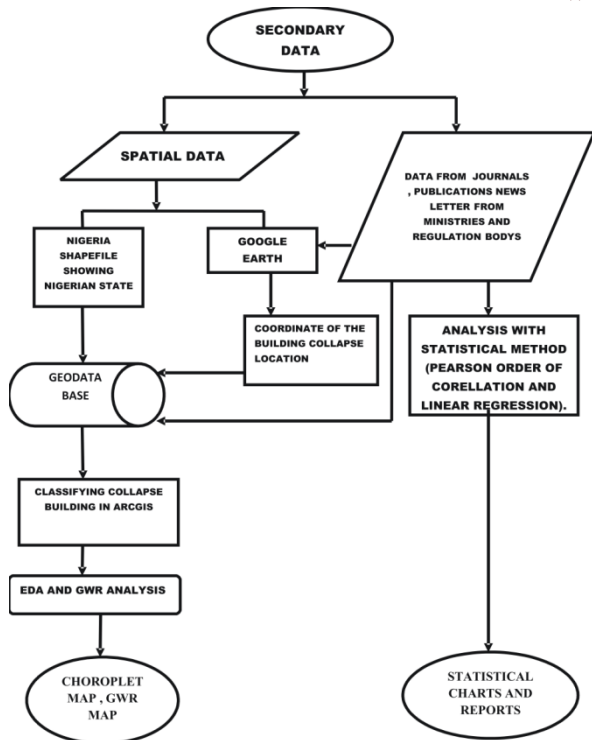


Figure 3.1: Methodology flow diagram

**IV. RESULTS AND DISCUSSIONS**

**A. Results**

**1. Mapping of Building Collapse**



Figure 4.1 shows the spatial distribution of building collapse in Nigeria between 1986 to 2016.

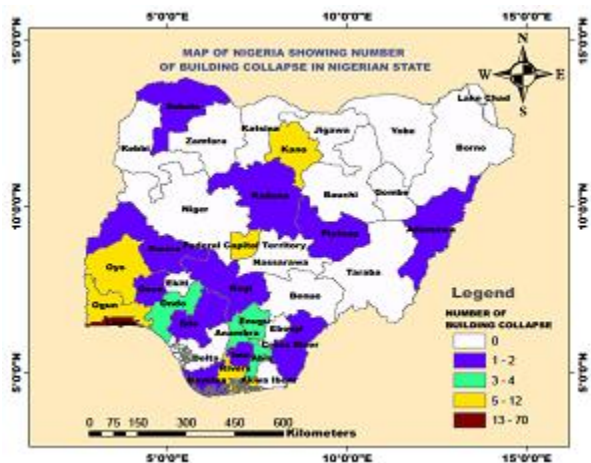


Figure 4.2: Map of Nigeria showing classified building collapse in Nigeria

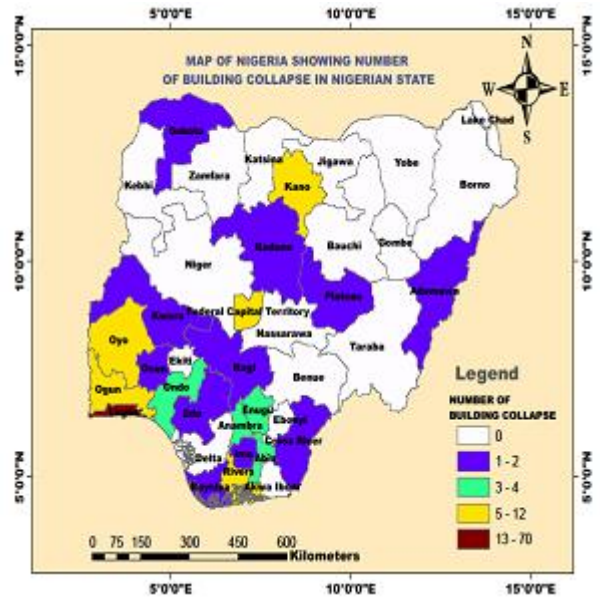


Figure 4.3: Map showing casualty from building collapse in the Nigerian state.



Figure 4.4: GWR map showing prediction of casualty from building collapse.

