International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online)
Vol. 12, Issue 2, pp: (128-143), Month: October 2024 - March 2025, Available at: www.researchpublish.com

A SURVEY OF BUILDING COLLAPSE AND CAUSES IN NIGERIA: CASE OF SOUTH EASTERN REGION

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DOI: https://doi.org/10.5281/zenodo.14858841

Published Date: 12-February-2025

Abstract: **This paper presents the results of the survey of building collapses in Nigeria in general and South East, Nigeria in particular. Several buildings have collapsed in Nigeria, many of which are neither reported, documented nor investigated. Although, the number of reported incidences of building collapses; is only an significant percentage of the overall building collapses that have occurred in Nigeria, the frequency, severity and spread of the reported incidents, are quite alarming. In fact many of these building collapse cases, which are neither reported, documented nor investigation, occurred in South Eastern region of Nigeria. These incidents of building collapse have resulted into colossal human, material and financial losses to the region. This underscores the need to investigate building collapses and causes in South Eastern region of Nigeria. The questionnaire method of survey, was employed in the investigation. The survey revealed that South Eastern region, has experienced high and ever-increasing incidents of building collapses. Most of the collapsed buildings were privately owned-, storeyed- and reinforced-concrete buildings under construction. The seven major causes of the building collapse in South East, Nigeria, were sub-standard building materials, ineffective supervision/monitoring, bad workmanship, non-adherence/ non-enforcement of codes and regulations, no/faulty design of buildings, natural and fire disasters, and lack of maintenance culture. However, the incidents of building collapse, could be eliminated or reduced to the barest minimum by reviewing, updating, enacting and enforcing the National Building Code Bill; providing adequate laboratories, equipment and machinery nationwide for conducting requisite tests; and ensuring the adoption of maintenance culture and performance of periodic integrity tests.**

Keywords: Survey, Building Collapse, Characteristics, Causes, South East, Nigeria.

1. INTRODUCTION

The incidence of building collapse in Nigeria, is accelerating and mortality rate is increasing exponentially, thereby putting Nigeria on a potential trajectory than most developing nations of the world. So far, it has become an endemic problem of epidemic proportion, which has defied all attempts at providing solution. The incidence of building collapse has become more frequent, widespread and very severe in most states of the federation of Nigeria.

According to Akugbo (2017), the rate at which buildings collapsed in Nigeria, skyrocked within 2012-2017. The occurrence of building collapse from 1974 to 2017, was estimated at two hundred and forty (240) collapsed buildings representing 29.58%. It is on record that forty-three (43) buildings collapsed in 2018 alone. Thus, the number of building that collapsed in 2019 alone, more than double the number that collapsed in 2018.

Since then, the incidence of building collapse, has maintained the upward trend without any sign of abating. The collapse of buildings in Nigeria, is so frequent that people have virtually lost count of the number of building collapses. Dimuna

(2010) reported that cases of building collapses had become very alarming and worrisome. The spate and frequency of occurrence, have become a source of great concern not only, to government, but to all well-meaning Nigerians, including professional stakeholders in the industry as the incidence has become so unprecedented (Ossai, 2012) The frequency of building collapse, has become a source of great concern, as the frequencies of occurrences and magnitudes of human, material and financial losses, have become quite alarming. Consequently, Ogunlade, Taiwo and Kayode (2012) were, wondering if the incessant cases of building collapses, were a deliberate design to reduce the population of the country. To solve the hydra-headed problem, Ajufo, Gumau and Inusa (2014) recommended that a state of emergency should be declared in the Nigeria Construction industry.

Due to the high and ever-increasing cases of building collapse in Nigeria, several hundreds of lives have been lost and properties worth billions of naira destroyed many of which were not reported Ifedolapo (2015) stated that most of these cases of building collapse, had resulted into colossal economic losses in terms of lives and properties Record showed that between 1971 to date, the average number of reported cases of building collapse, is not less than ten (10) annually, with no less than fifteen (15) lives lost yearly (Okereke, 2012). As a matter of fact, building collapse is considered the most severe problem in the construction industry, probably due to the high level of human and material losses associated with such occurrences which most of the time embarrased the government and construction professionals within and outside the country (Eze, 2012). In the construction industry, the severity of each building collapse. This is corroborated by Odeyemi, Giwa and Abdulasahab (2019), who stated that the number of deaths recorded in building collapse incidents, buttress the severity of the problem. This implies that a building collapse that resulted into more casualties would be said to be more severe than a building with fewer deaths. In this regard, the collapsed Synagogue Church of All Nation (SCOAN) building in 2014, whose casualty outstripped the total number of deaths due to similar mishaps in 2011, 2012 and 2013, put together, would be said to be more severe than those previous incidents.

Initially, these incidents of building collapse in Nigeria, were assumed to be restricted to major cities, particularly Port Harcourt, Lagos and Abuja. In his recommendation of ways of reducing building collapse to the barest minimum, Obiegbu (2012) stated that current repeated incidences of building collapses, occur majorly in the urban cities in Nigeria. According to Fasaki(2002), Dimuna (2010), and Olagunju, Aremi and Ogundele (2013), many lives and properties, have been lost in the collapse of buildings, mostly in Port Harcourt, Abuja and Lagos.

However, the incidents of building collapse, is not restricted to major cities as the media, has made people to believe. Vast literature indicated that the high rate of recurrence of building collapse, is not limited to the urban centers, but cut across cultural, ethnical and geographic formations (Ayedun, Durodola and Akinjare, 2011; and Olubi 2018). This assertion was corrobated by Ajufo, Gumau and Inusa, 2014, who stated that cases of buildings are not restricted by climatology or level of urbanization, as they cut across cultural and ethnic barriers.

2. OVERVIEW OF BUILDING COLLAPSES IN NIGERIA

Building Collapses should be differentiated from ordinary building failures such as deflections of building members, cracking of walls, damage of ceilings and floor finishes, etc. Dimuna (2010) defined building collapse as a state in which a building has literally caved in, crumbled or buckled; with the building no longer standing as originally constructed. It may be either total or partial, sudden or progressive collapse of building.

