Investigating the Causes, Effects and Remedies to Building Collapses in Rivers State, Nigeria

Joseph Chukwuka Okah
Department of Building Technology,
Port Harcourt Polytechnic, Rumuola,
Rivers State, Nigeria

DOI: 10.56201/ijemt.v8.no2.2022.pg53.71

Abstract
The incidences of building collapse today in Rivers State is alarming and is a source of worry to the occupants/users, stakeholders and government who suffer one loss or the other. As a result of this, this study was conducted to determine the causes, effects and remedies to building collapse in Rivers State. To achieve this, a total of 72 questionnaires out of a population target of 88 were distributed to stakeholders in the building industry to randomly sample their opinions and perceptions on the subject matter. However, 62 entries were valid and these perceptions were rated with a 4-point Likert's scale. Data analyses were done with Mean score, frequency and simple % while Cronbach's alpha was used to test the reliability of the data. Result showed that, out of the 19 test causal factors, 15 namely; foundation and structural failure, poor equipment and substandard materials etc which scored; 3.66, 3.61, 3.51 and were respectively accepted only 4 items including; inexperienced craftsmen, impact, explosion, volcanic eruption and earthquake and volcanic eruptions were rejected as they scored 2.48, 2.44, 2.47 and 2.19 respectively which is <2.5. Similarly, out of 11 test effects of building collapse, 9 including; loss of human lives, life threatening injuries, loss of capital investments etc were accepted with the respective mean scores; 3.73, 3.69, 3.74 and only 2; release of toxic pollutants and discouragement of property investment were rejected with the means scores; 2.48 and 2.08 respectively. On the other hand, all the 12 test remedial measures recommended namely; domestication of the National Building Code, arrest and prosecution of offenders, mandatory Geotechnical/structural design for plan permit, and proper/regular supervision etc were accepted with the respective mean; 3.63, 3.53, 3.27 and 3.27. The internal consistencies of sets of data for the causes, effects and remedies to building collapse are 0.88, 0.84 and 0.92 respectively which is excellent.

Keywords; *Foundation, Structural failure, Mean score, Quackery, Cronbach Alpha, Plan Permit, Quality Assurance, Building Regulation*

1.0 Introduction

1.1 Background of Study

Building collapse is a common phenomenon all over the world, but the frequency is alarming and worrisome in the past few years and recently in Nigeria. Perhaps, property development is one prime necessity of life that enhances comfort and economic wellbeing and as such, many individuals have gone into it for either personal uses or for investment purposes. The indiscriminate and uncontrolled participation of so many individuals who are not trained professionals in the sector has left the industry in serious problem (Nubor, 2020).

Building failure can be described as the inability of the building to perform the normal design function or expectations while collapse is when the building has broken down beyond maintenance (Dimuna, 2010). But technically, building failure occurs when the service load/stress exceeds the bearing resistance of the element. Structural failure can also occur when the applied moment exceeds the moment of resistance of the concrete or steel section (Mapp >Mus) (BS 8110, 1997 and Ettu, 2001).

Consequently, many lives and properties have been lost while life threatening injuries have been sustained in building collapses in Nigeria. Ede (2010) reported that from 2000-2010 over 47 cases of building collapses and over 300 deaths were recorded for Lagos, Port Harcourt and Abuja. Tears and anguish still remain in the minds of loved ones at the reminiscence of the collapse of Saque primary and secondary school Port Harcourt in June 1990 which left over 50 persons dead (Fagbenle & Oluwunmi, 2010). Similarly, Teme et al (2005) stated that a 5-storey Hotel under construction in Tombia Street, GRA Phase 3, Port Harcourt collapsed leaving over 30 persons dead. Chendo and Obi (2015) writes that a residential building under construction in Benjamin Okpara Str. Port Harcourt collapsed in 2006 killing 2 persons.

Recently, the collapse of a 7 storey building in GRA Phase 2, Port Harcourt in 2018 claimed over 25 lives and 22 injured (Youdeowei and Rowland, 2019). Most recently, a 21-storey building in Ikoyi, Lagos, 2021 claimed over 44 lives including the owner of the property (Premium times, 8th Nov; 2021). The rubbles of the Ikoyi collapse were yet to settle when another 4-storey building collapsed killing 2 persons in Lagos. The list is endless and the effects inestimable and irrecoverable, hence the need for proper regulation of this industry

The sector cannot be underestimated because of its output and the socio-economic development such as: shelter, infrastructure, employment and revenue generation associated with it which is lost when building collapses (Emekoma, 2019). In a report released by The Economic Intelligence Group, Access Bank Plc., (2021), The National Bureau of Statistics (NBS) stated that the total market size of the Nigerian construction industry is about ₦11.64 trillion as at 2020.

Unfortunately, there are still a number of buildings of similar circumstances (prone to collapse) dotting the skyline of many cities in Nigeria and nothing is been done to checkmate it.

However, Adebowale (2009) noted that the common causes have been traced to foundation failure, poor design and workmanship, use of substandard materials and ineffective enforcement of relevant laws Authorities. Most of these buildings are not approved or may be corruptly approved along water routes. Ayodeji (2011) attributed the collapse of building in Nigeria to foundation problems, natural occurrences, inadequate maintenance, unprofessional conduct etc.

