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Causes and Effects of Building Collapse in Lagos State, Nigeria

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Abstract
The study identified and evaluates the causes of building failure and examined the effects of building failure with respect to cost in Lagos State, Nigeria. The method employed in the collection of data includes the administration of questionnaire to professionals in the construction industry and case studies for the sites. A purposive sampling technique was used for selecting the sites visited, and selecting the construction professionals. Descriptive statistical techniques such as frequency distribution and percentages and mean response analysis were used to analyze data. The study revealed that the major causes of building failures were bad design, faulty construction, over loading, non-possession of approved drawings, Possession of approved drawings but non-compliance, and the use of quarks. In the two case studies considered, the total direct loss to the building owners was thirty eight million three hundred and eight five thousand, seven hundred and twenty one naira (38,385,721) which is about One hundred and ninety four thousand, eighty hundred and fifty one dollars ($194,851) at one hundred and ninety seven naira to one US dollars, central bank Nigeria of exchange rate as at 14th March, 2015.
Keywords: Building structures, Building failure, Building collapse, structural failure, Cost, Direct loss

1.0 INTRODUCTION

Buildings are structures, which serve as shelters for man, his properties and activities, When properly planned, designed and erected it gives desired satisfaction to the client or user. Some of the factors to be considered in measuring the standard of a building include durability, adequate stability to prevent its failure or discomfort to the users, resistance to weather, fire outbreak and other forms of accidents (Ikpo, 2006). The styles of building construction are constantly changing with introduction of new materials and techniques of construction. Consequently, the work involved in the design and construction stages of buildings are largely that of selecting materials, components and structures that will meet the expected building standards and aesthetics on economy basis. Several codes of practice universally accepted are available for the design and construction of buildings.

In 2006 the Federal Republic of Nigeria published the National Building Code which is undergoing review and in the processes of being passed into law by the national assembly of the Federal Republic of Nigeria in response to the number of cases of collapsed buildings recorded in the country. This has not yielded the desired results as most States in the country have not passed the Urban and Regional Planning Law to make the National Building Codes operational in their respective States. Building Code is a set of legal requirement of which the purpose is to promote good practice in the design, construction and maintenance of buildings, in the interest of the health, safety and welfare of people who use buildings. The Code sets out the basic requirements for the design and construction of buildings which represents a code of good building practice (Obiegbu, 2006).

Despite the availability of building codes and professionals in the Nigerian construction industry, the reported cases of building collapse had become very alarming and worrisome (Dimuna, 2010). The incidence of building failures and collapses has become major issues of concern in the development of the Nigeria nation as the frequencies of their occurrence and the magnitude of the losses in terms of lives and properties are now becoming very alarming, to the extent that it has become familiar occurrence, even to layman on the street in Nigeria (Fagbenle and Oluwunmi 2010). Many lives and properties have been lost in the collapse of buildings mostly in Port Harcourt, Abuja and Lagos (Fasakin, 2002; Dimuna, 2010; Olagunju et al, 2013).

The contribution of buildings to Nigeria's development has not yielded the desired potentials because of building failure/collapse and more recently their poor functional performance (Windapo and Rotimi, 2012). Therefore the study assessed the causes and effects of building failure with a view to bringing out the implications on national economy. The research examined the occurrence of building failures in Lagos state, Nigeria; identified and assessed the causes of building failure and also examined the effects of building failure in the study area with respect to cost.

2.0 REVIEW OF PREVIOUS WORK

Failure is an unacceptable difference between expected and observed performance. A failure can be considered as occurring in a component when that component can no longer perform its designed functions (Ayininuola, and Olalusi, 2004). Limited deflection in a floor which causes a certain amount of cracking/distortion in partitions could reasonably be considered as defect but not a failure, whereas excessive deflection resulting in serious damage to partitions, ceilings and floor finishes could be classed as a failure (Roddis, 1993).The total failure of the building elements and components can be referred to as building collapse (Ikpo, 2006). Collapse of a building may be either a partial, progressive and total or sudden collapse (Olusola et al, 2011). Folagbade(2001) and Chinwokwu (2000) enumerated forty-two (42) cases of building collapse as occurring between 1980and 1999 in Nigeria while Makinde (2007) listed fifty-four (54) cases occurring between January 2000 and June2007 alone. Some cases of building failure/ collapse are shown in figures 1 to 8.