For quite a long time, the country has witnessed a succession of building collapses. According to Ede (2010), the ugly incidence became noticeable in 1971, when a residential building collapsed in Makola, Ibadan, claimed a total of twenty-four (24) lives. This was followed by the collapse of a multi-storey building, sometime in 1974, which occurred, in the same Mokola area of Ibadan (Chendo and Obi, 2005). There were twenty-seven (27) casualties. In 1976, a partial collapse of a hostel building, occurred in Obafemi Awolowo University, Ile Ife, then known as University of Ife (Ajufo, Gumau and Inusa, 2014). Thereafter, a storey building collapsed in Ondo State, sometime in December, 1976, resulting into the loss of eight (8) lives and property worth millions.

Four building collapses were recorded in 1977. The first was the collapse of a two-storey building which occured in Oyo State in May, 1997, claiming (ten) 10 lives. Soon after, Government Secondary School building collapsed in Makarfi, Kaduna in July, 1997, resulting into the death of seven (7) people and huge economic losses (NBBRI, 2011). One month later (August, 1997 to be precise), a three-storey residential building collapsed in Barnawa Housing Estate, Kaduna and killed twenty eight (28) persons (Amusan 1991 and Ejeh, 2011). And in October of the same year, a four storey building collapsed in Borno, leading to the losses of ten (10) lives and property worth millions of naira (NBBRI, 2011). Another

building collapse that occurred in the 1970's, was a four storey-building that occurred in Port-Harcourt, Rivers state in the month of March, 1978. Altogether, a total of nine (9) building collapses, with one hundred and four (104) deaths, were recorded in Nigeria in the 1970's.

Unfortunately, the incidence of building collapses became more rampant and widespread in Nigeria, in the 1980's (i.e 1980-1989) with a total of twenty eight (28) building collapses resulting into one hundred and eighty eight (188) deaths and losses of property worth millions of naira. (Omenihu, Onundi and Akali, 2016). Thus, the total number of building collapse cases (i.e. 28 collapsed buildings) that occurred in the 1980's, was about triple the total number of buildings (i.e 9 buildings) that collapsed in the 1970's.

In the 1990's (i.e between 1990 and 1999, Nigeria experienced an exponentially increasing building collapses. Omenihu et al (2016) enumerated forty four (44) cases of building collapses with its attendant three hundred and four (304) deaths, which occurred between 1990 and 1999. This represents 157.14 percent increase over the 28 buildings that collapse in the 1980's.

The total number of buildings that collapsed between 2000 and 2009, is sixty nine (69), consisting of fifty four (54) incidences of building collapses that took place between January, 2000 and June, 2007 (Makinde, 2007), and another fifteen buildings that collapsed between November, 2007 and 2009 (Omenihu et al, 2016). This represents 152 percent increase over the 44 cases of building collapses that occurred in Nigeria between 2000 and 2009. Ede (2010) observed that by this decade, collapses of buildings have become so rampant without any sign of abating.

And for the decade, 2010-2019, there were one hundred and seven (107) building collapses recorded, with four hundred and thirty one (431) losses of lives. The collapsed buildings consists of forty five (45) buildings that collapsed with three hundred and eleven (311) deaths between 2010 and 2016 (Omenihu et al, 2016), four (4) buildings that collapsed with seventeen (17) lives lost in 2017 alone (Olubi, 2018), and fifty eight (58) incidents of building collapses with one hundred and three (103) deaths that occurred in 2018 and 2019. The 107 collapsed building that occurred between 2010 and 2019, represents 155 percent increase over the 69 cases of buildings that collapsed the previous decade.

Although, the number of reported building collapse cases, is only an insignificant percentage of the total number of buildings that collapsed in Nigeria, the frequency, severity and spread of the reported cases, are quite disturbing and alarming. The reported cases of building collapse, do not include several other unreported cases that may have occurred in remote parts of the country. Esonwune and Udeagwu (2012) stated that many more disastrous and non-disastrous incidents, had occurred in Nigeria which were neither reported nor discounted for in the books. They further stated that several buildings, have collapsed in Imo, Rivers, Kadunna, Ogun, Anambra, Osun states and other parts of Nigeria, which were never reported. Ewa (2018) stated that some cases of building collapse within the South-South region of Nigeria, are not documented nor reported; as a result, no panels of investigation, were set up to determine the causes of the incidences

The condition is the same in South Eastern region where many collapsed buildings, were neither reported, documented nor investigated. It is therefore, not surprising that Omenihu, Onundi and Alkali (2016), reported that only eight (8) buildings collapsed within South Eastern states out of one hundred and seventy five (175) building collapses that occurred in Nigeria between 1971 and 2016.

Apparently, the menace of building collapse with its attendant colossal losses in South Eastern region, is under – reported. On the contrary, the South Eastern region, has experienced a fair share of the building collapsed cases that have taken place in Nigeria. For example, Anambra state have witnessed numerous building collapses, many of which were neither reported, documented nor investigation. In 2012 alone (precisely between march and November), over nine (9) cases of building collapse, had been recorded in Anambra. In 2014, about eleven (11) building under construction were recorded to have occurred in different parts of the state (Obeta 2019), He further reported that two buildings collapsed in Oko, Anambra State in 2016, while another two building collapsed in Onitsha in 2019.

These building collapse incidents, do not include other building collapses that may have occurred in remote parts of Anambra state and other South Eastern states of Nigeria. Available statistics revealed that out of forty (43) cases of building collapse recorded in Nigeria in 2019, and another eighteen (18) cases in 2018, Lagos state with seventeen (17) building collapse incidents, ranked first, followed by Anambra and Abia States with seven (7) and four (4) building collapse incident respectively (Adugbo, Ibrahim and Shuibu 2019). Out of the total of fifty-eight (58) collapse recorded in Nigeria in 2018 and 2019, South Eastern region alone, experienced sixteen (16) building collapse incidents, representing about twenty-eight percent (28%) of total number collapses.

Thus, South East region of Nigeria has experienced numerous building collapse incidents resulting into unquantifiable losses of lives and properties, most of which were neither reported, documented nor investigated. Some of the building collapse incidents are compiled and presented in the Appendix 1.

