

**EVALUATION OF THE CAUSES OF BUILDING COLLAPSE IN
EDO STATE, NIGERIA**

BY

**OBASUYI NOSA CLEMENT
ENG1503661**

**A PROJECT SUBMITTED IN PARTIAL FULFILLMENT FOR THE
AWARD OF BACHELOR'S DEGREE IN ENGINEERING (B.ENG)**

IN

**DEPARTMENT OF CIVIL ENGINEERING,
FACULTY OF ENGINEERING,
UNIVERSITY OF BENIN,**

September, 2021.

CERTIFICATION

This is to certify that this project – EVALUATION OF THE CAUSES OF BUILDING COLLAPSE IN EDO STATE, NIGERIA – was undertaken by OBASUYI NOSA CLEMENT, ENG1503661, Department of Civil Engineering, Faculty of Engineering, University of Benin (UNIBEN), Edo State, Nigeria.

ENGR. DR. Mrs. RAWLINGS

PROJECT SUPERVISOR

.....

SIGNATURE AND DATE

ENGR. DR. S. IYEKE

HEAD OF DEPARTMENT

.....

SIGNATURE AND DATE

DEDICATION

This project is dedicated to God Almighty, the power and giver of wisdom and knowledge, my invaluable project supervisor; Engr. Dr. Mrs. Rawlings, this project wouldn't have been completed without her strict guidance and tutelage, and my wonderful parents for supporting me this far.

ACKNOWLEDGEMENT

My gratitude goes to the HOD, Engr. Dr. S. D. Iyeke for his support towards the success of this project. I wish to acknowledge my supervisor, Engr. Dr. Mrs. Rawlings for her unrelenting support, knowledge, and information during the course of this project. Special thanks to Engr. Dr. J. O. Okovido, Prof. O. E. Alutu, Prof. O. C. Izinyon, Prof. O. U. Orie, Dr. E. O. Eze, Engr. Dr. S. O. Osuji, Engr. Ehi Oria-Usifo, Engr. Dr. D. O. A. Osula, Engr. Dr. N. Ebuka, Engr. Dr. L. Akhigbe, Engr. Okolie, Engr. Osasu Osamuyi, Engr. Igne Morris, Engr. U. E. Kaji, Engr. R. Ilaboya, Mr. Sanni Ilavbarhe, Mr. Lucky and other staffs for the knowledge they shared with me during my five years of study at the University of Benin.

Special thanks to my parents, Rev. and Evang. (Mrs.) Obasuyi for their support and advice. I also acknowledge my siblings for their support throughout my study. Further appreciation goes to my course mates and the laboratory team at Civil Laboratory; Structural unit for their guidance and assistance towards the success of this project.

ABSTRACT

The age-less interaction between man and his built environment has always had positive and negative impacts on the two. Environmental disaster of varying origin from man-made to natural is one of the most negative effects of the built environment on man. An assessment of the magnitude of these disasters and an evaluation of the existing capacities to prevent, mitigate or prepare for them are necessary tools to provide future safe living for man in his built environment. Building collapse established to be caused by many factors is one of such disasters wielding its great impact of loss of lives and properties on man. This study evaluated the causes of building collapse in Edo State by identifying the major causes of collapse, assessing its effect, and also assessing the roles of government and construction professionals in mitigating the occurrence of building collapse in Edo State. The method use to carry out this study involves laboratory analysis of the materials harvested from the different building collapse sites, structural analysis of the collapse building and distribution of questionnaires to gather information relevant to the study. The study indicated that the causes of building failure and collapse stem principally from poor structural designs of buildings, low compressive strength of blocks, poor supervision, inexperience (use of incompetent hands), ignorance, evasion/non-compliance with building regulations and non-enforcement of building quality, standard and control on construction site/market. After identifying the major causes of collapse, this study concludes with necessary recommendations to prevent and stop further occurrence of building collapse in Edo State.

TABLE OF CONTENTS

TITLE PAGE	i
CERTIFICATION	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	ix
LIST OF FIGURES	x
CHAPTER ONE	1
INTRODUCTION	1
1.1 BACKGROUND OF THE STUDY	1
1.2 STATEMENT OF RESEARCH PROBLEM	3
1.3 AIM AND OBJECTIVES OF THE STUDY	4
1.4 JUSTIFICATION OF THE STUDY	5
1.5 LIMITATION OF THE STUDY	5
1.6 SCOPE OF THE STUDY	6
CHAPTER TWO	7
2.1 LITERATURE REVIEW	7

2.2	BUILDING FAILURE	8
2.3	EDO STATE AS A CASE STUDY	8
2.4	MAJOR CAUSES OF BUILDING COLLAPSE	9
2.5	EFFECTS OF BUILDING COLLAPSE IN EDO STATE	15
2.6	SUPERVISION/INSPECTION (ENFORCEMENT ON SITE)	16
2.7	PROTECTIVE MEASURES AGAINST BUILDING COLLAPSE	16
2.8	THE ROLES OF GOVERNMENT AND PROFESSIONALS IN MITIGATING THE OCCURRENCE OF BUILDING COLLAPSE IN EDO STATE	20
	CHAPTER THREE	29
	RESEARCH METHODOLOGY	29
3.1	INTRODUCTION	29
3.2	RESEARCH DESIGN	29
3.3	DATA COLLECTION INSTRUMENT	30
3.4	METHOD OF DATA COLLECTION	31
3.5	COLLAPSE SITE ANALYSIS	31
3.6	VALIDITY TEST	33
3.7	METHODS OF DATA PRESENTATION AND ANALYSIS	34
	CHAPTER FOUR	36
4.1	DATA PRESENTATION AND ANALYSIS	36
4.2	COLLAPSE SITE ANALYSIS	36

4.3 ANALYSIS OF THE COLLAPSED BUILDING	41
CHAPTER FIVE	47
5.1 CONCLUSION AND RECOMMENDATION	47
5.2 SUMMARY OF FINDINGS	47
5.3 CONCLUSIONS	48
5.4 RECOMMENDATION	49
REFERENCES	50
APPENDICES	54

LIST OF TABLES

Table 3.1:	Relationship between the Correlation Coefficient and Nature of Relationship	30
Table 4.1:	Compressive Strength of Blocks Harvested From the Collapse Sites	36
Table 4.2:	Structural Detailing of the Collapse Sites	37

LIST OF FIGURES

Figure 1:	Questionnaire Responses on the Causes of Building Collapse in Edo State	39
Figure 2:	Questionnaire Responses on the Effects of Building Collapse in Edo State	40
Figure 3:	Questionnaire Responses on the Measures Mitigate the Occurrence Of Building Collapse in Edo State.	41

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Since Nigeria gained independence in 1960, the government has desperately continued to make concerted effort in the area of quantitative and not qualitative supply of mass housing through huge budgetary and policy provisions but, surprisingly, the rate at which existing ones are collapsing calls for an urgent attention. The site of building collapse scattered across the length and breadth of Nigeria is quite alarming that it is unimaginable what effects it will have on the building industry and Nigeria economy as a whole. One could imagine what edifices these buildings would have been if only they were constructed accordingly.