In Rivers state, the urban population in Port Harcourt is increasing daily due to the influx of people into the city (urban migration) causing the over-stretching of the available infrastructure and landed properties (Fadamiro, 2002). This has resulted in the depletion of land spaces thus moving property development to adjoining marshy and swampy lands close to the creeks and river posing construction

challenges (Youdeowei and Nwankwoala, 2010). Thus Ayotamuno and Enu-Obari (2017) discovered that the built-up area of Port Harcourt had increased from 16.5% in 1984 to 51.38% in 2014 and is still in the rise. This has become a herculean task for Rivers State Government to handle.
Therefore, there is the need to evaluate the causes, effects and challenges of the incidences of building collapse in Rivers State and suggest remedies to forestall future occurrences.

1.2 Statement of the Problem

The recent case of the 7-storey building that collapsed in GRA Phase 2 that claimed over 25 lives and 22 persons with life-threatening injuries (Youdeowei and Rowland, 2019) and total loss of capital investment and halting of economic activities in the industry is inestimable and irrecoverable. The role of the sector is very important and cannot be underestimated because of its output and the socio-economic development which is lost when building collapses (Emekoma, 2019).
Ayodeji (2011) have traced the common causes of these failures to foundation failure, poor design and workmanship, use of substandard materials.
In view of the above, there is the need to evaluate the causes and effects and suggest remedial measures to forestall future occurrences

1.3 Aim of Study

The aim of this study is to evaluate the causes and effects of building collapse in Rivers State and suggesting remedial measures to forestall future occurrences

1.4 Objectives of Study

The study will examine the following objectives:

i. To identify the causes of building collapse in Rivers state
ii. To identify effects of building collapse
iii. To suggest remedial measures to forestall future occurrence in Rivers state
iv. To make recommendations to control the trend

1.5 Area of Study

This study was carried out in Port Harcourt metropolis comprising Port Harcourt City and Obi-Akpor LGAs, and Igwuruta, and Aluu areas of Ikwerre LGA which are amongst the eight LGAs that forms the Greater Port Harcourt City Development Authority (GPHDA). The reason being that these areas have witnessed the highest rate of property development in recent times (Ayotamuno and Enu-Obari, 2017). The breakdown of the population of the LGAs is shown in table 1.0.

Table 1.0: Population distribution of the LGAs from (2006-2014)

S/No	LGA	2006 Population Census	2014 Population projection
1	Port Harcourt	541,115	696,189
2	Obio-Akpor	464,789	597,989
4	Ikwerre	189,726	244,098
5	**Total**	1,195,630	1,538,276

Source: National Population Commission Census (2006) and projection.

Table 2.0: The coordinates of the studied area

S/No	LGA	Coordinates

			Latitude	Longitude
1	Port Harcourt		4.778970 N	7.016250 E
2	Obio-Akpor		4.883660 N	7.028610 E
4	Ikwerre	Igwuruta	5.019390 N	7.000060 E
		Aluu	4.937460 N	6.941410 E

Source: Author's field work

2.0 Literature Review

2.1 Technical/theoretical analysis of Design Conditions and Building Failure

As earlier defined technically, building failure occurs when the ultimate design load/stress is exceeded during service. Structural failure can also occur when the applied moment (M_{app}) exceeds the moment of resistance of the concrete (M_{us}) or steel section ($M_{app} > M_{us}$) (BS 8110, 1997 and Ettu, 2001).
BS 8110 (1997), defined the two major conditions for reinforced structural concrete design as:

i. Ultimate Limit state

This limit indicates the ultimate load/stress above which the structural element is expected to fail.
Therefore, no ultimate limit should be reached by rupture/crushing, flexure or buckling under the worst combination of ultimate loads (Ettu, 2001). Thus service loads must be within the ultimate stress.

ii. Serviceability Limit state

This limit sets the conditions for the design of reinforced concrete members to control cracking and deflection, vibration etc. When reached, failure is imminent and the structure becomes unsafe. It is reached when deflection exceeds L/250 below the supports of horizontal members or L/350 after the erection of partitions where L is the span and cracks width exceeds 0.3mm, (BS 8110, 1997).

2.1.1 Foundation Design criteria

According to Garg (2009) foundation design considerations are as follows:

iii. Ultimate Limit state

The ultimate load transferred from the super structure through the foundation to the soil must not exceed the bearing capacity (BC) of the soil. The foundation designed must be such that the design load/stress from the highest supported level of the superstructure is safely transmitted to the foundation

i. Settlement

The differential settlement suffered must be within the tolerant limit of the super structure implying that it should never cause an unacceptable damage nor interfere with the function of the structure.
Skempton and MacDonald recommend that for shallow foundation, maximum settlement should not exceed 65-70mm for isolated foundation and 65-100mm for raft foundation on clay soils.
Foundation failure can occur in three distinct ways:

i. Bearing Capacity Failure

This is as a result of the imposed load exceeding the bearing resistance (bearing capacity) of the soil resulting in differential settlement. Such failures are usually followed by "heave" outside the buildings signifying the extrusion of soils from under the foundation levels (Teme et al, 2008 and Garg, 2009)..

ii. Punching Failure

This refers to the type of failure in 'sinking' manner. It occurs with small 'heave'. The column punches through the base and causes disruption in the entire loading system and finally a collapse occur.

iii. Overturning/Flexural failure

This is the tilting pattern of columns and cantilevers arising from the un-even distribution of stresses due to poor detailing and strapping (Oyenuga, 2000). No noticeable heave on the surface of the soil.