3. METHODOLOGY

The method adopted in the research work, is exploratory research design, particularly, questionnaire survey. The questionnaire was designed to establish the characteristics and causes of building collapse in South East, Nigeria, and proffer solutions to building collapse menace. The target population consists of one thousand, five hundred and ninety-eight (1598) practicing building professionals, who are duly registered with their respective regulatory bodies. And, random sampling technique was used to obtain a representative number of respondents for meaningful statistical analyses. The sample size, S_r, of three hundred and twenty (320) respondents, was obtained using the following equation

$$S_r = \frac{N}{1 + Ne^2}$$

Where 'N' is the total population and 'e' is the margin of error (5% was used in this work)

The questionnaire was divided into two parts. The first part of the questionnaire, dealt with respondent's general information while the second part had to do with various aspects of building collapses, causes and in South East Nigeria, in order to obtain the requisite responses from the building professionals.

However, two hundred and forty (240) valid questionnaires were returned and used in the study. This represented a response rate of seventy-five percent (75%). The likert scale was used to measure the weight of respondents' perception of building collapses and their characteristics, and causes in South East Nigeria.

The likert scale provided five different options for the respondents to choose the one that indicates the extent to which they agreed with the statement in the questionnaire. The options range from strongly agreed (rated 5); agreed (rated 4) undecided (rated 3); disagreed (rated 2) to strongly disagreed (rated 1). Descriptive statistics such as frequencies, percentages, mean item scores (MIS), and relative importance index (RII) were used in the analyses of the data collected through the questionnaires.

4. RESULTS AND DISCUSSION

4.1 Results

The data collected through the valid questionnaires, were collated, documented, and evaluated as follows:

4.1.1 Demographic data included information on the academic qualifications, profession, working experiences and job positions of the respondents.

These are presented in Tables 1-4

Table 1: Highest Academic Qualification of Respondents

S/N	Academic qualification	Frequency	Percent (%)	Cumulative percent (%)
1.	SSCE/GEC/NECO	0	0	0
2.	Diploma	22	9	9
3.	HND/B.SC/B.ENG	108	45	54
4.	M.SC/M.ING/MBA	98	41	95
5.	PH/D	12	5	100
	TOTAL	240	100	

Table 2: Respondents' Professions

S/N	Professional qualification	Frequency	Percent (%)	Cumulative Percent (%)
1.	BUILDING	94	39	39
2.	ARCHITECT	33	14	53
3.	ENGINEER	46	19	72
4.	SURVEYOR	55	23	95
5.	TOWN PLANNER	12	5	100
	TOTAL	240	100	

Table 3: Work Experience of Respondents

S/N	Working Experience	Frequency	Percent (%)	Cumulative Percent (%)
1.	> 5 YEARS	67	28	28
2.	5-10 YEARS	101	42	70
3.	11-15 YEARS	38	16	86
4.	16-20 YEARS	22	9	95
5.	> 20 YEARS	12	5	100
	TOTAL	240	100	

TABLE 4: JOB POSITION OF RESPONENTS

S/N	Job Position	Frequency	Percent (%)	Cumulative Percent (%)
1.	CHAIRMAN/CEO	24	10	10
2.	DIRECTOR	05	2	12
3.	MANAGER/HOD	43	18	30
4.	SENIOR STAFF	113	47	77
5.	CONTRACT STAFF	55	23	100
	TOTAL	240	100	

4.1.2 Analyses of Data

The main data collected from the questionnaire, were analyzed and presented in the Tables 5 and 6

Table 5: Distribution of Respondents' Perception on the Characteristics of Collapsed Buildings

Problems of collapsed buildings	SA(5)	A(4)	U(3)	D(2)	SD(1)	Mean	RII
Problems of collapsed buildings are frequent in SE	189(945)	43(172)	5(15)	2(4)	1(1)	4.74	0.95
Collapsed of building in SE, Nigeria is widespread	132(660)	69(276)	0(0)	35(70)	4(4)	4.21	0.85
Most Collapsed buildings in SE, Nigeria are reinforced concrete buildings	196(980)	26(104)	3(9)	15(30)	0(0)	4.68	0.94
Collapsed buildings in SE, Nigeria, are storey-building.	145(725)	58(232)	0(0)	29(58)	8(8)	4.26	0.85
Buildings collapsed mostly during construction	120(600)	62(248)	11(33)	41(82)	6(6)	3.87	0.77
Collapsed buildings in SE, Nigeria, are privately-owned	207(1035)	22(88)	1(3)	8(16)	2(2)	4.77	0.95
Collapsed buildings in SE, Nigeria, are neither investigated nor reported	50(250)	123(492)	2(6)	61(122)	4(4)	3.64	0.72

Where SA = Strongly Agreed

A = Agreed

U = Undecided

D = Disagreed

SD = Strongly Disagreed

RII = Relative Important Index

SE = South East

Table 6: Respondents' Perception of Causes of Building Collapses in South East, Nigeria

Causes of Building Collapses in South East, Nigeria	SA(5)	A(4)	U(3)	D(2)	SD (1)	Mean	RII
Substandard materials	85(425)	143(572)	3(9)	8(16)	1(1)	4.25	0.85
Structural Defects	196(980)	26(104)	3(9)	15(30)	0(0)	4.68	0.94
Ineffective supervision/monitoring	73(365)	155(620)	1(3)	11(22)	0(0)	4.21	0.84
Bad workmanship	132(660)	69(276)	0(0)	35(70)	4(4)	4.21	0.84
Natural and fire disasters	47(235)	147(588)	5(15)	28(56)	13(13)	3.78	0.76
Non/Partial adherence to approved codes regulations	46(230)	180(720)	0(0)	14(28)	0(0)	4.08	0.82
Non/inadequate maintenance	1(5)	118(472)	4(12)	117(234)	0(0)	3.01	0.60
No/faulty design	33(165)	185(740)	2(6)	18(36)	0(0)	3.95	0.79

4.2 Discussion

4.2.1 Characteristics of Buildings Collapse in South East, Nigeria

The characteristics of building collapses in South East, Nigeria, are important part of the data needed for in-depth and extensive investigation of building collapses, and the roles of quality management of building materials in building collapses in South East, Nigeria. The Table 5 gives a summary of the important characteristics of building collapses in South East, Nigeria.