Statistics shows that Nigeria, especially Lagos State has become the “world’s junk-yard” of collapsed buildings worth billions of naira (Aigbokhan, 2004). It is quite unimaginable that a country blessed with so much great potentials in its construction industry can experience such magnitude of building collapse. Bamidele 2000, defined building as an “enclosure for spaces designed for specific use, meant to control local climate, distribute services and evacuate waste”. Buildings can also be defined as structural entities capable of securing self by transmitting weights to the ground (Opara, 2007). Hence, buildings are structures for human activities, which must be safe for the occupant. However, these same buildings have been posing treats and dangers to people either during or after construction as a result of its collapse.

Collapse as a whole occurs when part or whole body of a structure fails and suddenly gives way, the structure, as a result of this failure, could not meet the purpose for which it was designed for. Building collapse is an extreme case of building failure. It means the super-structure crashes down totally or partially (Ameh, 2007). Building failure occurs when there is a defect in one or more elements of the building caused by inability of the material making up the components of such building elements to perform its original function effectively, which may finally lead to building collapse. Buildings are meant to provide conveniences and shelter to the people, but the same buildings are now posing as a danger trap to these people. Building is expected to meet certain basic requirements such as durability, design performance, cost effectiveness, quality, safety and timely completion (Oloyede, 2010).

Generally, buildings are expected to be elegant and functional but many projects are constructed that do not meet any of these basic requirements. The recurring incidence of building collapse, some of which claimed innocent lives is a consequence of this. Many studies has been carried out and various workshops organized in major cities of the country by various bodies, government agencies and institution in order to look into causes of the incidence of building collapse in Nigeria, but none has been able to come out with how each of the determined factors directly lead to building collapse in the country.

Several factors can cause building collapse not just in Nigeria, anywhere in the world and these factors are primarily based on structural design and quality management according to Oloyede, 2010. The quality management entails material variability, testing variability, judgment factor, contractors' variability, poorly skilled workmen and unprofessional conduct. This study aimed at evaluating the causes of building collapse in Edo State, Nigeria along with the effect and solution.

1.2 STATEMENT OF RESEARCH PROBLEM

Building collapse is a defect or imperfection, deficiency or fault in a building element or component. It may also be as a result of omission of performance. The degree of building collapse can therefore be related to the extent or degree of deviation of a building from the “as – built” state which is in most cases represent the acceptable standard within the neighborhood, locality, state or country (Chinwokwu, 2000).

The incessant buildings collapse in Nigeria has become a great concern to all the stakeholders – the professionals in building industry, government, private developers, clients and users, as well as the neighborhood residents and this stated facts makes this project of top priority.

The effects of this disaster are devastating and have led to the death of many individuals in Edo State and across the country. Records holds that four hundred and twenty-six (426) deaths and two hundred and thirty-one (231) injuries were observed as resultant calamities of building collapse in Nigeria. Not only in Edo State, other states like Lagos and for instance, are struggling on how to deal with the persistent occurrence of building collapse.

Based on research done in the past by engineers, most of them passed out a verdict that these collapses are a result of which poor quality of materials. From the number of casualties earlier stated, workmanship accounted for one hundred and eleven deaths (representing 26%) and one hundred and twelve injuries (representing 45%) respectively. This also depict that this very factor has a significant resultant effect on building collapse in Nigeria. Hence, the need to address the causes of building collapse in the country form the basis for this study to find out the major causes, effects and probable remedial measures to collapse of buildings in Nigeria, using

Edo State as a case study, making this study highly important and relevant to all construction workers and the government.

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of this research is to evaluate the causes of building collapse in Edo State. The Objectives of the study are to:

- To identify the major causes of building collapse in Edo State Nigeria;
- To assess the effects of building collapse in Edo State;
- To assess the roles of Government and construction professionals in mitigating the occurrence of building collapse in Edo State.

1.4 JUSTIFICATION OF THE STUDY

Factors affecting building collapse in Edo have been a major concern in Nigeria as it threatens human lives and properties in the state because of the high rate of building collapse at close intervals (e.g. the collapse of Liberty Power Bible Church, Power Palace at Asoro Slope, off Ekenwan Road in Benin City on September 28th 2014, and the collapse of the Central Hospital Building under construction at Sapele Road, Benin City on June 4th 2012) and the increasing rate of building construction with substandard materials kept increasing. People erect buildings without considering some factors and codes which are necessary to be put into place before

embarking on any development and these calls for a reason to emphasize on the legal action to put an end to those disasters.

Part of the reasons for this study is to reawaken the consciousness of the Edo State government about these collapse incidents and intimate with the government by given them power to enforce law and safe guard the lives and properties of the citizenry that lives in housing general and life of the buildings by ensuring strict enforcement of housing and safety policies. It is also meant to enlighten developers, the mason men etc., on the needs for them to involve professionals in construction so that structural failure and building collapse can be avoided.

1.5 LIMITATION OF THE STUDY

Financial constraint- Insufficient fund tends to impede the study. The researcher is faced with the challenge of the relevant materials, literature or information and in the process of data collection (internet, questionnaire and interview).

1.6 SCOPE OF THE STUDY

This study is involve the investigation of five (5) mainly collapse in Edo State (One building collapse in Benin City, and four in Auchi. Hence, the study involves the use of case study method to determine the case study method to determine the cause of building collapse in Edo State. Its effect and the role of Government and construction professional in mitigating the

occurrence of building collapse in Edo State. Samples from the building collapse soil were taken and analyzed. Also drawings (including the building plan and design) and aerial photograph of the collapse building were sourced for and used.

CHAPTER TWO

2.1 LITERATURE REVIEW

Building collapse is a familiar occurrence to a lot of persons in Nigeria. When part or whole body of the structure has failed and suddenly gave way, the building, as a result of this failure, could not meet the purpose for which it was designed, the building is said to have collapsed. The occurrences of building collapse in the country nowadays, especially in the last five years have reached a very disgraceful and embarrassing level, which is unacceptable. It is as a result of structural failure of the building. We need to know that structural failure is the loss of sustaining capacity or stability of a structure, characterized by a considerable increase in strain without a proportional increase in load (Windapo, 2006).

Building collapse may result into a rupture or an essential component of the structure, which increases more rapidly than the increase in imposed load. Building collapse occurs when a building falls down or fall in suddenly, often breaking apart. During rainy season as, the month of may for instance, cause few weak uncompleted buildings, somewhere to cave in, the scores of passers taking cover from the rain under these buildings would fall victim. The lucky ones would be maim for life while the unfortunate ones would die on the spot or later end up in hospital for most of their lives.

2.2 BUILDING FAILURE

Failure is an unacceptable difference between expected and observed performance. A failure can be considered as occurring in a component when that component can no longer be relied upon to fulfill its designed functions. Limited deflection in a floor which causes a certain amount of cracking/distortion in partitions could reasonably be considered as defect but not a failure, whereas excessive deflection resulting in serious damage to partitions, ceilings and floor finishes could be classed as a failure (Wisner, 2004). Those who investigate and report on failures of engineered facilities are in a good position to identify trends leading to structural safety problems and to suggest topics for critical research to militate against this trend (Obiechina, 2005).