Table 1: Result of GWR Analysis

Object Id	Variable Name	Variable	Definition
1	Band With	2.02611	
2	Residual Squares	17.614079	
3	Effective Number	15.028846	
4	Sigma	0.875666	
5	AICc	117.009769	
6	R2	0.996359	
7	R2 Adjusted	0.994135	
8	Dependent Variable	0	NO_OF_Collapse
9	Explanatory Variable	1	NO_OF_CASUALTY

2. Factors responsible for building collapse

Table 2: Frequency Distribution for Causes of Building Collapse

S/NO	Cause	Frequency	Percentage %
1	Excessive loading	3	1.39
2	Structural failure	58	26.85
3	Substandard materials	23	10.65
4	Faulty design	12	5.56
5	Inappropriate foundation	13	6.02
6	Carelessness	3	1.39
7	Heavy rain	10	4.63
8	Poor workmanship	13	6.02
9	Approval violation	7	3.24
10	Use of quacks	17	7.87
11	Geotechnical violation	2	0.93
12	Design violation	8	3.7
13	Regulations violation	4	1.85
14	Lack of maintenance	1	0.46
15	No reported cause	42	19.44
	<b>Total</b>	<b>216</b>	<b>100</b>

Table 3: Summary of collapsed buildings and casualties between 1986 and 2016 in Nigeria

S/NO	Year	Number of collapses	Number of lives lost	% of Collapse Occurrence
1	1986 – 1990	15	144	10
2	1991 – 1995	20	112	13.33
3	1996 – 2000	24	175	16
4	2001 – 2005	21	241	14
5	2006 – 2010	29	358	19.33
6	2011 – 2016	41	285	27.33
	Total	150	1315	100

$$r_s = 1 - \frac{6\sum d^2}{N(N^2 - 1)} \dots (1)$$

Where

$r_s$ = Spearman rank order correlation coefficient

1= unity for a perfect correlation

6= Constant Value

$\sum d^2$ = 6 (sum of difference in rank squared)

N= 6 (number of scores)

Substituting the values into equation (1), we have:

$$r_s = 1 - \frac{6(6)}{6(6^2 - 1)}$$

$$r_s = 1 - \frac{36}{6(36 - 1)} = 1 - 0.1714 = 0.8286$$

Similarly, to forecast the numbers of collapse and casualties that may occur in future, if nothing is done to prevent future occurrence, the linear regression analysis was conducted on these data, using equations 2(a, b &c) by substituting Table 4.0 into them.

S/No	Year	Collapse (x)	Lives lost (y)	x <sup>2</sup>	xy	Projected number of Lives Lost (Y)
1	1986 – 1990	15	144	225	2160	150.249
2	1991 – 1995	20	112	400	2240	184.704
3	1996 – 2000	24	175	576	4200	212.268
4	2001 – 2005	21	241	441	5061	191.595
5	2006 – 2010	29	358	841	10382	246.723
6	2011 – 2016	41	285	1681	11685	329.415
	<b>Total</b>	<b>150</b>	<b>1315</b>	<b>4164</b>	<b>35728</b>	<b>1314.954</b>

$$Y = A + Bx \dots (2)$$

Where Y = Projected number of lives that would be lost y = Dependent Variable = Number of lives lost x = Independent Variable = Number of collapsed buildings A = Slope and B = Intercept of the linear curve or quotient of the variable x

$$A = \frac{\sum y \sum x^2 - \sum x \sum xy}{n \sum x^2 - (\sum x)^2}$$

$$B = \frac{n \sum xy - \sum x \sum y}{n \sum x^2 - (\sum x)^2}$$

$$A = \frac{(1315)(4164) - (150)(35728)}{(6)(4164) - (150)^2} = 46.884$$

$$B = \frac{(6)(35728) - (150)(1315)}{(6)(4164) - (150)^2} = 6.891$$

Therefore,  $Y = 46.884 + 6.891x \dots (3)$  for the 5yrs intervals. To account for the interval of 5 years in the table above, we have

$$Y = 234.42 + 34.455x \dots (4)$$

For this linear relationship, if x = 50 yrs (i.e. 1986 to 2036), the total number of lives to be lost

$$Y = 234.42 + 34.455(50) = 1957.17$$

**DISCUSSION**

The result shows that there is a heavy cluster of building collapse in the southern part of the study area which includes Lagos, Rivers and Oyo States polygon. It was also revealed that Lagos has the highest building collapse in Nigeria with the highest casualties as shown in Figure 4.2 and Figure 4.3 respectively.

Geographical weighted regression analysis shows the results in figure 4.4 and table 1 that residual square of 17.614 which is less than 50 indicates that the model fits to the study while sigma 0.87566 which is less than 1 from the table signifies that there is close relationship between the building collapse and life lost as tested by Omineruet *al* (2010).

Moreover, R-Squared ( $R^2$ ) of 0.996359 shows that the discrepancy between the model and the data has low significance and shows that building collapse has a high effect on the casualty.