2.2 Conceptual Framework

The condition and quality of buildings is a fundamental component of the quality of human life. However, several factors contribute to successful execution of high quality building. So, when building collapses, then some or all of these factors have been jettisoned - the reason for this study.

2.3 Reported Cases of Building collapses

Table 3.0: Cases of Building Collapse in Nigeria

S/ No	Location	Date	Building type	Causes	Casualty
1	Saque secondary school, Port Harcourt	16th June 1990	One-storey building	Operational change (addition of floors)	Over 50 lives lost, a host injured
2	Illoabuchi, Diobu, Pot Harcourt	July, 1991	Primary school building	Not investigated	Unreported
5	Tombia str, GRA 3, Port Harcourt	July, 2005	5-Storey Hotel building	Foundation Failure	30 deaths
6	308 Abacha Road, GRA 2, Port Harcourt	2005	3-storey building	Foundation failure	No casualty
7	Benjamin Okpara street, Port Harcourt	2006	1-storey building under construction	Foundation failure	2 injured
8	Diobu, Port Harcourt	2009	Bungalow	Rainstorm	2 deaths
9	Elelenwo, Port Harcourt	9th Oct; 2010	2-storey building	Poor workmanship and Foundation	7 lives lost, a host injured
10	Kaduna metropolis	12th July, 2013	Old 3-storey building	No investigation	50 tenants trapped
11	298 Akpajo Road, Elelenwo, Port Harcourt	7th August, 2013	2-storey Building	Structural failure/substandard material	No casualty
12	Ibadan, Oyo state,	3rd May, 2014	Uncompleted 2-storey building	No investigation	1 casualty
13	Synagogue Church of All Nations, Lagos.	12th Sept; 2014	4-storey building	Operational changes/Foundation	115 killed, 84 injured
14	Kano University of Technology building	2014	2-storey building	Structural Failure	20 labourers dead
15	Orji, Imo State	April, 2015	3-storey building	Error in design	None
16	NPA Warehouse in Port Harcourt	9th May, 2016	Warehouse	Poor maintenance	5 deaths
17	Reigners Bible Church, Uyo	10th Dec; 2016	Auditorium	Cave-in of Roof/Trusses	26 killed and 150 injured

18	NYSC road, Alakahia, Port Harcourt	10th March, 2017	3-storey building	Foundation failure /Poor workmanship	No casualty
19	Immanuel High School Rumubiakani Port Harcourt	2018	4-story building	Foundation failure	No reported casualty
20	Woji Road GRA Phase 2, Port Harcourt	Nov; 2018	7 -storey building	Foundation failure	over 25 lives lost & 22 injured
21	Umaru Musa Yar'Adua Drive, Owerri, Imo State	30th April, 2020	8-Storey building under construction	No specifications and standards	Unspecified but many
22	Diobu, Ikoku, Azikiwe Axis.	April, 2021.	1- storey building	Structural failure	1 casualty
23	Woji town, Port Harcourt	22nd Sept, 2021	Bungalow	Erosion/Foundation failure	1 dead, 2 injures

Source: (Fagbenle & Oluwunmi, 2010, Chendo and Obi, 2015, Teme et al, 2008, Oyibode, 2016, Guardian, April 16, 2017, New York Times, 17th June, 1990)

Fig 1.0: Collapsed school building at Rumubiakani

2.4 Review of Causes of building collapse from previous studies

Researchers have also studied some of these collapses through independent investigation to unravel the causes and effects of these building collapses. They causes of building collapse include:

2.4.1 Substandard material

Olagunju et al. (2013) writes that the use of substandard material contributes up to 10% of building collapse in Nigeria. Gambir (2005) stated that when the mix ratio does not comply with specification, the compressive strength will be less than standard resulting to failure. Similarly, Wambua & Ogembo (2018) also identified low quality materials as the major cause of building collapse because the material cannot develop strength equal to the ultimate strength to sustain the design load.

2.4.2 Foundation failure

Folagbade (2001) noted that the common causes have been traced to foundation failure, poor design and workmanship. Teme et al. (2008) discovered that the collapse of the 3-storey building at Tombia street, GRA III was due to the rapid but incomplete dissipation of pore water pressure (μ) which affected the shear strength of the soil, and hence, the bearing capacity of the soil.
Youdeowei and Rowland (2019) writes that the collapse of the 7-storey building under construction at GRA II, Port Harcourt was as a result of poor foundation design from poor geotechnical investigation. They discovered the pile foundation was resting on a false stratum.
Similarly, Okah (2021) in the investigation of the collapsed 4-story building belonging to Immanuel High School Rumubiakani, Port Harcourt identified foundation failure as the cause of the collapse. He noted that the BC of 108.80KN/m^2 was inadequate for the shallow foundation, hence recommended pile foundation to terminate at 25m pile stratum.