2.3 EDO STATE AS A CASE STUDY

Edo State lies on latitude 0.734N and longitude 0.645E. It is low lying except towards the north axis where the Northern and Esan plateaus range from 183 Meters of the Kukuruku Hills and 672 Meters of the Somorika Hills. It is a small state with a population of over 3 million from the last conducted census, covering a land area of 19,794 km square. The state is also noted for agricultural products like rubber, cocoa, cashew nuts and is blessed with precious stones like Quartz, Dolomite, Granite Stone and Lime Stone used in the production of Cement at Okpella, and this makes it one of the most populous cities in Africa. Being one of the industrial as well as commercial center of the country the city has a high population density and abundant economic opportunities, which in turn has led to over utilization of available utilities and resources, and the increasing rate of urbanization has resulted in pressure on land use, and so on.

2.4 MAJOR CAUSES OF BUILDING COLLAPSE

A structure is said to have failed when it reaches limit state. The limit state is a state where the structure becomes unsuitable for its intended use (Bosede, 2014). This could be as a result of excessive deflection, cracking, or other circumstances, which will make it unsuitable. Bankoff in 2003 attributed building failures to four basic stages of building life (i.e. planning design, construction and services). Oyewande added natural causes to the list. This may however, be described as circumstantial failure since it include causes like vehicular impact and fire incidents, which are not natural.

In Edo State Nigeria, building failures have been attributed to the following causes: design faults (50%), faults on construction site (40%) and product failure (10%). Hewitt ascribed faulty design, faulty execution of work and use of faulty materials as major causes of structural failures.

2.4.1 Planning

The planning stage involves considering several design option while bearing in mind the function, which the structure will serve with a view to adopting the most cost effective option.

2.4.2 Design Stage

Bad design does not primarily mean errors in computation of figures, but the failure to take into account the estimated load the structure will carry. Also, erroneous theories, reliance on inaccurate data, ignorance of the effects of repeated or impulsive stresses, and improper choice

of materials or misunderstanding of their properties are what make up a bad design. The engineer is responsible for these failures, which are created at the drawing board.

Structural design is concerned with transmitting the various forms of load, which a structure will likely be subjected to, during its working life to the foundation. Most authors attribute building collapse to faulty designs (Oloye 2010, Omenihu 2016, Hassan 2016, Adewole 2014, Ayodeji 2011). Design-related causes of building collapse refer to those causes of building collapse that occur prior to the engagement of a contractor.

Broadly, design-related issues do not only refer to the inputs of the structural engineer, whose duty it is to analyse the structure for the optimum distribution of its dead and live loads [Olusola, K. O., Ojambati 2011]. Design related issues encompass decisions such as choice of site, financial provision for the project and other duties of the design team and the client. While it is generally expected that the structural engineer would have considered all relevant issues before arriving at a design, it is sometimes not the case. Despite this, structural engineers are hardly indicted for culpability for building collapse in Nigeria. Infirm implementation of building design and construction policies may be blamed for this. According to (Oloyede 2010, Fakere) policy control issues such as poor town planning approval/development monitoring process contribute to building collapse in Nigeria. According to professionals (Obot I. D. 2016, Ifedolapo), the government rarely make the sanctions against planning control defaulters public to serve as a deterrent to others who may wish to act the same way.

The lengthy litigation processes that usually follow building collapses in Nigeria often result in the public losing interest in the cases, without following throughout the final outcome. In some cases, buildings collapse as a result of clients' choice of difficult sites [Olusola 2011, Yunusa 2017] such as water-logged, made-up and marshy sites. Problematic sites necessitate the use of

expensive foundation types for which the client may not be financially prepared. In the traditional procurement method (predominantly practiced in Nigeria), the expertise of the design team bears heavily on the outcome of building projects. The contractor is merely employed to construct an already designed facility. As a result, extant flaws within the design, such as wrong assumption of the bearing capacity of the soil could lead to the building's structural failure, especially, if the contractor goes ahead to build exactly as designed. Conceptually, therefore, design-related factors affect the construction of a building and may lead to its eventual collapse. Construction-related factors are usually viewed as the immediate causes of building collapse, whereas the remote causes are sometimes design-related.

2.4.3 Construction Stage

Faulty construction has been the most important cause of structural failure. The engineer is also at fault here, if inspection has been lax. This includes the use of salty sand or wrong type of soil to make concrete, the substitution of inferior steel for that specified, bad riveting or even improper tightening torque of nuts, excessive use of the drift pin to make holes line up, bad welds, and other practices well known to the construction worker.

Normally, it is the responsibility of contractors to physically erect a building on site. The contractor works within certain constraints. He has an already made design to which he did not contribute. He has a site chosen by the client, which may be challenging construction-wise. It is expected of the contractor that he already possesses the capacity within his organization to surmount the construction challenge of the project. Nevertheless, insome cases, contractors lack the requisite manpower capacity to undertake a project. Ifedolapo (Ejiofor 2018) pointed out that to minimize incidences of building collapse in Nigeria, it is needful to be sure of the

competences of those who design, approve, supervise and erect buildings. Unfortunately, indigenous contractors in Nigeria are notorious for engaging quacks as supervisors of construction projects. Oloyede et al.(Oloyede, 2010) and Hassan et al. (Hassan, I. O., 2016) attributed the causes of building failure to faulty construction methodology, which results from the engagement of unqualified personnel. The use of quacks has been top of the list on the factors causing building collapse (Omenihu 2016, Hassan 2016, Essien 2017, Limaye 2014).Some authors believe that poor workmanship is a key factor contributing to building collapse in Nigeria (Omenihu 2016,Tanko, Ilesanmi 2012,Ayodeji 2011,Yanusa 2017).This could be related to the failure of the previously vibrant apprenticeship system in the Nigerian construction industry. It used to be common for upcoming artisans and tradesmen to stay under the tutelage of established artisans, and become independent only after mastering the trade.

Craftsmen of nowadays mostly accommodate only a brief stint with experienced artisans, and thereafter venture out on their own with inadequate knowledge and training. In some cases, collapse of buildings result from the use of poor quality materials during construction (Oloyede 2010, Akinyemi 2016,Osteraas 1988, Fakere, A., Olusola 2011, Ayodeji 2011). In the bid to reduce construction cost, the contractor or the client may reduce the quality of the material specified by the designer of a building. Compromises and other unethical practices by consultants and contractors encourage or directly lead to the use of poor-quality materials. Currently, a strong regulatory framework to ensure the use of only quality materials in building construction is absent. Although consultants are expected to ensure that the contractor utilized quality materials during construction, sometimes they abdicate this role due to unethical compromises with the contractor.

Inadvertently, hardly has any study attempted to statistically group the causes of building collapse in Nigeria in order to determine their taxonomy. Such a grouping can best be realized using an unsupervised statistical grouping technique that will circumvent researchers' biases and provide stakeholders with where to look for answers when a building collapses.

2.4.4 Service Stage

At the service stage, it ought to be ensured that the structure is not used for such a purpose that will lead to the imposition of load beyond the design provision. This has been the cause of certain failures.

An aspect widely neglected at the service stage is maintenance. Usage of structures results to certain deterioration like plumbing, electrical and sewage system, which require periodic servicing.