From Table 2, structural failure (26.85%), use of substandard materials (10.65%) and use of quacks (7.89%) were the chief causes of building collapse in Nigeria from 1986 to 2016. A huge chunk of the collapses had no reported cause (19.44%) with structural failure taken the lead; these were in line with the findings of Abimbola *et al* (2012). Least reported causes

are lack of maintenance (0.46%), geotechnical violation (0.93%), carelessness and excessive loading (1.39%) and regulations violation (1.85%). Table 3 revealed that year range 2011 – 2016 (27.33%) had the most reported occurrence of building collapse followed by 2006 – 2010 (19.33%) and 1996 – 2000 (16.99%). However, mortality due to building collapse was worse in the period 2006 – 2010 with 358 casualties followed by 2011 – 2016 with 285 mortalities.

A positive  $r_s = 0.8286$  result from Spearman rank-order correlation coefficient in table 4, is an indication of a strong positive relationship between individual ranks obtained in the number of collapsed buildings and the number of lives lost. This practically means that, the higher the number of collapsed buildings, the higher the lives lost and vice versa.

Likewise, in Table 5, the result of linear regression analyses that forecast the future lives that may become the casualties interpret that an approximate number of 1958 lives would be lost in 50 years from 1986 to 2036 if the current situation is not corrected; this is in line with Kadri, *et al* (2018).

## CONCLUSION

The incidences of structural failures, substandard materials and poor workmanship, use of quacks and approval violations have influenced the frequency of the occurrence of building collapse and the magnitude of the losses both in terms of lives and properties. This research work revealed that all these constitute 54.63% of major factors leading to building collapse in Nigeria. This study shows that of all six geo-political zones and Federal Capital Territory of Nigeria, southern region recorded the higher part of building collapse in the country with Lagos State alone recorded 70 building collapse cases between 1986 and 2016. This work also uses Geographic Information System to show spatial distribution of areas where building collapse is rampant in Nigeria using point future and representing the value of numbers of building collapse in states and the casualties. Using choropleth map, GWR model shows that there is close relationship between building collapse and the life lost with sigma value of less than 1 and shows the coefficient of prediction of the lives that may be lost in building collapse per state.

## RECOMMENDATIONS

### Government

- i. The Standard Organisation of Nigeria should vigorously pursue all those in the production and importation of substandard building materials and bring them to justice.
- ii. Ministry of Housing and Urban Development should use the zoning approach to limit the number of floors in the areas associated with very loose subsoil and suspected geotechnical deficiency; it should even go further to stipulate the type of foundation to be used.
- iii. The state governments, through the appropriate ministry, should, as a matter of urgency, streamline the process of granting building plan approvals.
- iv. A monitoring team should be set up under the commissioner of Works and Housing to make a regular visit to different construction sites with a view of assessing how well contractors and supervisors (consultant engineer and architect) play their roles.
- v. State ministry in charge of building plan approval should also ensure that the engineers supervising

building construction take the responsibility of structural integrity and are properly documented including taken main photographs.

- vi. The engineer should as well be interviewed by a professional colleague who should not be below the rank of director or its equivalent in the relevant ministry; this will forestall any impersonation, forgery and denial in the future.
- vii. The government should put in place a policy for checking existing building periodically, every five to ten years to ascertain their suitability for human habitation.
- viii. The local planning authority should concern itself with only approval of buildings of two floors and any floor higher than two floors should be done by the state ministry of works.

### Developers

- i. Clients or developer will need to be circumspect in the choice of a prime consultant to ensure they engage competent prime consultants with integrity.
- ii. Clients or developers should rely on professional advice to engage the contractor to execute their projects. This will not only ensure that the right contractor gets the job but that it gets it done correctly and on time.
- iii. Developers should also endeavour to sign proper contracts with both prime consultant and the contractor, defining responsibilities and obligations.

### Professional bodies

Professional bodies like Council for Regulation of Engineering in Nigeria (COREN) and their corresponding societies or associations will be expected to conduct mandatory and regular workshops/seminar for their members to keep them abreast of current development in their chosen profession. These bodies should set up units to monitor the activities of the members, make random visits to the project sites where those who are found wanting in the discharge of their duties should be sanctioned.

### Civil Society and Non-Governmental Organisations

Civil societies, especially the NGO, should act as watchdog to report any new development and even the restructuring of the old structure to the relevant authorities. They should also intensify the campaign against building collapse and its danger in mass media. Based on the result of the research, the following recommendations are made:

- Measures should be put in place to ensure schools are more evenly distributed within the study area, putting the minimum distance apart from one another into consideration
- Zonal authorities should have a strong enforcement on the criteria for site suitability for new schools
- School should be located in the neighborhood centers in order to achieve the 2km minimum distance from most of the residential buildings.
- Literature research has shown that improper distribution of schools is not only peculiar to the study area, but also a large number of communities. This calls for more appropriate planning of school distribution on a much broader geographic region.

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