In Nigeria, the common causes of building collapse have been traced to bad design, faulty construction, use of low quality materials, hasty construction, foundation failure, lack of proper supervision, ineffective enforcement of building codes by the relevant Town Planning Authorities, lack of proper maintenance e.t.c. (Folagbade, 2001 and Badejo, 2009; Ogunsemi, 2002) .

Hall (1984) ascribed faulty design, faulty execution of work and use of faulty materials as major causes of structural failures. Federick and James (1989) suggested that the overturning of structures due to heavy wind loads, sliding of structures due to high wind, roof uplift or sliding, and building sway due to lateral loads are major types of building failures. On the other hand, Akinpelu (2002) categorized the following as major causes of structural failure: environmental changes; natural and man-made hazards; improper presentation and interpretation in the design. Richard (2002) opined that deterioration of reinforced concrete could occur as a result of corrosion of the reinforcement caused by carbonation and chloride ingress, cracking caused by overloading, subsidence or basic design faults, and construction defects. Case studies by Ogunsemi (2002) and Folagbade (2002) show that poor structural design, use of substandard building materials, non-compliance with approved building design, poor workmanship, and lack of qualified and appropriate professionals to ensure quality construction, and cost control among others are major causes of building failures in the contemporary Nigeria. (Olusola et al, 2011) examined technological and non-technological factors that were responsible for the occurrence of collapse buildings in the South-Western Nigeria. They identified technological factors to include building design, design error, site production, and use of poor materials, faulty design of foundation among others. While non – technological factors were lack of site –trade training and corruption etc.

Ayininuola and Olalusi, (2004) noted that the reasons for structural failures were due to limited knowledge of building structural behaviour and unanticipated environmental phenomena

Fagbenle and Oluwunmi, (2010) blamed the high rate of building collapse on the very low level of compliance with approval of building plans before construction commencement, ineffective monitoring mechanism put in place by the relevant government agencies and the low level of awareness of the existing Building/Planning Regulations by clients/contractors.

Several productive lives and properties have been lost in the various incidents of building collapses in Nigeria, and these losses, which would only truly be felt by future generations, have negatively impacted the socio-economic status of its citizenry (Olajumoke et al, 2009). Windapo and Rotimi, (2012) revealed that in 20.3% of the incidents, of building collapsed there was no loss of life, between one and five lives were lost in 44.4% of the incidents, and the worst case scenario was the loss of over 21 lives in 9.3% of incidents. The number of life lost in building collapse incidents give an indication of the severity of the problem, and where live was not lost, physical injuries are just as severe. However any case of building failure would ultimately result in loss of productive time which does not augur well for sustainable development goals (Windapo and Rotimi; 2012).The incident of structural failures and building collapse in the past decades has resulted in the loss of many lives and properties worth several millions of Naira. From the foregoing in all the cases of building failure/collapse reviewed from open literature there is no empirical evidence to show the quantum of economic loss to the clients and the nation at large, this study will attempt to fill this gap.

3.0 RESEARCH METHODOLOGY

The method employed in the collection of data includes the administration of questionnaires and case studies for the sites. A purposive sampling technique was used in this survey for selecting the sites visited and selecting the construction professionals. The selection of Lagos State as the case study was because it has recorded the highest cases of building collapse in Nigeria. It is the second largest city in Nigeria and most populous cities in Africa. Being the industrial as well as commercial centre of the country the city has a high population density and abundant economic opportunities, which in turn has led to over utilization of available utilities and resources (Ayininuola and Olalusi, 2004).

The questionnaire was administered on the participants in the construction industries. One hundred (100) copies of questionnaires were administered but seventy (75) were returned, Two building collapse sites

were purposive selected and used as case study for this research work. In other to effectively determine the factor that are responsible for failure of building, the 5-point rating scale was used to rate the causes and effect of building failure. Two cases studies were chosen and used in this research work. They were analyzed with respect to quantum of the cost lost as a result of building failure. Physical measurements in the collapse site were taken as the information used in this study. Cost from similar building was used in order to obtain cost per metre of the floor area of the collapsed buildings. Mean response analysis was used to analyze issues that relate to the causes, effect of building failure, and factors that would help checkmate the incidence of building failure.