Apart from these, there are other major agencies, which cause deterioration and, consequently buildings require to be given the necessary attention to avoid eventual failure. Such agencies are:

2.4.5 Disasters

The major cause of collapse in the world scene is the occurrence of disasters. There are two classes of disasters. These classes are Natural and Man-made disasters.

Natural Disasters: Building could collapse as a result of natural disaster-heavy rainfall, volcanic eruption etc. failure could still occur after all concerned the client the consultants, contractors and others, must have taken all precautions. No building is design to withstand natural disaster

such as earthquake, floods, thunder storm, seepage, hurricane, scour, extremes temperature, biological and chemical effect; one or combination of these forced either manifest in foundation or structural failure, settlement due to the compressibility of the soil could leads to collapse of building.

Man-made Disasters: These are caused by the action of humans. They include: wars, bomb explosions, plane crashes, vehicular accidents, mining activities, and gas or chemical explosions. When these disasters occur, the effect is like that of natural disasters except that buildings may not be buried into the ground, but they may be totally grounded.

2.4.6 Poor Implementation of Housing Policies

Ineffective implementation of the building regulation and planning control have not achieved the desired technical, social and economic result, all the building professionals and controlling agencies are waiting to have a collapse before implementation of controls.

Apart from the effect of developmental control functions of some government agencies as felt in very few houses, most houses in our urban and rural areas were built without approved plans or the actual construction has actually deviated away from the approved plan. While buildings in developed countries retain their structural stability for many centuries, this is not the case for many buildings in Nigeria that show signs of failure within decades of their construction.

Proper implementation and enforcement of housing policies will require that only plans that are certified to be structurally stable be approved. It will also require that inspections be carried out to see to it that deviations from what was approved are not made, but that approved plans are followed to the details. Proper enforcement of housing policies still goes further to regulate the

condition of buildings in the society. Inspections are carried out to note the condition of the already existing structures on regular basis. Recommendations that expose structures that are on the way to failure are made.

2.4.7 Unprofessional Conduct

This is the national cankerworm that has permeated the total national fabric and involves improper demands made on contractors' payments by the CR's merely to certify quality test results (even when they satisfy specifications), payment certificates, additional works obtain payments, etc. Such unprofessional conduct inevitably force increases in the cost of contractors' production which he must recover, somehow, to stay in business.

2.5 EFFECTS OF BUILDING COLLAPSE IN EDO STATE

Failure is an unacceptable difference between expected and observed performance. A failure can be considered as occurring in a component when that component can no longer be relied upon to fulfill its principal functions.

2.5.1 Abrupt Loss of Lives and Property:

When a building suddenly caves in is no doubt very serious because it is always accompanied to unpreventable loss of innocent lives and their properties as well e.g. the collapse of The new Central Hospital, a 109 year old building under re-construction in Benin City killing an Italian

civil engineer, trapped several others in the wreckage and materials running into millions of Naira was destroyed.

2.5.2 Casualty:

The bitter lamentations at the scene were quite touching and thought-provoking but these have been the tradition for years now because there has been no record of a building that collapse in Edo state that has not resulted to serious injuries. Other effects of building collapse are; Homelessness and, insecurity to affected persons, theft at scenes.

2.6 SUPERVISION/INSPECTION (ENFORCEMENT ON SITE)

Though supervision can only be carried out by the Builder whiles the architect or engineer engage in the inspection of the work. Supervision involves the intricate knowledge of workmanship and materials while inspection is only to ensure adherence to contract documents especially the drawings. Aqua group stipulates that the object of supervision is primarily to ensure that employers requirements as expressed in the contract documents are correctly interpreted and the problems which are bound to arise are satisfactorily resolve. Averting building collapse depends largely on effective supervision of work.

2.7 PROTECTIVE MEASURES AGAINST BUILDING COLLAPSE

These are measures taken to avoid the development of failure in any residential building structure. These measures will help make residential building structures continue to remain in their structurally stable state; Alexander (2002) indicated that the following measure will have to be taken:

2.7.1 Underground Moisture Management

Moisture problems in existing basements are very common, but often are not understood or properly treated. In a basement that is seldom used and separate from the living spaces above, this may not present a great problem. However, most basements in Minnesota are connected to the rest of the house through ductwork or other openings.

In addition, basements are increasingly used as finished living and bedroom spaces. In these cases, moisture problems are not only annoying and uncomfortable, but can lead to significant health problems. Molds and mildew can grow in damp carpets and beneath wall coverings. Finishing a basement without first dealing with the moisture problems can result in making health conditions worse and lead to significant damage as well. Basement water problems are solvable, but there is a cost to doing it right. There are various approach to tackle this problem, some of them include:

Method 1: *Install proper gutters and downspouts and correct grading*

A great number of basement water problems can be solved by handling rainwater and surface drainage properly using gutters and downspouts with extenders or splash blocks to carry the

water away from the foundation. Sloping the grade away from the house, which may require hauling fill to the site, is very important. This should be done before any below-grade drainage system is installed, since the above-grade corrections may solve the problem. Even if a drainage system is required, removing water at the source as much as possible is necessary.

Method 2: *Exterior drainage system*

Installing an exterior drainage system at an existing building is the most costly, but also the most effective water control approach. This requires digging up the area around the foundation and rebuilding it similar to a new house installation. It also requires digging up shrubs and other obstacles around the house.

Usually, waterproofing and insulation are installed at the same time, in addition to making any repairs to the structure. The traditional exterior drainage systems use free-draining sand in the backfill. Drain tile can be placed beside or on top of the footing. Level drain pipe installations are satisfactory. A minimum of 12 inches of coarse aggregate should be placed around the drain tile.

2.7.2 Protection against Biological Attacks

Buildings can be protected against biological attacks by Weatherizing i.e. by sealing the building cracks around the doors and windows.

Cracks around windows and doors allow conditioned air to escape the building, and outdoor air to enter. Sealing these gaps can reduce the amount of air flow between the building and the environment, thus improving energy efficiency, and slowing the rate at which contamination enters the building from the surrounding.

In large buildings subject to very cold weather, reducing the leakiness of the upper floors can greatly reduce flows caused by the stack effect; such reduction is desirable because such flows can transport contamination rapidly through the building, and can contaminate stairwells that are needed for evacuation.

Many large buildings have a small exterior-surface-to-volume ratio. In such buildings, weatherization is unlikely to have a large effect on reducing casualties from an outdoor chemical/bio biological release. On the other hand, this improvement might pay for itself in a few years through reduced energy cost, and improve occupant comfort (especially in the offices on the perimeter of the building), in addition to potentially improving safety for a chemical/biological attack. Details of the cost-benefit trade-off will depend on construction details (such as the leakiness of the building shell), local energy costs and climate, and other factors.

2.7.3 Maintenance

The universe is dynamic and so is everything in it including our earth and the things in it. Some sets of universal laws are the guiding principles that will not allow the dynamism of the universe to get out of hand. Some natural laws keep our ever-dynamic earth not to digress from its orbit. An example of such law is the gravitational pull. Apart from that the earth regenerates and recycles its components as a natural means of maintaining itself.