2.4.3 Structural failure

In another note, Chendo and Obi (2015), reported the collapse of the building under construction in Benjamin Okpara Street, Port Harcourt in 2006 was due to structural failure. The concrete structure was not allowed to set at a reasonable time before continuation of work. Structural failure is directly concerned with poor structural design of beams, columns, struts and other structural members which were subjected to loading, cracking etc. Fagbenle (2010) reported that the collapsed Saque comprehensive school in Port Harcourt was partly due to absence of structural design.

2.4.4 Poor Workmanship/Supervision

Folagbade (2001) noted that the common causes of building collapse have been traced to poor design and supervision/workmanship. Most professionals neglect their supervisory roles and go about other businesses leaving the site at the mercy of artisans. Poor supervision results in non-adherence to design standards and professional etiquettes.

2.4.5 Quackery and Professional Incompetence

Oluwaseun and Olamide (2013) observed that the building industry is full of quacks and incapable contractors and that their involvement in building construction has led to incidences of building collapses in the recent past. Omeife and Windapo (2013) noted that engagement of quacks results in poor construction and interpretation of designs. The 5-story building at Tombia Str., Port Harcourt collapsed partly due to hasty construction (Teme et al, 2008). Some professionals jettison soil investigation and make assumption too.

2.4.6 Poor Attitudes of Developers

Dimuna, (2010) casts a slur on the competence of architects, structural engineers and builders – who are responsible for designing built sites. These professionals are being attacked for the recurring incidences of building collapse. However, property owners derail from approved plans relying on previous jobs and imaginations which make them culpable too.Thus Adebowale et al. (2016) asserted that the main challenge to contend with is the engagement of the services of quacks as a short-cut measure in order to 'save cost' rather than engaging professionals. COREN have said that most of the investigated collapses in the recent past were handled by quacks.

2.4.7 Illegal conversion/operational change

Adebowale et al. (2016) observed that property owners because of greed often change the operational use of the building by engaging in illegal conversion different from the approved one often done without adequate modification in compliance with building standards/codes. Chendo and Obi (2015) also posited that illegal conversions whereby buildings approved for administrative purpose are converted to workshops or conference/event center without adequate modifications have collapsed. Examples are: Saque Comprehensive School and 7-storey building at Woji Road GRA Phase 2, all in Port Harcourt and The Synagogue Church of All Nation (SCOAN).

2.4.8 Corruption and Sharp Practices

Some professionals engage in sharp practices like preparation of low quality concrete and supply of substandard materials. Anosike and Inyang-Udoh (2015) noted that corruption may be at different stages: contract level, planning and design approval, construction stages & completion or it may occur in the form of bribery, deception or collusion. Professionals collude with craftsmen to over-space bars, adopt short-cut working method or perpetrate irregularities for personal gains. Politicians front businessmen to get contract which they cannot execute (Chendo and Obi, 2015).

2.4.9 Natural Occurrences

Ayodeji (2011) attributed the failure and collapse of building in Nigeria to foundation problems, natural occurrences, poor supervision etc. This was supported by Ayedun et al. (2012) who attributed building failure to either natural or materials phenomena. A natural phenomenon may be attributable to earth quakes, storm/wind erosion which can overturn, slide, sway or uplift the building parts. Arayela and Adam (2001) reported that most building collapse cases in Nigeria are caused by natural disasters.

2.5 Effect of building collapse

The countless and inestimable effect of building collapse in Rivers State cannot be over-emphasize. Consequent upon the collapse of buildings in our society, the socio-economic implications is huge especially when lives are lost. As stated above, in several cases, lives and life-threatening injuries that is irrecoverable or irreparable are lost under the rubbles (Ede, 2010)

Similarly, the capital investment loss is huge and irrecoverable and most owners never recover from the psychological trauma (Akande et al. 2016). Professionals and contractors involved in building collapses losses their integrity especially when their licences are withdrawn (Chendo and Obi, 2015)

The effects could be human, economic and environmental. The vibration effect of the collapsed building on adjacent/adjoining buildings is adverse making the building unsafe for habitation.

2.6 Remedy

Many researchers have recommended remedies to mitigate the problems. Stella (2010) recommended that there is need for a functional Building Code such as the National Building Code 2006 to be enforced to control building collapse. The professional bodies like NIA, NSE, and NIOB etc. through their government regulatory bodies like Council for Regulation of Engineering in Nigeria (COREN) and Council of Registered Builders of Nigeria (CORBON) etc. need to wake up and ensure effective monitoring to control quackery and ensure violators are punished.

Adebowale et al. (2016) suggested the inclusion of geotechnical investigation, structural analysis including bending moments and shear force diagrams and mandatory handling of the project by a registered professional as mandatory conditions for approval of plans.

3.0 Methodology

3.1 Design of Study

The Survey design method which enables the researcher to randomly sample the opinions and perceptions of stakeholders in the building industry on the subject matter through structured questionnaire was used. These stakeholders are drawn from the private and public sectors. The former includes; certified officers of the ministry of works, housing and Physical planning and Urban Development while that of the latter includes; The Civil engineers, Architects, Builders, Town Planners, Estate surveyors, registered building contractors and certified craftsmen all in Rivers State.

3.2 Population of Study

The expected population target is 88 drawn from certified stakeholders in private and public sectors in Rivers State. The participants from the private sector were reached through the secretaries of the professional organisations; Nigeria Society of Engineers (NSE), Nigeria Institute of Builders (NIOB), in their Port Harcourt Offices while the public participants were reached through their Ministry offices.