The information in Table 5 showed that most of the respondents strongly agreed that the incidence of building collapse in South East, Nigeria, was very frequent. This was evidenced in the item's mean score of 4.74. This finding is in line with the assertion of Ogunlade, Taiwo and Kayode (2012), who posited that frequency of building collapses in Nigeria, has become so disturbing that one wonders if it is deliberate to reduce the population of the country. The rate at which buildings collapsed in South East in particular, and Nigeria in general, has become so rampant that one has virtually lost count of the number in quantitative terms. Oyedele (2018) stated that building collapse incidents in Nigeria, is as constant as the northern star. Infact, Omenihu et al. (2016), stated the frequency of collapse is progressing to about 23.43% in 2016. Building collapse, though a common phenomenon all over the world, is more rampant and devastating in the developing countries (Akinyemi, Dare, Anthony and Debora, 2016).

Building collapse in South East, Nigeria was also characterized by its wide geographical spread. The mean, x, score of 4.21 for this item in Table 5, indicated that the respondents strongly felt that building collapses, was highly prevalent in South East, Nigeria. This contradicts earlier assumption that suggest high prevalence in the major cities of Nigeria such Lagos, Abuja, Port Harcourt and Enugu Ajufo, Gumau, and Inusa (2014), stated that building collapses, are widespread in all major cities in Nigeria. But, this survey result, is in good agreement with the view of Oyodele (2018), that there was no state in Nigeria, out of the 36 states and the Federal Capital Territory (FCT), in which building collapse had not occurred. Obiegbu (2013), reported that most of the states of the federation, had witnessed construction failures and ultimate collapse in recent times. And, Okolie (2013), stated that recently, commercial towns like Onitsha and Akwa, the state capital of Anambra State, including other smaller towns, were not left out of building collapses. Within the year, 2012 alone (precisely between March and November), over nine (9) cases of building collapse, were recorded in Anambra. All these building collapse incidents indicate that the phenomenon is widespread in South Eastern States of Nigeria.

A cursory glance at Table 5, revealed other important characteristics of building collapses in South East Nigeria, such as most collapsed buildings being both "storeyed-and reinforced concrete-buildings". Their respective mean, x scores of 4.26 and 4.68, showed that the respondents strongly agreed that the collapsed building were both storeyed- and reinforced-concrete buildings. This result of the survey is in consonance with the view point of Oyodele (2018), who stated that building collapse usually occurred in building with two floors up to five floors. He observed that collapsed of buildings, do not occur in bungalows and buildings with more than five floors, except where building collapse was due to erosion.

From the Table 5, it is observed that, there was a consensus among the respondents that most collapse buildings in South East, Nigeria, were privately-owned. This finding was affirmed by Okolie (2013), who stated that 98% of the collapsed buildings in Anambra state in the last three years, were owned by private ownership. Therefore. most collapsed building in South East, Nigeria, were residential buildings owned privately by individuals.

Also the results of the survey in Table 5, showed that there was a strong belief (as evidenced by the mean, X, score of 3.87) among the respondents, that most building collapses in South East, Nigeria, occurred during construction. The finding was confirmed by Obiegbu (2013), who reported that most collapsed buildings occurred during construction stage. To be specific, Okolie (2013), stated that 70% of those collapsed buildings, were at the construction stage. Another important characteristics of building collapse in South East State of Nigeria, was that the building collapses, were neither investigated nor reported as indicated by the item's mean(x)score of 3.64 in Table 5. This is in agreement with the assertion of Esonwune and Udeagwu (2013) who reported that more disastrous and non- disastrous incidents, had occurred, which were neither reported nor accounted for in the books. Several building, have collapsed in Imo state, Rivers, Kaduna, Ogun, Anambra, Osun, and other part of Nigeria, which were neither reported nor investigated. The under-reporting of building collapses, are due to the Nigeria media, whose reports centers on urban centers alone.

4.2.2 Causes of Building Collapse Incidents in South Eastern Region of Nigeria.

The survey results in Table 5, show the summaries of the MIS analysis and the ranking of the causes of building collapses in South East, Nigeria. The results are discussed as follows:

a) Structural Failure/Defect

From the Table 5, it is evident that structural failure/defect ranked first with mean score and RII values of 4.68 and 0.94 respectively. The high mean value of 4.68, implies that most of the respondents believed that structural failure/defects caused most of the building collapses in the South East, Nigeria. And Akande Debo-Saiye, Akinjobi, Alao and Akinrogunde (2016), posited that building collapses mostly resulted from defects and failures in buildings, when they are not quickly, properly and adequately corrected. Mohamed and Annuar (2011) asserted that structural failures/defect in building are caused by sub-standard building materials. Thus, building collapses apparently caused by structural defects/failures, should be actually attributed to sub-standard materials.

b) Sub-standard building Materials

A cursory look at Table 5 reveals that sub-standard building material was another major cause of building collapses in South East, Nigeria. It was ranked second with mean score and RII values of 4.26 and 0.85. Since, the mean score of 4.26, fell within the range of 3.5 and 4.5 proposed by Mohamed and Annuar (2011), it could be stated the respondents agreed that sub-standard building material, is a major cause of building collapses. This finding is in agreement with the submission of Bamigboye et. al. (2019), that a lot of people in the profession believed that inferior materials, have contributed to building collapses in Nigeria. The concluded that 10 – 25 % of buildings that collapsed in Nigeria, were as a result of the use of poor quality building materials. Majority of investigations revealed sub-standard building materials as the main cause of building failures and collapses (Hamma- Adama and Kouider,2017). Dimuna (2010), Agwu (2014), Ayedun, Durodola and Akinjare (2011) and Ayodeji (2011), described sub-standard building materials as the main cause of building failures and collapses. Hamma – Adama and Tahar (2017) reported that quality of building material being compromised is one of the main causes of building collapses in Nigeria. The main structural materials that are compromised, include cement, reinforcing steel and concrete. Chendo and Obi (2005) reported that fake cement was used in the construction of an uncompleted three story building that collapsed in a water logged area in Owerri. Due to the fact that cement is expensive, it easily adulterated by greedy building material marketers, who used to re-bag cement before re-selling them to builders and the findings of Ajufo Gumau and Inusa (2014) confirmed that contractors prefer to use sub-standard steel reinforcement in construction of buildings. One of the major reason for the compromise and adulteration, is corruption and greed, which make the stakeholders of building industry not to observe due diligence in carrying out their responsibilities. According to Ewa (2018), contractors cut corners, consultants look the other way, while approving and supervising officers, engage in corrupt practices.