2.8 THE ROLES OF GOVERNMENT AND PROFESSIONALS IN MITIGATING THE OCCURRENCE OF BUILDING COLLAPSE IN EDO STATE

When a building has already shown a feature or some features of structural failure, what remedy can be offered to correct such anomalies? Any measure taken to redeem such situation is termed corrective measures or remedies to structural failure. These measures will be discussed below under 3 different headings:

2.8.1 The Role of the Federal Government

The problem is that a lot of blame is put on the government. In as much as we must have a responsible government with a political will to make laws to regulate activities in the building industry, the truth is that people frustrate government's efforts and this makes enforcement difficult. Most times, substandard materials are used, incompetent and unqualified people are employed by building owners, and professionals are disrespected. If there is respect for professionalism and government has the political will to carry out its regulatory role, I think we can minimize incidence of building collapse; although it is a difficult thing to achieve. This is because we have some so-called professionals that are ready to compromise ethics for profits. We have clients that are also not ready to pay those that know the job. Sunday Oyediran, (2016) suggested that;

Producers of materials are also complicit. As far as I am concerned, the Standards Organization of Nigeria is a lame duck. Take the iron rod as an example of a very critical structural element. Iron rods come in length and diameter. When you get to the market and you need a rod of 12mm

diameter, you hardly get that. You can only get 11mm. So, when the structural engineer defaults here, those that are supposed to carry out the construction will also not be able to use the exactly defined material and this will result in a deficient construction work. The shortcuts by the producers are part of the problems that accumulate to the problem of building collapse.

The recurring incidence of building collapse in Nigeria is sad. One of the causes of building collapse is that inferior materials are used during construction works. Also, there is no thorough supervision by the relevant bodies and agencies of government. Before the construction or development of a property, a surveyor will have to survey the site; if the surveying is wrong, it will affect the building. So, government in all states of the federation should provide survey infrastructure to ensure accurate surveying of sites.

As one of the ways to check building collapse, the government should hold contractors of collapsed buildings responsible and punish them.

In addition, regulatory laws must be enforced in the sector. Some professionals do not do their work as they should, while some clients also do not care much. If a building collapses, all the professionals involved — the architect, surveyor and engineers — should be investigated, so that the actual person responsible would be discovered and punished.

There are many laws and regulations guiding construction and building of properties in the country, but those laws are not enforced. People do not obey laws; they just do what they want to do. Government should enforce the laws and regulations in the building industry.

Sadiq Afodun, (2016) insisted that;

- Government should also ensure that only competent people are given jobs. There should also be mass enlightenment so that clients will only give contracts to genuine

professionals. Many people dodge cost, but end up endangering the lives of people and also wasting resources.

- All the stakeholders in the building sector seem to be involved one way or the other in the collapse of buildings. But primarily, the government should ensure that professionals are given the job. The professionals, structural engineers, architects, should be allowed to play their roles. Also, there must be soil testing. The fact that one particular material worked in an environment may not necessarily make it work in another environment.
- Cutting corners is also one of the reasons of building collapse. There are people who are not honest, even when you have all the professionals there. By the time they are building, they are not using the right materials. Even when the materials are available, the so-called professionals are also changing some of the materials. So, thorough supervision is very important. I will advise the government to always make sure that professionals are involved and properly supervised, and the right materials are bought.

Hussein Oloyede, (2016) also stated that;

- Every progressive nation and well organized society is supposed to have laws that regulate the practice of building construction. Every nation is supposed to have a building code that provides such regulations. Unfortunately in Nigeria, the National Building Code has been submitted to the National Assembly for approval, but it has not gone through over the years.

- Secondly, in each state, there are supposed to be development control agencies at the ministry of physical planning and urban development. Before any building is developed, it is supposed to undergo due process, meaning there must be building plans submitted for approval and once all the necessary architectural and structural designs are checked, then there will be reduction in design failure. Once that is done, the main thing will be construction and government must ensure that the process on site conforms to the design. Most of the problems are on the site because people don't use professional builders certified to manage building production process. And if quacks are used, the foundation for failure has been laid.

According to KunleAwobodu, (2016), he said;

- The government also needs to do more in the area of manpower; they don't have enough hands to monitor activities on site. The government should organize a national conference on development control to address the issue of a building code and specification from foundation. The professional bodies should also come together and set up a development control resource center because development control under government is not working, according to engineers who work on site. Government must come up with specific legislations and set up specific standards. For instance, before a foundation is started, there should be specifications to follow. When the stage of blockwork starts, there must be specification and testing and there must be somebody to check the iron rods at the stage of putting the slabs to ensure it is of the acceptable standard. This should be done all the way to roofing. People die on slippery floors, so monitoring should be done all the way to finishing too.

- Government should create enough jobs for people in the area of monitoring. There are building checkers; they should be engaged. Then there should be strict penalties for failure, for everybody in the building construction chain.

Tonye Braide, (2016) suggested that,

There is also a need to develop a development control mechanism that is tied to insurance, so that when a building is subject to the right control mechanism process, its insurance premium will start to drop and when it doesn't go through the proper process, the insurance premium will be higher. And if there is a failure, if 50 people die for instance, if N10m is to be paid as compensation, the insurance will pay and immediately, the owner of the building will be made to pay about N500m bond, even if he has to sell his property. This will make developers to pay the right professionals lesser, such as N5m, than to pay N500m as compensation. If we must enforce anything, there must be punishment for offenders and reward for compliance.

2.8.1.1 Redress from Federal Government for Losses Sustained Through Building Collapse In Nigeria

- Council for Regulation of Engineering in Nigeria COREN, the Nigeria Institute of Builders NIOBS, the Nigerian Institute of Architects NIA, the Planning Authorities etc. and the Government should jointly work together.
- Demolition exercise should be carried out on the buildings that had gone beyond repairs and where possible, they should rehabilitate the ones that need rehabilitation.
- Quackery and non-professionals should be faced out by professional bodies, Federal, state and local govt. agencies.

- Mass housing units should be provided by the government and parastatals so as to assist the less privileged.
- More funds, vehicles, personnel, updated maps and the security of monitoring and enforcement staff should be ensured.
- The general public should be as well sensitized on the issue and incessant increase of building collapse and to avoid staying in dilapidated structures.
- Clients and the general public should as well be sensitized to construct their buildings to standard, consult professionals and avoid substandard materials for the construction of their abodes to avoid collapse building.

2.8.2 The Role of Construction Professionals

- The Architect

An architect is a qualified person appointed to prepare the architectural plans of the building works. The architect prepares building plans for approval and to supervise the architectural works during construction. The qualified architect is usually an architect registered and has in force a practicing certificate under the architectural act.

- Structural Engineer

This term refers to the qualified person appointed to prepare the structural plans of the building works. The structural Engineer for short prepares structural plans for approval and to supervise the structural works during construction. The qualified structural engineer must be registered in the branch of civil or structural engineering under the professional engineer's acts and has in force a practicing certificate under that act.