3.3 Sampling size distribution

The sample size was determined from the Taro Yamine population reduction formula:

$n = \frac{N}{1+N\,(e^2)}$ -------------------- (I)

Assuming the confidence level of 95%

N= Population size = 88 n = Sample size e = Accepted tolerable error = 5%

Therefore, $\frac{88}{1+88\,(0.05^2)} = 72\ (approx.)$

The sampling size will be 72.

3.4 Research Instrument

The research instrument considered in this study is the questionnaire instrument. A total of 72 structured questionnaires were sent out to the respondents.

The instrument was divided into three sections:

i. Section A elicited response on the on the causes of building collapse in Rivers State
ii. Section B elicited response on the effects of building collapse
iii. Section D elicited response on the remedies to controlling building collapse

3.4 Scoring of Research Instrument

The questionnaire was rated on a 4-point scale according to the Likert scale.

Table 3.0 Scoring of the Questionnaire response:

S/No	Response	Score
1	Strongly Agree (SA)	4
2	Agree (A)	3
3	Disagree (D)	2
4	Strongly Disagree (SD)	1

Research survey; 2021

3.5 Method of data Analysis

The information gathered was presented in tabular form while data were analysed with frequency, mean and simple percentage (%). The simple % formula is as follows:

$$\mathbf{F} = \frac{\text{Number of Respondents (R)} \times 100}{\text{Sample size (n)}} \text{---------} \text{(II)}$$

Where F = % frequency, R = number of respondents n = Sample size

Secondly, the mean score was performed with formula:

$$\boldsymbol{M_S} = \frac{\sum_{k=1}^{4} \binom{4}{k} W_k \times n_k}{(n_r)} \text{--------} \text{(III)}$$

Where M_s = Mean Score, $\mathbf{W_k}$ = Score attached to each response in the scale 1-4 ,
$\mathbf{n_k}$ = Response for each score, $\mathbf{n_r}$ = Total No of responses

3.6 Reliability of the Instrument

Cronbach Alpha method is a champion among the psychometric tests used to test internal consistency; hence, it was used to determine the internal consistency of the survey. The formula is:

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\Sigma S^2 Y}{S^2 X}\right] \text{-----------} \text{(IV)}$$

Where α= Cronbach's Alpha, K = No items being questioned, $\Sigma S^2 Y$ = Sum of K item score variance, S^2X = Variance of total score

4.0 Data Presentation and Result Discussion

4.1 Data Demography

Table 4.0: the distribution of administered and returned entries

S/No	**Entry Description**	**Frequency**	**Percentage (%)**
1	No of Questionnaires Sent	72	100
2	No of entries Received	67	93.1
3	Invalid data	5	6.9
4	No of entries used	62	86.1

Research survey; 2021

Table 4.1: Age distribution of the respondents

S/No	Age Bracket	Frequency	Percentage (%)
1	18-25	8	12.9
2	26-40	30	48.4
3	41-55	18	29.0
4	56 and above	6	9.7
Total		**62**	**100**

Research survey; 2021

Table 4.2 shows the highest educational qualification of the respondents. Those with First School Leaving Certificate (FSLC) is Nil, O' Level is 9.7%, BSc/B.Eng/HND is 58%, MSc is 24.2%, PhD is 8.1%. This show how enlighten and how they understand the subject matter

Table 4.2: Educational qualification of the respondents

S/No	**Educational qualification**	**Frequency**	**Percentage (%)**
1	FSLC	Nil	Nil
2	O' Level	6	9.7

3	BSc/B.Eng/HND	36	58
4	MSc	15	24.2
5	PhD	5	8.1
Total		**62**	**100**

Research survey; 2021

The demography of the respondents shows that: 12 questionnaires were sent to the public sector namely; Ministry of Works, Housing and Physical Planning & Urban Development and 11 were returned representing 91.7% return % while 60 questionnaires were sent to the private sector namely; built environment professionals and certified building construction contractors and 51 were returned representing 85% return %.

Table 4.3: Demography of the respondents

S/No	Work Experience	Frequency	Percentage (%)
1	1-5	10	16.1
2	6-10	30	48.4
3	11-20	16	25.8
4	21 and above	6	9.7
Total		**62**	**100**

Research survey; 2021

4.2.1 Causes of Building collapse

The data presented in Table 4.4 represents the result on the causes of building collapse in Rivers State

Table 4.4: Causes of building collapse

S/ No	Causes of Building Collapse	No of Respondents(n_k) for each Score (W_k)				n_r	M_s	% FA	% FD	Remark
		4	3	2	1					
Maximum value						**62**	**4**	**100**	**100**	
Design Problem										
1	Foundation Failure	45	13	4	0	62	3.66	93.5	6.5	Accepted
2	Structural Failure	42	16	4	0	62	3.61	93.5	6.5	Accepted
Execution/Operational Problem										
3	Use of Poor Equipment and Substandard material	41	15	4	2	62	3.53	90.3	9.7	Accepted
4	Poor Supervision /Workmanship	43	16	2	1	62	3.63	95.2	4.8	Accepted
5	Illegal Conversion /Operational change	42	15	2	3	62	3.55	91.9	8.1	Accepted
6	Poor Maintenance	40	18	1	3	62	3.53	93.5	6.5	Accepted
Stakeholders' Problem										
7	Quackery & Professional Incompetence	44	15	1	2	62	3.63	95.2	4.8	Accepted
8	Inexperienced Craftsmen	16	13	18	15	62	2.48	46.8	53.2	Rejected
9	Corruption	39	18	3	2	62	3.52	91.9	8.1	Accepted
10	Incompetent Contractor	37	15	7	3	62	3.39	83.9	16.1	Accepted