4.0 DATA ANALYSIS AND DISSCUSSION

(Insert Table1)

Table 1 shows the working experience of the respondents sampled. The result shows that 26.7% of the respondent was within the working experience of less than 5 years, 25.3% were within the working experience of 5-9 years, 29.3% were within the working experience of 10-14 years, 13.3% were within the working experience of 15-19 years and 5.3% were within the working experience of 20 years and above. The implication is that the respondents sampled have the experience to contribute to this study.

(Insert Table 2)

Table 2 shows the academic qualification of respondents. The result shows that 1.3% of the respondents were SSCE/NECO/GCE holder, 10.7% of respondents were OND/DIPLOMA holders, 74.7% of respondents were HND/B.Sc holders and 13.3% of respondents were MBA/M.Sc holder. The implication is that the respondents have the required knowledge to contribute to the research work.

(Insert Table 3)

Table 3 shows the professional qualification of the respondents sampled. The result shows that 9.3% of the respondents were Town planner, 22.7% of the respondents were Architect, 29.3% of the respondents were Builder¸ 14.3% of the respondents were Engineer and Estate surveyor while 7% of the respondents were Quantity Surveyor. This implies that the respondents were all participants in the construction industry.

(Insert Table 4)

Table 4 shows mean response analysis calculated for the factors responsible for structural failure and building collapse. The result shows that faulty construction ranked number one, followed by bad design, the use of quarks, overloading of structure and non possession of approved drawings, possession of approved drawings but non- compliance, poor quality of materials, poor workmanship, and error in design.

(Insert Table 5 vis-a-vis Figure 1)

Table 5 shows a case study of a block of 4 Flats- 2 and 3bedrooms units that collapsed in Lagos State while construction was ongoing and all its structural elements up to roofing were already in place. The result shows that the cost of the collapsed building was estimated as Ten million one hundred and forty seven thousand, three hundred and eighty four naira only (#10,147,384), which is about fifty one thousand, five hundred and ten dollars **($ 51,510**) at one hundred and ninety seven naira to one us dollars Nigeria central bank exchange rate as at 14TH March, 2015.

(Insert Table 6 vis-a-vis Figure 2)

Table 6 shows a case study of shopping complex that collapsed while the building was already in use. The result shows that the estimated cost of the collapsed building to the client was twenty eighty million two hundred and thirty eight thousand, three hundred and thirty seven naira (#**28,238,337)** which is about one hundred and forty three thousand, three hundred and forty two dollars (**$143,342**) at one hundred and ninety seven naira to one us dollars Nigeria central bank exchange rate as at 14TH March, 2015.This is inclusive of cost of demolition and cart away debris offsite.

(Insert Table 7)

Table 7 shows the mean response analysis computed for factors that would help to checkmate the incidence of structural failure and building collapse at pre-construction and post-implementation phase of building development. The result shows that design strictly to code of practice came first followed in order determination of soil bearing capacity, ensuring that buildings are constructed in accordance to designs, adequate supervision, carrying out proper site investigation, Strictly adherence to working drawing, Avoiding the use of quacks and adherence to specification, proper presentation and interpretation of working drawing, design with experience, produce working drawings before commencing construction on site, and obtaining approval before commencing construction on site.

Discussion of Findings

The study measured the strength of the identified factors responsible for structural failure and building collapse. The study revealed that the major factors responsible for building failure were bad design, faulty construction, over loading, non-possession of approved drawings, possession of approved drawings but non-compliance, the use of quarks, error in design, bad workmanship, bad communication, and flood, lack of maintenance culture,

poor quality materials and inadequate fund.