- Geotechnical Engineer

Geotechnical Engineer prepares the underground building works plans relating to the geotechnical aspects for approval and to supervise the geotechnical aspects of the works during construction. The qualified Geotechnical engineer is a specialist registered in the branch of geotechnical engineering under the professional engineer's acts and has in force a practicing certificate under that acts. While the geotechnical engineer is needed only when there are underground building works, a developer or builder should consider appointing a qualified geotechnical engineer for geotechnical aspects of any works if the site has difficult ground conditions.

- Quantity Surveyor

A Quantity Surveyor is a construction industry professional who specializes in estimating the value of construction works and can also be referred to as a 'Cost Engineer'. The Quantity Surveyor is exclusively responsible to carry out a detailed look on the priced bills and prepares a report. The term quantity surveying derives from the role taken in quantifying the various resources that it takes to construct a given project, such as labor, supervision, plant and materials. Quantity surveyors use their skills to determine the cost of building work ranging from small refurbishment works through to assessing the construction value of new multi-million naira road project. The Quantity surveyor is a key member of the design team. He is the essential link between the client who commissions a construction project, the architect and engineers who design it, and the builder who builds it. He is the expert in construction costs, construction

management and construction communication. Burgess, (1984), described him as ‘design light’ of the architect/engineers in the construction and allied industries.

- Building Services Engineer

Building Services Engineers bring buildings to life by designing the mechanical and electrical systems that allow people to function within an enclosed structure. Building service engineering involves the production and maintenance of a stable internal environment that has the correct temperature, air quality and lighting levels. It requires the provision of all the necessary backup support systems such as power, hot and cold water and lifts. The installation of life protection systems such as fire alarms, escape routes and sprinklers is an important responsibility as well.

- Project Manager

The Project Manager has the primary responsibility for planning a particular construction job and overseeing its progress along the way. The Project Manager looks over a proposed project to determine how and when the work will be performed. The Project Manager also develops a deliverable schedule to provide a road map that the construction team must stick to in order to finish the job in a timely and constructive manner. The construction manager or project manager must review the project in depth in order to be prepared to handle tasks that come up along the way (Obiechina, 2005). The construction project manager is not only responsible for planning the work and making sure it gets done, but also supervising the hard hats who do it. That means coordinating and directing the efforts of construction workers.

2.8.3 The Role of Building Regulatory Authority

Building regulatory authorities have the role of carrying out a vocation exercise of the structural stability of houses in their areas of authority with a view to advising on the possible rectification where possible, while those beyond repairs should be demolished before causing more havoc to the society.

Owners of buildings that are not structurally stable should be served notices that would make them know the structural stability of their building and what measures to be taken within a specified period. When such buildings are slated for demolition, arrangements should be made without delay to evacuate all occupants and demolition should follow. Monitoring of the situation of residential and commercial buildings should be carried out regularly and punishments or fines should be meted on building owners of structures that were found flawed.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter explains the methodology and the approach to data collection in this study. The chapter is organized in the following manner. It will discuss extensively on the research design, target population, sampling frame, sampling size, sample technique, data collection instrument, procedure/means of data collection as well as the method of data presentation and analysis.

3.2 RESEARCH DESIGN

This study was carried out with the use of case study method involving survey study. The survey study was most suitable for the study because it gives room for site assessment and data collection.

Relevant data were collected from secondary sources through the investigation of past building collapse in Nigeria. Analysis of past documents from both internal and external sources (in various incidence of building collapse in Edo State) was adopted as the research instruments in gathering data (secondary data). The data (regardless of the location and based on the available information) were partly gotten from The Nigeria Institution of Building, previous research works and various newspapers (through the dailies and their website).

The analysis of the collected data was carried out using the following descriptive and analytical scientific methods: percentiles, Pearson product moment, correlation coefficient and regression analysis.

Pearson Product Moment Correlation Coefficient (r): This method was adopted in this research to assess the causal relationship between building collapse and its causes. The basis of decision according to Okonko (2001) is shown below:

Table 3.1 Shows the Relationship between the Correlation Coefficient and Nature of Relationship.

Table 3.1 Relationship between the Correlation Coefficient and Nature of Relationship

Correlation Coefficient	Nature of Relationship
0.0 to 0.30 (0.00 to -0.30)	Little or no correlation
0.30 to 0.50 (-.30 to -.50)	Low positive (negative) correlation
0.50 to 0.70 (-.50 to -.70)	Moderate positive(negative) correlation
0.70 to 0.90 (-.70 to -.90)	High positive (negative)correlation
0.90 to 1.00 (-.90 to -1.0)	Very high positive(negative) correlation

3.3 DATA COLLECTION INSTRUMENT

The data for the study were generated through the results gotten from laboratory test conducted in samples obtained from the sites (building collapse sites visited) and also through a well-structured questionnaire survey. This approach was used in the study due to the qualitative nature of this research.

3.4 METHOD OF DATA COLLECTION

Data were obtained from Auchi, and Benin City in Edo State. As the research study involve the use of case study method, these data were collected from main building collapse site across this town and city, namely; Federal Girls Junction, Off Ugbowo Road, Benin City; No. 24 Idonije Street, Off Up-garage Road Auchi; No. 10 Egbeadokhai Street, Off General Hospital Road, Auchi; No. 22 Egbeadokhai Street, Auchi; and No. 30 Inu-Umuru Street, Auchi. Also, closed questions type of questionnaires were used as a means of data collection. These questionnaire were distributed to professionals in the construction field in Edo State (including Civil Engineers, Architects, and Quantity Surveyors)

3.5 COLLAPSE SITE ANALYSIS

The following analyses were carried out on the five chosen cases to help in determining the actual cause(s) of building collapse in Edo State. It includes;

3.5.1 CUBE TEST

The compressive strength of the concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Concrete compressive strength for general construction varies from 15 MPa (2200 psi) to 30 MPa (4400 psi) and higher in commercial and industrial structures.

Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during the production of concrete, etc. Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates. Test for compressive strength is carried out either on a cube or cylinder. For this study, the test for compressive strength was carried out on cube samples. Various standard codes recommend a concrete cylinder or concrete cube as the standard specimen for the test.

To carry out this experiment, first the dimensions of the samples in each case were taken. The bearing surface of the testing machine and the cube was placed in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast. The specimen was aligned centrally on the base plate of the machine. The movable portion was rotated gently by hand so that it touches the top surface of the specimen. The load was applied gradually without shock and continuously at the rate of $140 \text{ kg/cm}^2/\text{minute}$ till the specimen fails. This was done for the harvested blocks in each of the cases.

3.5.2 STRUCTURAL ANALYSIS

Structural design is an essential aspect in most civil engineering; it deals directly with the structural strength and integrity of buildings or structures. Structural designs are used to ensure the safety and stability of the structure before the addition of creative designs into the structure and these designs also help to provide all crucial information about foundations, walls, floors, roof types, steep beams, material quality, and more to ensure that the structure is built to be safe and sound. In this study, the structural analyses of the five cases were analyzed, in order to obtain information about the foundations, walls, floors, beams and column. This is done to ascertain if the cause of collapse was a result of structural failure (failure of any of the structural members). This analysis was done with respect to the principles of structural design and design codes.