11	Poor Attitudes of Developers	38	19	2	3	62	3.48	91.9	8.1	Accepted
	Regulatory Problem									
12	Non-enforcement of regulations	40	13	5	4	62	3.44	85.5	14.5	Accepted
13	Poor Government policy	37	16	6	3	62	3.40	85.5	14.5	Accepted
	Accidents									
14	Fire	37	17	3	5	62	3.39	87.1	12.9	Accepted
15	Explosion	19	9	14	20	62	2.44	45.2	54.8	Rejected
16	Impact	20	9	13	20	62	2.47	46.8	53.2	Rejected
	Natural Occurrences									
17	Flood	38	16	5	3	62	3.44	87.1	12.9	Accepted
18	Wind (Hurricane, typhoon, Cyclone etc.)	18	15	14	15	62	2.58	53.2	46.8	Accepted
19	Earthquake and Volcano	10	12	20	20	62	2.19	35.5	64.5	Rejected

Research survey; 2021
Midpoint (Average mean score) = 2.50
Ms > 2.50 = Accepted % Frequency Agreed = % FA
Ms < 2.50 = Unaccepted % Frequency Disagreed = % FD

I. Design Failure

Table 4.4 shows that 93.5% of the respondents agreed that foundation failure is a major cause of building collapse, while the mean score is 3.66 which is the highest in this study, hence accepted. This corroborated the positions of literature that most building collapses in Port Harcourt has element of foundation failure (Youdeowei and Rowland, 2019). The reason being that the population increase here has caused property development to shift to available swamps and marshy soils (Ayotamuno and Enu-Obari, 2017) that pose challenge to building (Youdeowei & Nwankwoala, 2010).
Structural failure scored 3.61 producing an agreement frequency of 93.5% which was accepted.

II. Execution/Operational Problem

According to table 4.4, poor equipment and substandard material scored 3.53 and agreement frequency of 90.3% which was accepted. The result confirms literature data for this causal factor.
Poor Workmanship/Supervision scored 3.63 and an agreement frequency of 95.2% indicating the acceptability of the factor.
Table 4.4 also shows that Illegal Conversion/Operational change scored a significant mean of 3.55 and an agreement frequency of 91.9% which is acceptable. This factor is very common as most building collapses mentioned above are linked to operational change/conversion due to greed.
For poor maintenance, the mean score is 3.53 while 93.5% of the respondents agreed that poor maintenance is one of the causes of building collapse which is acceptable. The poor maintenance culture of owners and occupants has overtime resulted to building collapse (Fadamiro, 2002).

III. Stakeholders' Problem

Result also shows that Quackery & professional Incompetence scored 3.63 while 95.2% agreed that it is a major cause of building collapse and a serious challenge to contend with.

However, inexperienced craftsmen scored 2.48 and 46.8% of acceptability frequency which fell short of the condition, hence rejected. The argument is that if a craftsman is under-performing, he should be fired and an experienced one hired.
Corruption and sharp practices perpetrated by the contractors and professionals scored 3.52 and 91.9% of the respondents agreed that it is a causal factor and has been described as a major challenge.
Incompetent Contractors scored 3.39 and a % frequency of agreement, 83.9% which is acceptable.
Interestingly, the greedy Attitudes of Developers adopting short-cut measures scored 3.48 and a % agreement frequency of 91.9% which shows that it is a causal factor.

IV. Regulatory Problem

Non-enforcement of building regulation scored 3.44 and a % FA of 85.5% indicating a causal factor which was accepted. The implication is that offenders are not usually punished.
Poor Government Policy scored 3.40 while the agreement frequency is 85.5% indicating acceptability. This is a direct result of the non-domestication of the National Building Code, 2006 in Rivers State to regulate the building Industry.

V. Accidents

The frequent fire incidents which engulfed buildings recently in Port Harcourt were confirmed by the result as it scored 3.39 and an agreement frequency of 87.1% proving its acceptability.
Contrarily, Explosion scored of 2.44 and only 45.2% of acceptable frequency which was rejected. They noted that explosion seldom occur in Rivers State.
Similarly, the mean score of impact is 2.47, while only 46.8% of the respondents agreed that it is a causal factor, hence, rejected.

VI. Natural Occurrences

Flood according to table 4.4 is huge as it scored 3.44 and a % frequency of agreement of 87.1% indicating acceptability. They noted that flood has recently assumed a dangerous dimension.
Wind scored 2.58 while an acceptable 53.2% of the respondents agreed that it is a challenge.
Earthquake and Volcanic Eruptions score 2.19 and a % FA of 35.5% which fell short of average score of 2.5 hence rejected. Respondents noted that earthquake and volcano seldom occur in Nigeria.