This finding has justified the assertion that the use of sub-standard building materials, is the major cause of building failures and collapses. Hamma – Adama and Kouider (2017) asserted that steel reinforcement, structural steel and cement (in descending order), are the major building materials causing building collapses.

c) Bad/Poor Workmanship

The third cause of building collapses in South East, Nigeria was workmanship (which had mean score and RII values of 4.21 and 0.84 respectively). A mean score value of 4.21 implies that majority of the respondents (84.2% to be precise) agreed that “poor workmanship” was a significant cause of building collapses in South East, Nigeria. Good workmanship requires faithfully and accurately reproducing on construction site, a building as conceived and design originally. It defines

how well or poorly executed a building is. It has to do with how a building is constructed (i e skill) and the outcome of the construction process (quality).(i.e Skill)

Ogunsemi(2002) asserted that poor quality materials and workmanship accounted for over 36% of building collapses in Nigeria, while Chinwokwu (2000) confirmed that failure to investigate the quality of materials and workmanship in Nigeria building industry, will certainly continue to result into building collapses. Ademoroti (1991) reported that the use of poor materials and poor standard workmanship creep into construction as factors needed to lower the overall cost of construction. Poorly skilled workmen in conjunction with incompetent contractors, is one of the reasons behind the incidents of building collapses in Nigeria. Ayodeji(2011) stated that the level of competences of different categories of labour in Nigeria (though, it varies from one city and contractor to another), through investigation, is found to be reducing day by day. Presently, there is a decline in the requisite competence skills, technical know - how and exposure needed for good workmanship. The decline in requisite skills and expertise, may be because of lack of enough practical training, especially for artisans and craftsmen (Olusola, Ojambati and Lawal, 2011).

The situation is made worse by clients, contractors and developers, who prefer to employ/engage unskilled workers in order to save costs. Ede (2010) accuses developers of cutting costs by employing unskilled workers who are cheaper than trained builders. Olusola (2002) asserted that poor skills make it difficult or impossible for workers to perceive and apply the concept of quality control and limits of tolerance for building production. Even, an incompetent builder, can neither interpret building drawings nor set out correctly, a building. Many contractors do not know the techniques involved in building jobs neither, do they have enough idea of the building materials they are using. Because of lack of adequate practical training for artisans and craftsmen, and professionals, quality building works within the industry, are in decline.

In other words, lack of intricate knowledge of workmanship, results into building defects and failures, which, in turn lead to poor construction quality. Examples of these construction defects are poor concrete works, wall cracks, leaks and uneven floors. And, Ejiofor(2018) stated that poor construction quality, has been identified as major cause of building collapses worldwide.

d) Ineffective Supervision/Monitoring

Going by the mean score and RII values of 4.21 and 0.84 respectively (as given in Table 5), "ineffective supervision of building process", is the second factor ranked third (3^{rd}) that caused building collapses. It could be inferred from this mean score, that the respondents believed that ineffective supervision, was another significant cause of building collapses in South East, Nigeria. There is a good agreement between this finding and the report of Fakere et al (2012), which stated that improper supervision of construction work have led to the collapse of building structures.

On the other hand, Hamma – Adama and Kouider (2017) rated supervision, the most substantial cause of building collapses in the Nigerian construction industry. Supervision involves overseeing the resources needed for construction (eg construction processes and personnel) in order to ensure that a building is correctly and safely produced to the satisfaction of the client. The essence is to ensure that a client's requirements as expressed in the contract documents, are correctly interpreted and constructed on site within cost (budget), within time (schedule) and to acceptable quality (standard).

It requires intricate knowledge of workmanship and materials to handle unforeseen construction problems that may not have manifested during design. The importance of construction supervision, cannot be over – emphasized, particularly in a country like Nigeria, where people are not known to obey rules voluntarily. Also, critical aspects of construction, require the expert supervision of professionals, if human errors are to be avoided in good time. According to Ejiofor (2018), there is always a critical aspect of delivery, where expert supervision is essential. Consequently, Mohamad and Annuar (2011) stated the need for monitoring and supervision to be carried out often and regularly, while Fakere et al (2012), recommended that systematic supervision of buildings, should be enforced at the local government level and penalties for failure to comply with the building standards and regulations should be provided for. They suggested that all building construction works, should be well designed and supervised by registered members of the appropriate profession. Olusola et al (2011), stated that every stage of construction work, must be supervised by an appropriate qualified professionals. Unfortunately, appropriate qualified personnel seldomly engaged and used in building construction.

e) **Non/Partial Adherence to Approved Codes and Regulations**

It is evident from Table 6 that "non/partial adherence to the provisions of codes and regulations" (with mean score and RII values of 4.08 and 0.82), was another significant cause of building collapse. This finding is in agreement with the assertion of Omenihu et al (2016), that non-adherence to the provisions of local and international codes of practice is a major cause

of building collapse. But, Adebowale et al (2016) stated that the contravention of these regulations and standards, have continued unabated as reported in many parts of the country, thereby resulting in building failures and collapse. In a communiqué issued at the end of a two-day seminar on structural failure and building collapse in August, 1996, professionals in the building industry, declared that the main cause of failures and collapses included, but not limited to lack of adherence to specifications by contractors. Other investigators, who attributed building collapse to non/partial adherence to the provisions of codes and regulations, included Olubi and Adewale, (2018) and Oloyede et al, (2010).