3.5.3 QUESTIONNAIRE

Questionnaires are research instruments consisting of a series of questions for the purpose of gathering information from respondents. They provide a quick and efficient way of obtaining information from a large sample of people or from a targeted audience. For these reasons, this research involved the use of a well-structured questionnaire to acquire information from professionals in the civil engineering field on the causes and effects of building collapse in Edo State, including measures to mitigate the occurrence of building collapse in the state.

3.6 VALIDITY TEST

Dilman's study (as cited by Oni, 2010) recommends that pre-testing the questionnaire should be carried out and that it should include different groups, such as colleagues and potential users of the data. Therefore, in order to confirm that data collected is comprehensive and to establish the most productive firm of data analysis, the initial draft of the questionnaire must be presented to researcher's supervisor and pre-tested within colleagues. The input and result generated from the data should be used to refine the questionnaire before general survey will be carried out.

3.7 METHODS OF DATA PRESENTATION AND ANALYSIS

There is need to employ appropriate method of data analysis so as to accurately process these data. Hence, the case study method is used for the analysis of this project. Case study method is the most widely used method in academia for researchers interested in qualitative research (Baskarada, 2014). Research students select the case study as a method without understanding array of factors that can affect the outcome of their research. Since considerable time and resources are required in conducting researches (General Accounting Office, 1990), any sort of misapprehension regarding the research objective and application of the methodology as well as the validation of the findings may lead to unintended negative consequences (Baskarada, 2014).

Due to the long-lasting significance of quantitative research methodology, most business researchers are trained extensively in quantitative methods as compared to qualitative methods (Eriksson & Kovalainen, 2015). Secondly, it has been observed that management researchers have quite limited repertoire of methodological approaches to work with while conducting the

researches (Bazeley, 2015; Molina-Azorín & Cameron, 2015). The multiple case studies used in this research as an application of step-by-step guideline are specifically designed to facilitate these business and management researchers.

This research presents an easy to read, practical, experience-based, step-by-step guided path to select, conduct, and complete the qualitative case study successfully. As mentioned before, the objective is not to criticize or review the existing literature on case study method. Rather, attempt is made to synthesize what we already know for new researchers that can save their time and lead them toward a right direction.

CHAPTER FOUR

4.1 DATA PRESENTATION AND ANALYSIS

This chapter focuses on analyzing the data collected through laboratory experiments, structural analysis and a field survey (structured questionnaire).

4.2 COLLAPSE SITE ANALYSIS

Table 4.1 shows results of the compressive strength of blocks harvested from the collapse sites used in this study.

Table 4.1: Compressive Strength of Blocks Harvested From the Collapse Sites

S/N	SAMPLES	COMPRESSIVE STRENGTH (N/mm ²)
1	Case 1	14.04
2	Case 2	12.60
3	Case 3	9.89
4	Case 4	16.58
5	Case 5	8.41

Table 4.2 provides information on the structural detailing of the individual cases.

Table 4.2: Structural Detailing of the Collapse Sites

Case 1	Depth of Footing	4.2m below ground level
	Type of Foundation	Shallow foundation
	Size of beam	355mm x 320mm
	Beam reinforcement	2 bars of 10mm thickness bottom, 2 bars of 10mm top
	Size of column	200mm x 260mm
	Column reinforcement	4 bars 10mm steel @120mm c/c
	Thickness of slab	97.5mm (3.8")
	Slab reinforcement	Y10@100mm c/c
	Grade of concrete	M20
Case 2	Depth of Footing	4m below ground level
	Type of Foundation	Shallow foundation
	Size of beam	300mm x 310mm
	Beam reinforcement	2 bars of 8mm thickness bottom, 2 bars of 8mm top
	Size of column	225mm x 250mm
	Column reinforcement	4 bars 10mm steel @120mm c/c
Case 3	Depth of Footing	4.2m below ground level

	Type of Foundation	Shallow foundation
	Size of beam	350mm x 320mm
	Beam reinforcement	2 bars of 12mm thickness bottom, 2 bars of 10mm top
	Size of column	225mm x 250mm
	Column reinforcement	4 bars 12mm steel with stirrups of 8mm steel rings @150mm c/c
Case 4	Depth of Footing	3.9m below ground level
	Type of Foundation	Shallow foundation
	Size of beam	290mm x 280mm
	Beam reinforcement	2 bars of 8mm thickness bottom, 2 bars of 10mm top
	Size of column	200mm x 260mm
	Column reinforcement	4 bars 10mm steel @120mm c/c
Case 5	Depth of Footing	3.8m below ground level
	Type of Foundation	Shallow foundation
	Size of beam	295mm x 300mm
	Beam reinforcement	2 bars of 10mm thickness bottom, 2 bars of 10mm top
	Size of column	200mm x 250mm
	Column reinforcement	4 bars 8mm steel @130mm c/c

The figures below display the results gotten from the questionnaires distributed.

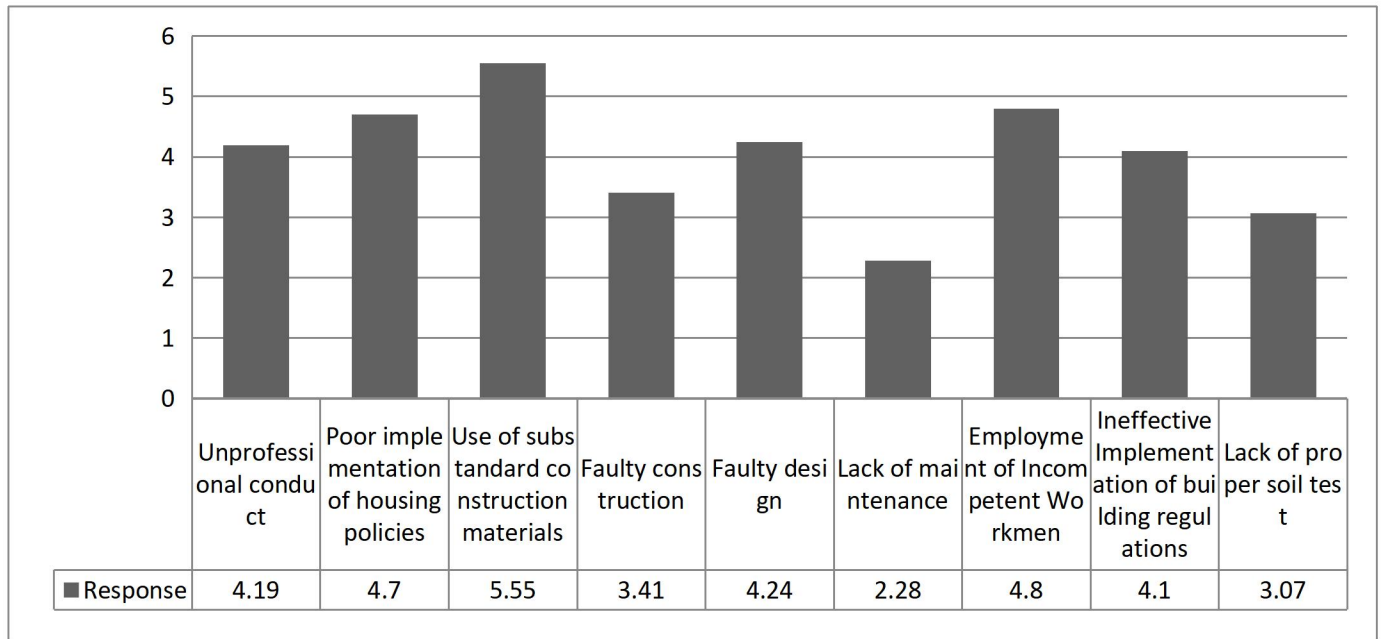


Figure 1: Questionnaire Responses on the Causes of Building Collapse in Edo State.