4.2.2 Effect of building collapse

Table 4.5: Effect of building collapse

S/ No	Effects of Building Collapse	No of Respondents (n_k) for each Score (W_k)				n_r	M_s	% FA	% FD	Remark
		4	3	2	1					
Maximum value						**62**	**4**	**100**	**100**	
Effect on Occupants										
1	Loss of human lives	46	15	1	0	62	3.73	98.4	1.6	Accepted
2	Life threatening injuries	44	17	1	0	62	3.69	98.4	1.6	Accepted
3	Psychological trauma	42	16	2	2	62	3.58	93.5	6.5	Accepted
Effect on the Economy										
4	Loss of capital investment	47	14	1	0	62	3.74	98.4	1.6	Accepted
5	Unproductive GDP	42	15	2	3	62	3.55	91.9	8.1	Accepted
6	Business interruption	40	14	5	3	62	3.47	87.1	12.9	Accepted

Environmental Effect										
7	Emission of CO_2 and dust into the air	20	17	12	13	62	2.71	59.7	40.3	Accepted
8	Release of Toxic Pollutants into the air	16	13	18	15	62	2.48	46.8	53.2	Rejected
	Sociological Effect - Loss of Confidence and Integrity									
9	Loss of new contracts	39	18	3	2	62	3.52	91.9	8.1	Accepted
10	Withdrawal of practicing Licence	37	15	7	3	62	3.39	83.9	16.1	Rejected
11	Discouragement in property investment	9	10	20	23	62	2.08	30.6	69.4	Rejected

Research survey; 2021

I. Effect on Occupants

Result in table 4.5 shows that loss of human lives scored 3.73, while 98.4% of the respondents said it is a major effect of building collapse, hence, accepted. The result confirms the position of Arayela and Adam (2001) which corroborated high loss of human lives in building collapses and one of the most significant effects of building collapse.
Life threatening injuries scored 3.69 and an agreement frequency of 98.4% which was accepted, while Psychological trauma scored 3.58 and a % frequency (FA) of 93.5% indicating acceptability.

II. Effect on the Economy

Loss of capital investment scored a significant mean score of 3.74, while 98.4% agreed that it is a major effect making it highly acceptable. The strength of this factor is confirmed by the data from literature which noted that the loss of capital investment is irrecoverable.
Irrecoverable loss of capital investment renders the GDP generated completely useless, hence, Unproductive GDP scored 3.55 and an acceptable % frequency (FA) of 91.9%.
Business interruption had a mean score of 3.47 and a % frequency of 87.1% indicating the acceptability. This is derived from cordoning off the adjoining areas which interrupts business.

III. Environmental Effect

The result also showed that the Emission of CO_2 and large dust into the air scored 2.71, while 59.7% of the respondents agreed that this is a causal factor which was accepted. Though the dynamics of the emission of CO_2 was still not too clear to most respondents but nevertheless accepted.
Release of Toxic Pollutants score 2.48 and an agreement frequency of 46.8%. According to most of the respondents, they cannot confirm this effect, hence, it was rejected.

IV. Sociological Effect – Loss of Confidence and Integrity

Table 4.5 shows that Loss of new contracts scored 3.52 and an acceptable frequency of 91.9%. This shows that contractors involved in building collapsed are afraid of losing new contracts.
Similarly, the mean score of 'withdrawal of practicing License' is 3.39 and an agreement frequency of 83.9% which was accepted while the mean score of 'discouragement in property Investment' is 2.08 and an agreement % of 30.6% which was rejected because it fell short of the average score.

4.2.3 Remedies to tackle the problem

The following remedies were suggested to ameliorate the situation:

Table 4.6 Remedial Measures to tackle the problem

S/ No	Remedies to Building Collapse	No of Respondents (n_k) for each Score (W_k)				n_r	M_s	% FA	% FD	Remark
		4	3	2	1					
Maximum value						**62**	**4**	**100**	**100**	
Regulatory Instruments										
1	Collaboration of State with Federal regulatory bodies	40	15	4	3	62	3.48	88.7	11.3	Accepted
2	Domestication of the National Building Code in Rivers State	44	15	1	2	62	3.63	95.2	4.8	Accepted
3	Enactment of State Building regulation laws	36	14	8	4	62	3.32	80.6	19.4	Accepted
Enforcement and Punishment of Offenders										
4	Arrest and Prosecution of corrupt professionals	40	17	3	2	62	3.53	91.9	8.1	Accepted
5	Arrest and prosecution of quacks	43	16	2	1	62	3.63	95.2	4.8	Accepted
6	Withdrawal of Practicing Licenses	40	12	4	6	62	3.39	83.9	16.1	Accepted
7	Blacklisting of corrupt contractors by BPE	32	12	7	11	62	3.05	71.0	29.0	Accepted
Supervisory/Technical and Approval Measures										
8	Mandatory Geotechnical and structural design for Plan Permit	36	14	5	7	62	3.27	80.6	19.4	Accepted
9	Mandatory Registration number and personnel seal for Plan approval	39	18	3	2	62	3.52	91.9	8.1	Accepted
10	Regular supervision	35	13	10	4	62	3.27	77.4	22.6	Accepted
11	Use of quality materials in building	45	12	2	3	62	3.60	91.9	8.1	Accepted
	Awareness Campaign									
12	Training of professionals and Public sensitisation	40	11	5	6	62	3.37	82.3	17.7	Accepted

Research survey; 2021

I. Regulatory Instruments

Table 4.6 shows that collaboration of state with federal regulatory bodies like COREN to control the menace of building collapse scored 3.50 and a % frequency (FA) of 71.4% which was accepted.