There are various forms of non/partial adherence to codes and regulations that cause collapse in Nigeria. These included, but not limited to the following forms:

i. Non-provision of code and its non-adherence, which leads to building collapse (Oyedele, 2018)
ii. Regulation and bye-law violations (Omenihu et al, 2016 and Adebanjo, 2005)
iii. Illegal alteration of the number of storey's of a building without recourse to the original design (NBRRI, 2012; Windapo, 2006; and Chendo and Obi, 2015)
iv. Misuse of building (operational conversion of a building) eg residential building being used as a school (Ayaba, Olagunja and Akande,)
v. Non/partial compliance with approved building designs/plans (Ogunsemi, 2002, Folagbade, 2000; Fagbenle and Olawunmi, 2010)
vi. Unauthorized alteration of approved building drawing or building without drawings (Madu, 2005)
vii. Translocation of building drawings to different sites (Madu, 2005; Chendo and Obi, 2015)
viii. Bad/poor/faulty design (Richard, 2002; Hall, 1984; Osaghele, Ikpo and Ajayi, 2015 Ogunsemi, 2002; Folagbade, 2000; Oyedele, 2015)
ix. Improper/wrong presentation and interpretation of design/plan (Akinpelu 2002)
x. production of unrealistic or unclear specifications (Salau, 2015)
xi. Non-adherence to specifications and plans (Ajufo, Gumau and Inusa, 2014)
xii. Use of sub-standard material and/or substitution of original material specified with cheaper and local materials (Madu, 2005)
xiii. Poor workmanship (Olubi and Adewolu, 2018)
xiv. Negligence of professionalism (ethical responsibility to the client, design team and society as enshrined in professional code of conduct) (Olayinka et-al, 2015)
xv. Negligence of the use of appropriate personnel in building construction

Despite the importance of building codes and regulations in ensuring safely and structural integrity of buildings, there is very low level of compliance with building codes and regulations across the different states of South Eastern region. All forms of deliberate or ignorant violations of the provisions of building codes and regulations, compromise building standards; which in turn lead to building failures and collapses in many parts of South East region, in particular and Nigeria in general.

f) **No /Faulty Design**

Table 6 revealed that faulty design of building, is another major cause of building collapses in South East, Nigeria. This is evidenced in its high mean score and RII values of 3.95 and 0.79. It is ranked the sixth factor that caused collapse of buildings. This discovery agrees with the conclusion of Olusola, Ojambati and Lawal (2011), that the major cause of building structures, could be traced down to defective structural design of building elements with the neglect of basic considerations of design procedures, including wrong estimation of ground- bearing structures. As a matter of fact, Ayinnola and Olalusi (2004) cited in Babatunde and Opawole (2009), stated that 50% of building collapses in Nigeria, is due to design faults. There are several other researchers, who attributed building collapses to faulty design. These researchers include Hall (1984) cited in Usman et al (2010); Ayedun et al (2011); Ayininuola and Olalusi (2004); Ede (2014) Oloyede et al (2010); Olajumoke, Oke, Fajobi and Ogedengbe (2009) Ogusemi (2002); and Folagbade Ikpo and Ajayi (2015).

However, good designs by qualified professionals, are required to prolong the life span of buildings (Olusola et al, 2011). Design is the process of translating the client's brief (needs and requirement) into technical drawings, detailed plans and/or models , which skilled workers/contractors, can follow to construct the building. It involves the analysis of basic needs of the client, developing and detailing plans according to the client needs and resources, bearing in mind aesthetics and technical characteristics as well as basic rules of construction. Although, designs are usually based on clients brief (needs and requirements), references are usually made to standards such as architectural considerations, structural provisions, safety issues and services requirements (Hamma-adama and Kouider, 2017). All these considerations are necessary to produce safe, functional and aesthetic building design captured accurately and completely in working drawings and specifications. Thus the essential principle of design is to produce a building that meets client's requirement (Dimuna, 2010) and be fit (Hamma-adama and Kouider, 2017).

The four main components of design process are creation of a schematic design, design development, approval of construction documents and building processes design. In essence, there are various forms of design. These includes architectural design, structural design and design of services. Architectural design is carried out at the inception of a building project by the architect. It is the process of analyzing the basic needs of a client/project, creating the building form, and setting out space layout, dimensions and all other requirements, which will contribute to the quality, functionality, serviceability etc of a building. Functionality and aesthetics of the created space, are two key elements of architectural design process whose purpose is to transform the client's needs and requirements into a set of technical design blue prints and specifications for the construction of a building. Simply put, an architectural design results into the architectural drawings which communicates how a building will look and is to be constructed. Architectural design is the responsibility of an architect, who according to Dimuna (2010), initiates and finalizes the design of a building, which he ensures that its form and functions are in order.

On the other hand, the structural design has to do with producing a stable and robust building structure for carrying the required loads, and safely transmitting vertical and horizontal forces to the ground through suitable foundation. (Olusola et al, 2011). And, the structural design process usually based on architectural design, involves the structural analysis of the architectural drawing of the building in order to determine the forces the building will be subjected to (at the ultimate limit state); design of the building (which has to do with the selection of appropriate sections of the structural elements and reinforcements required and carrying out checks at serviceability limit state to ensure that the building and its elements do not fail); and then detailing the building and its elements. The structural design process results into the production of structural drawings and specifications of an intended building. A building designed by a competent structural engineer, must have adequate strength and stability to be able to withstand the applied forces without collapsing, deforming and overturning. According to Ataev (1985), the basic requirements of any structural component of a building, is that it should be strong enough to carry and support all possible types of loads to which it is likely to be subjected. This means that, it must not collapse when loads are applied, and the deformation must not be excessive (Fakere et al, 2012). Since the strength and stability of a building, is the most important and significant building characteristics that determine the capacity of a building to carry imposed load without collapsing, deforming and/or overturning, structural design is the most prominent and relevant to the stability/collapse of any building. And, sound structural design and its proper implementation (at the construction stage) from all angle, is the role of the structural engineer and anything short of that, is a potential risk to building stability (Hamma-adama and Kouider, 2017). Other important designs are the designs of services, usually carried out by mechanical and electrical engineers. These services include water reticulation and sanitation facilities, heating and cooling systems, fire extinguishing system and electrical and communication installation. The design and installation of these facilities, systems and equipment ensure functionality and safety in buildings.