In the first case study (A block of 4 flats 2&3 bedrooms), research reveals that an estimated cost of Ten million one hundred and forty seven thousand, three hundred and eighty four naira (#10,147,384) which about fifty one thousand, five hundred and ten dollars ($ 51,510) was direct loss to the building owner. In the second case study (shopping complex), an estimated cost of twenty eighty million two hundred and thirty eight thousand, three hundred and thirty seven naira (#28,238,337) which about one hundred and forty three thousand, three hundred and four two dollars ($143,342) inclusive of cost of demolition and cart away debris offsite was direct loss to the building owner.

The study also revealed the factors that could help checkmate the incidents of building failure/collapse as: design strictly to code of practice, determination of bearing capacity, ensuring that buildings are constructed in accordance to designs, adequate supervision, carrying out proper site investigation, strictly adherence to working drawing, avoiding the use of quacks and adherence to specification, proper presentation and interpretation of working drawing, design with experience, produce working drawings before commencing construction on site, and obtaining approval before commencing construction on site.

5.0 CONCLUSION AND RECOMMENDATIONS

The study examined the causes and effects of building failure with respect to cost in Lagos State, Nigeria. The study concluded that the major causes of building failures were bad design, faulty construction, over loading, non-possession of approved drawings, Possession of approved drawings but non-compliance, the use of quarks, error in design, poor workmanship, and poor communication. Also, the level of compliance with the approval of building plans before construction commencement was found to be very low. This could be hinged on the ineffective monitoring mechanism put in place by the relevant government agencies and the low level of awareness of the existing Building Control Agency by clients/contractors.

In the two case studies considered, the total direct loss to the building owners was thirty eight million three hundred and eight five thousand, seven hundred and twenty one naira (38,385,721) which is about one hundred and ninety four thousand, eight hundred and fifty one dollars ($194,851).

The study therefore recommends strict adherence to code of practice, determination of bearing capacity of soil before design, getting approval before commencing construction on site, Building Control Officials should ensure compliance with approved building plans, adequate supervision, carrying out proper site investigation, strict conformance to working drawings, prohibiting the use of quacks and adherence to specification.

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APPENDIX
TABLES

Table1 Respondents Working Experience

Working Experience	Frequency	Percent	Cumulative Percent
<5 years	20	26.7	26.7
5-9 years	19	25.3	52.0
10-14 years	22	29.3	81.3
15-19 years	10	13.3	94.7
20 years and above	4	5.3	100.0
Total	75	100.0	

Table 2 Academic Qualification of the Respondents

Academic Qualification	Frequency	Percent	Cumulative Percent
ssce/neco/gce	1	1.3	1.3
ND/diploma	8	10.7	12.0
Hnd/B.sc	56	74.7	86.7
MBA/M.sc	10	13.3	100.0
Total	75	100.0	

Table 3 Professional Qualification of the Respondents

Professional Qualification	Frequency	Percent	Cumulative Percent
Town Planner	7	9.3	9.3
Architect	17	22.7	32.0
Builder	22	29.3	61.3
Engineer	11	14.7	76.0
Estate surveyor	11	14.7	90.7
Quantity surveyor	7	9.3	100.0
Total	75	100.0	

Table 4. Factors responsible for building failure/ collapse

Causes of structural failure/ building collapse	Mean	Ranking
Faulty construction	4.6667	1ST
Bad design	4.5600	2ND
The use of quarks	4.3867	3RD
Over loading	4.2933	4TH
Non-possession of approved drawings	4.2667	5TH
Possession of approved drawings but non-compliance	4.1867	6TH
Poor quality of materials	4.1733	7TH
Bad workmanship	4.1733	8TH
Error in design	4.0267	9TH
Lack of maintenance culture	4.0133	10TH
Flood	3.8000	11TH
Bad communication	3.5200	12TH
Inadequate fund	3.5067	13TH

Table 5 Case Study of A Block of 4 Flats- 2&3Bedrooms units (See: Plate 1) Appendix.