However, domestication of the National Building Code (NNBC) 2006 in Rivers State had a high mean

score of 3.51 and a % agreement of 91.8% indicating high acceptability. The non-domestication of this code has led to the non-enforcement of the relevant provisions of the code in Rivers State. Only few states in the federation have domesticated the NNBC.
Similarly, a mean score of 3.26 was recorded and 80.0% of the respondents agreed that the enactment of building regulation and facility management and maintenance laws is a remedy which was accepted.

II. Enforcement and Punishment of offenders

Arrest and prosecution of corrupt professionals according to table 4.6 scored 3.52 and 83.3% agreement frequency which was accepted
Interestingly, arrest and prosecution of quacks scored 3.57, while 92.3% of the respondents agreed that this solution can mitigate the problem, hence it was accepted. This result shows that controlling quackery can go a long way in addressing the problem of building collapse.
Withdrawal of practicing License scored 3.00, while a % frequency (FA) of 71.4% was recorded indicating acceptability of this measure.
Similarly, blacklisting of corrupt contractors by BPE recorded 3.17, while 78.8% of the respondents agreed that it is an appropriate measure because it will call the integrity of the contractor to question.

III. Supervisory/Technical and Approval Measures

From the result in table 4.6, the inclusion of geotechnical and structural information as a mandatory pre-condition for plan permit scored 3.08 and acceptance frequency of 71.8% which was accepted.
Similarly, 63.5% of the respondents agreed that Registration number and personnel seal as a pre-condition for plan approval is an appropriate measure, while the 2.68 score recorded was accepted.
Regular supervision scored 3.27, while the % F.A is 77.4% indicating acceptability.
The use of quality materials scored 3.18 and an acceptance % of 74.1%. The use of substandard material is a major challenge, so, quality assurance is key to sustainability of a building's service life.

IV. Training and Awareness Campaign

Result shows that training and re-training of new generation practising professionals and public sensitisation by professional organisations scored 2.71, while the frequency of acceptance is 60.0% which was accepted. The training and re-training of new generation practising professionals is necessary (Adebowale, 2016) coupled with public sensitisation by professional organisations on the causes and dangers of building collapse

4.3 Reliability Test

The internal consistency of the data was determined by the Cronbach's alpha. Therefore the internal consistencies of the data in table 4.4, 4.5 and 4.6 on the causes, effects and remedies are 0.88, 0.84 and 0.93 as shown in tables: 4.8, 4.9 and 4.10 respectively which are all excellent

Table 4.7: **Case Processing Summary**

		N	%
Cases	Valid	62	100.0
	Excluded[a]	0	0.0
	Total	62	100.0

a. Listwise deletion based on all variables in the procedure

Table 4.8: Reliability Statistics: Causes of building collapse

Cronbach's alpha	No of items
0.88	19

Table 4.9: Reliability Statistics: Effects of building collapse

Cronbach's alpha	No of items
0.84	11

Table 4.10: Reliability Statistics: Remedies to building collapse

Cronbach's alpha	No of items
0.92	12

4.4 Conclusions

The purpose of this study was to determine the causes, effects and remedies to building collapse in Rivers State. To achieve this, a total of 72 questionnaires out of a population target of 88 were distributed to stakeholders in the building industry to randomly sample their opinions and perceptions on the subject matter. However, 62 entries were valid after 72 entries were returned and these perceptions were rated with a 4-point Likert's scale. Data analyses were done with Mean score, frequency and simple % while Cronbach's alpha was used to test the reliability of the data. Conclusively, out of the 19 test causal factors, 15, namely; foundation and structural failure, poor equipment and substandard materials etc, were accepted as major contributory factors while only 4 items; inexperienced craftsmen, explosion, impact and earthquake and volcanic eruptions were rejected because of their low mean score below 2.5 average score, hence they are not major contributory factors to building collapses in Rivers state. Similarly, only release of toxic pollutants and discouragement of property investment were rejected out of 11 test effects. The factors accepted are; Loss of human lives, life threatening injuries, loss of capital investments etc. All the 12 test remedial measures namely: collaboration with COREN, CORBON etc., domestication of National Building Code, arrest and prosecution of quacks etc were accepted as appropriate remedial measures because they all scored above the average score of 2.5. Finally, internal consistencies of the data on the causes, effects and remedies to building collapse are 0.88, 0.84 and 0.92 respectively which are all excellent.

5.0 Recommendations

The study recommends the following;

i. There should be effective synergy between the state government and national professional regulatory bodies like COREN, CORBON, NIA etc. for effective regulation
ii. Rivers state government should domesticate the National Building Code (NNBC) 2006, enact robust regulatory laws, ensure effective enforcement of the laws, withdraw their practicing license and blacklist corrupt and incapable contractors
iii. Geotechnical and structural designs must be a mandatory pre-condition for plan permit
iv. Similarly, registration numbers and personnel seals must be provided for plan approval
v. The regulatory bodies should ensure quality assurance is maintained and regular supervision ensured to control sharp practices in site.

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