Most buildings are hardly designed before construction while those designed are grossly inadequate. Both cases result into collapse of buildings. Ometa (1987) attributed faulty design of buildings to the neglect of real professional advice.

g) **Natural and Fire Disaster**

Another significant factor that caused building collapses in South East Nigeria, is "natural and fire disasters. The Table 6 indicated that it was ranked 6th with mean (x) score and R11 values of 3.78 and 0.76 respectively. This survey outcome, was affirmed by Olubi and (2018), who reported that natural factors, were responsible for the collapse of fourteen (14) buildings (representing 64%) out of two hundred and four (204) reported building collapses that occurred in Nigeria between 1974 and 2018. Some of such cases of building collapses caused by natural disasters in Nigeria, were reported by Arayela and Adam (2001). Natural disasters are disasters caused by nature or natural forces such as earthquake, wind, rain and

typhoon. This was corroborated by Adewolu et al (2018), who stated that natural forces such as earthquakes and tremors, landslide, flooding, high velocity wind like hurricane outsides the control of man, can also be responsible for failure and collapse.

In Nigeria the common natural disasters include rainform, flooding, thunderstorm, windstorm, landslide and erosion. All these disasters are dependent of the geographical location and its prevailing weather and environmental conditions of the immediate environment of the building site. Severe weather and environmental conditions adversely, affects the quality and stability of buildings. Under hot condition, buildings experience diffential thermal expansion, leading to cracking of buildings. Some other weather conditions that influence the quality and stability of building, is rainfall. Ayodeji (2011) stated that one of the major natural factors that result into building collapse, is rainfall. When there is a heavy downpour of rain, there is a possibility that one or more buildings (completed or uncompleted) somewhere, would cave in (Chinwokwu, 2000). For example, an uncompleted 3-storey building collapsed in a water logged area of Owerri during a heavy downpour on the night of November, 2012. Also a 4-storey building under construction collapsed at No. 24 Obanye Street in Onitsha, during a downpour on 5th September, 2013 (Chendo and Obi, 2015).

In fact, rainstorm affects buildings adversely in many ways; first and foremost, heavy rainfall weakens concrete and make it unable to support design load. Besides persistent and prolong rainstorm, which occurs during the peak of rainy season, increase water table, which lowers the bearing capacity of the soil supporting the foundation of buildings. Worse still, heavy and persistent rainfall, give rise to devastating flood and landslide, both of which have been responsible for building collapses in the past.

Another form of disaster whish cause the collapse of buildings in Nigeria is fire outbreak. It is another significant factor which cause the collapse of buildings by weakening and/or cracking of structural elements and making them unable to carry the load imposed on there. According to Olagunju (2002) fire weakens structural members such as concrete, steel reinforcement bar and steel trusses. Another adverse effect of fire outbreak, is that it transforms ductile reinforcing steel bars into brittle reinforcing steel which fractures easily. Ajufor et al ( ) stated, that this may lead to partial or total collapse. It must be noted that fire disasters, are usually worsened by the use of flammable materials such as gloss paint in construction of building. The flammable materials aid in spreading fire easily to other parts.

h) **Adequate Maintenance and Repair**

A close examination of Table 6, reveal, that “adequate maintenance” is not a commonly used control measure to avert building collapse in South East, Nigeria. This is indicated by its low means (X) score and R11 values of 3.01 and 0.60 respectively. This finding is consistent with the conclusion of Dare (2002) that generally, less attention is paid to maintenance in Nigeria. In other words, there is no maintenance cultures in Nigeria. Oydele (2018) reported that lack of maintenance culture, was one of the existing conditions of Nigeria cities and environment, that created the need for the National Council on Higway and Urban Development to evolve the National Building Code (NBC).

Olusola et al (2018) opined that lack of maintenance of buildings, can lead to building collapse from accidental circumstial, weather or time-tested defects. But Oyedele (2018), Olubi and Adewolu (2018) and Adebowale et al (2016), stated categorically that lack of maintenance culture, was among the major factors responsible for building collapses in Nigeria. Other researchers who corroborated this finding are Folagbade (2001), Ogunsemi (2002) and Badejo (2009). Without adequate maintenance of buildings, buildings would quickly fall into a state of disrepair, distress and finally collapse. Therefore, building maintenance is vital for keeping buildings in good condition and prolonging the life span of buildings of more importance, is structural maintenance which prevents buildings from becoming distressed and collapsing.

Structural maintenance is a continuous and on-going process of preserving, rectifying or reconstructing same or all structural components that ensures that a building, is in a good working condition and aesthetically pleasing. It includes without limitations, all required alterations, replacements, repairs, modifications and/or upgrades of structural components of a building. The objectives of structural maintenance of a building is to ensure that the building in question is safe, comfortable, aesthetically pleasing and fully operational for occupants and users. And, the primary benefits of structural maintenance of a building, are to keep buildings healthy and functioning properly, make them aesthetically pleasant, ensure building safety and longevity, enhance its utility and value, and save costs on repairs.

Although it is impossible to prevent deterioration and damage, there are three main types of structural maintenance that can be used to preserve or restore the structural integrity and visual building. The first type of structural maintenance, is routine maintenance which designed to protect a building from deterioration and prevent malfunction. It is carried out regularly

according to a predetermined schedule, which may be daily, weekly, monthly or yearly. Preventative maintenance, is the second type of structural maintenance. It helps in upholding the structural integrity and aesthetics of a building by ensuring that structural components, are in good and working conditions, thereby averting future failure and eventual collapse. It involves scheduling and taking precautionary and proactive maintenance tasks needed to avert building failure and collapse. The different forms of preventative maintenance, are time-based maintenance (TBM), usage-based maintenance (UBM), condition-based maintenance (CBM) and predictive maintenance (PDM). The third type of structural maintenance, is curative maintenance. This type of maintenance is used to correct any failure and/or damage that have occurred in a building, for a example, water leaks due to cracked, broken or crushed pipes, may be notified during a maintenance check or while fixing another problem. Such a problem is usually fixed through curative maintenance in order to preserve the structural integrity and water- tight condition of the building.