Similar project: **Case study of 4 block, 2 & 3 bedroom flat**	Collapsed building: **Case study of A block of 4 flats, 2& 3 bedroom**
Base year-26th of October, 2012 Contract sum = #30,572,093.75 Gross floor area = 466 m^2 Cost/m^2 =	Current year 12th of February, 2013 Contract sum = ? Gross floor area = Cost/m^2 =
Cost/ m^2 = The contract sum / Gross floor area Cost/ m^2 = 30,572,093.75= #65,605.35 466 Cost/m^2 = #65,605.35	Gross floor area Ground floor area = 9.5*23.7= 225.15 1st floor area = 9.5*23.7= 225.15 Total gross floor area= 450.30 m^2 The total contract sum of the collapsed building is 65,605.35*450.30 = #28,191,189.11 Add 10% adjustment factor = # 2,819,118.91 #31,010,308.02 Note Adjustment factor are interest rate on capital and inflation.

Deduction of element not yet constructed

Doors	#4,330,000.00
Windows	#1,485,000.00
Plumbing	#1,951,218.75
Electrical	#2,601,625.00
Fitting & features	#1,350,000.00
Wall finishes	#2,460,670.00
Floor finishes	#2,523,050.00
Ceiling finishes	#1,100,200.00
Paint & decoration	#1,158,530.00
#18,966,293.75	
Add	
10% adjustment factor	# 1,896,629.34
#20,862,923.09	

Note
Adjustment factor is use to validate the cost of construction of the project of the base year so as to bring it to the present cost of construction of the current year.

Contract sum - elemental not yet constructed
#31,010,308.02 – #20,862,923.09 = #10,147,384.93
Therefore

The cost of construction before building failure is #10,147,384.93

Table 6 Case Study of Shopping Complex (See: Plate 2) Appendix

Similar project: **Case study of shopping complex**	Collapsed Building: **Case study of shopping complex**
Base year-2nd of December, 2012 Contract sum = #24,917,110.00 Gross floor area = 582 m^2 Cost/m^2 =	Current year 12th of February, 2013 Contract sum? Gross floor area = Cost/m^2 =
Cost/ m^2 = The contract sum / Gross floor area Cost/ m^2 = 24,917,110.00 = #42,812.90 582 Cost/m^2 = #42,812.90	Gross floor area Panel 1 = 2(4.88*26.03)= 254.05 Panel 2 = 7.2*4.88 = 35.05 Ground floor area = 289.19 1st floor area 289.19 Total gross floor area = 578.38m^2 The total contract sum of the collapsed building is 42,812.90*578.38 = #24,762,125.10 Add 10% adjustment factor = # 2,476,212.51 #27,238,337.61 Add Cost of demolition # 800,000.00 Cart away debris offsite # 200,000.00 **# 28,238,337.61** Note Adjustment factor are interest rate on capital and inflation.

Table 7 Factors that would help to checkmate the incidence of Structural Failure and Building Collapse at Pre-Construction and Post Implementation Phases of Building Development

Factors that would help to checkmate the incidence of structural failure at pre-construction and post implementation phases of building development	Mean	Ranking
Design strictly to code of practice	4.8000	1ST
Determination of bearing capacity of soil before designs	4.7733	2ND
Adequate supervision	4.6267	3RD
Carried out site investigation	4.5867	4TH
Strictly adherence to working drawing	4.5333	5TH
Ensure buildings are constructed in accordance to designs	4.4267	6TH
Avoid the use of quacks and follow specification	4.3733	7TH
Proper presentation and interpretation of working drawing	4.3600	8TH
Design with experience	4.3467	9TH
Produce working drawings before commencing construction on site	4.0933	10TH
Getting approval before commencing construction on site	3.2000	11TH

Figure 1: A Block of 4 Flats- 2&3Bedrooms units at 8, Jadesimistreet, ileepooba, Ikorodu, Lagos State, Nigeria.

Figure 2: Shopping complex at agbede transformer ikorodu , Lagos State, Nigeria.

OTHER BUILDING COLLAPSE SITES

Figure 3 Collapse site at 20 Doyin Omololu Street Lagos State, Nigeria.

Figure 4: Collapse site at13 Awolowo way Ikeja Lagos State,Nigeria

Figure 5: Collapse site at Idunmota Lagos State, Nigeria

Figure 6: Collapse site at IbaAlaba Lagos State, Nigeria.

Figure 7: Collaose site at Badore Lagos State, Nigeria.

Figure 8: Collapse site of a multi storey building in Lagos, State, Nigeria.

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