5. PREVENTION OF BUILDING COLLAPSES

In order to eliminate or reduce to the barest minimum, the increasing building collapse trend, the following suggestions should be adopted:

i. The National Building Code bill, should be reviewed and updated in line with new materials, current technology, and good practices and then passed into law

ii. Adequate laboratories equipment and machinery, ought to be provided nationwide for carrying out requisite tests.

iii. Buildings must be property planned, designed and contract documents produced by appropriate professionals

iv. Feasibility studies site investigation, soil tests, material tests, etc, must be thoroughly performed at the appropriate time

v. The provisions of the approved building codes and regulations, must be strictly adhered to/enforced by the appropriate agencies of the government and professional bodies

vi. Violators of building codes and regulations, should be investigated and if found guilty, they should be sanctioned and penalized.

vii. Clients and developers should be made to adopt maintenance culture in order to ensure periodic maintenance of buildings

viii. Buildings should be subjected planned and periodic integrity tests

6. CONCLUSION

The survey revealed that South Eastern region of Nigeria, has been experiencing high and ever-increasing incidents of building collapse, many of which were neither reported recorded nor investigated. Infact, the incidents of building collapse have become more frequent widespread and very severe. And, most of the collapsed buildings, were privately owned – storeyed, and reinforced – concrete buildings under construction

Secondly, the survey established seven major factors responsible for the collapse of buildings in South Eastern region of Nigeria. The most predominant factor (ranked first), was sub-standard building materials, which encompasses structural defects. This was followed by ineffective supervision/monitoring and bad workmanship (both of which ranked second), non-adherence/non-enforcement of the provisions of building codes and regulations (ranked third), no/faulty design of buildings (ranked fourth), natural and fire disasters (ranked fifth) but actual cause of building collapse, may be a combination of factors, which vary from building to building

However, it is believed that building collapse, can be eliminated or reduced to the barest minimum by implementing the aforementioned suggestions on ways to prevent building collapses.

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Appendix: Some Building Collapses that Occurred in South East Nigeria between 1985 2020

S/N	Year	Type of Building	Location of Building	Possible Cause(s)	Lives lost
1.	September 1985	Tradefair Pavilion Complex	Enugu	Not reported	Not reported
2.	February 1986	High Court Building	Isiala, Imo State	Structural Failure	2
3.	1986	Two storey Residential Building	Ona street, Enugu	Uninvestigated	2
4.	June 1997	3-storey building under construction	Enugu	Not reported	20
5.	October 2004	3-storey Building	Umuahia	Unknown	4
6.	June 2005	4-storey Building	Aba	Unknown	25
7.	August 2009	Wall structure (Fence)	Agbayi Crescent, GRA Enugu	Improper drainage	1
8.	August 2011	2-storey Residential Building	Awka	Unknown	Unknown
9.	2012	3-storey Building	16 Nnobi Street, Enugu	Structural Defects	Not Available
10.	2012	1-storey Building	Awka, Amanbra State	Defective Materials	Not reported
11.	2012	Uncompleted 3- storey Building	Owerri, Imo State	Flooding	Not reported
12.	2012	4-storey Building	Agbama Estate, Umuahia	Non-adherence to Building Regulation	Undisclosed No of Squatters died
13.	2012	Uncompleted 2- storey Building	No 10, Amaram Extension, Owerri, Imo State	Not Investigated	None
14.	November 2012	Church Building	Nnewi South LGA	Undisclosed	5
15.	2013	4-storey Building	24Abanye Street, Onitsha	Heavy rainfall, Flooding	Not Available
16.	May, 2013	3-Storey Building	Agbama, Umuahia	Not Reported	7
17.	2nd June, 2014	Uncompleted 4- Storey Building	Onitsha, Anambra State	Structural Failure	4
18.	September, 2014	3-Storey Building	Adazi-Ani Anaocha LGA Anambra State	Structural Failure	1
19.	2014	Building	Oko, Anambra	Not Reported	2
20.	2016	Students' Hostel Building	Okoani Village, Oko, Anambra	Not reported	3
21.	2016	3-Storey Building	Oko Anambra	Undisclosed	7
22.	August 2016	Uncompleted Building	Uratta Village, Owerri, Imo State	Undisclosed	2
23.	March, 2017	2-Storey Building	Mkpokiti Layout, Enugu	Not Reported	None
24.	24 July, 2017	3-Storey Building	Umuguma, Owerri West	Not Reported	Unconfirmed Number Trapped
25.	June 13, 2017	4-Storey Residential Building	Oko, Anambra State	Not Reported	Not Reported
26.	July, 2017	4-Storey Building	Ulakwo, Owerri	Not Reported	None
27.	August, 2017	2-Storey Building	Mbaise Road, by Fire Service, Owerri	Undisclosed	4
28.	July, 2018	4-Storey Building	Obosi, Idemili North LGA, Anambra State	Overloading	None
29.	October, 2018	3-Storey Building	Nnewi, Anambra State	Undisclosed	11 Injured
30.	May, 2019	4-Storey Building	Onitsha, Anambra State	Not Investigated	5
31.	May, 2019	2 Storey building	Amaram Ext Owerri	Not Investigated	Not Reported
32.	May, 2019	Deck attachment of a building	No 54, Modebe Avenue, Onitsha, Anambra State	Not Investigated	Not Reported
33.	April, 2020	7-Storey Building	Yaradua Avenue Owerri	Yet to be Investigated	Not Reported

Sources: Fakere, Fadairo, and Fakere, 2012; Matawa, 2013; Olabosipo and Adedamola, 2010; Ajufoh, Gumau and Inusa, 2014; Ejiofor, 2018 and Dimuna, 2006.