Fig. 1 shows the identified causes of building collapse in Edo State from the registered respondents. It shows that the identified causes such as; Employment of Incompetent workmen which was ranked 1st; Poor implementation of housing policies was ranked 2nd; Use of substandard construction materials was ranked 3rd; Unprofessional conduct was ranked 4th; Faulty construction was ranked 5th; Faulty design was ranked 6th; Lack of Maintenance was ranked 7th; Ineffective Implementation of building regulations was ranked 8th; Lack of proper soil test was ranked 9th.

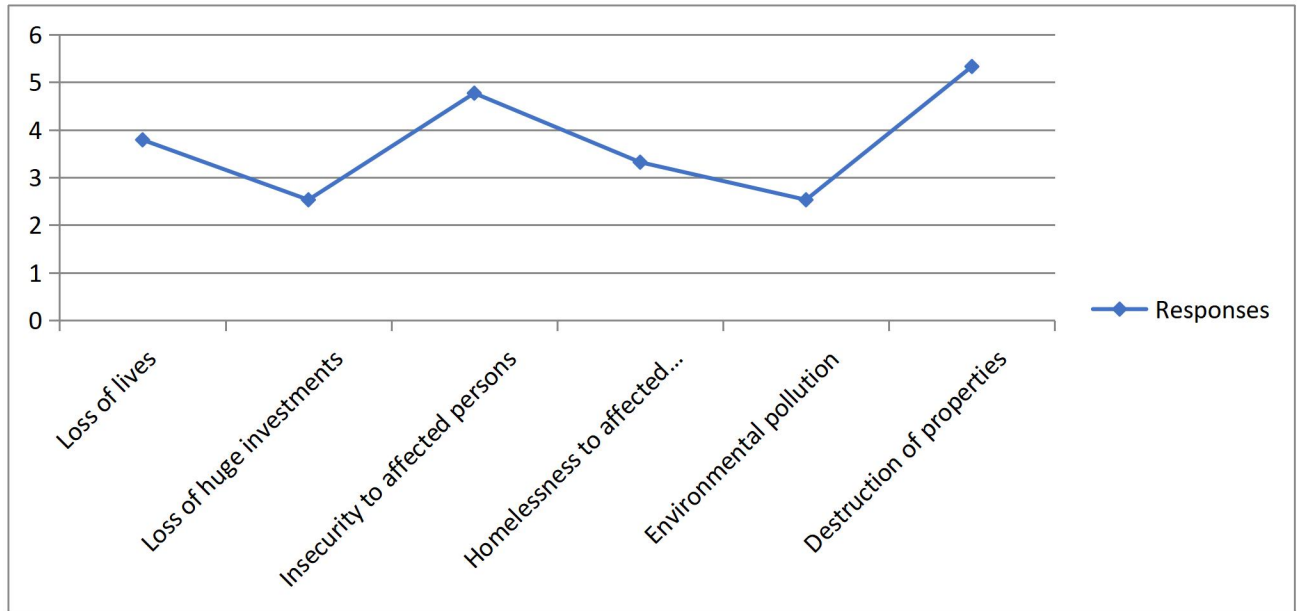


Figure 2: Questionnaire Responses on the Effects of Building Collapse in Edo State.

Fig. 2 reveals the identified effects of building collapse in Edo State. Destruction of properties was ranked 1st; Insecurity to affected persons was ranked 2nd; Homelessness to affected persons was ranked 4th; Loss of lives was ranked 3rd; Environmental pollution was ranked 5th; Loss of huge investments was ranked 6th.

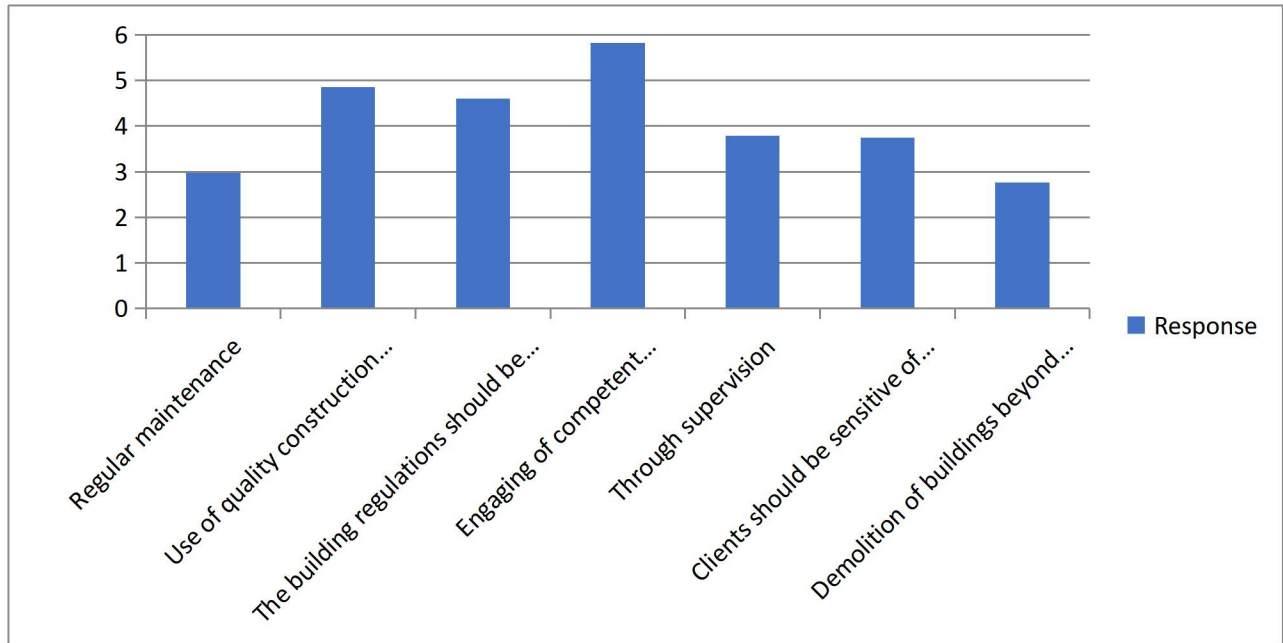


Figure 3: Questionnaire Responses on the Measures to Mitigate the Occurrence of Building Collapse in Edo State.

Fig. 3 shows the measures to mitigate the occurrence of building collapse in Edo State. Engaging of competent professionals ranked 1st. Use of quality construction materials ranked 2nd. The building regulations should be adhered to ranked 3rd. Clients should be sensitive of quality works ranked 4th. Through Supervision ranked 5th. Regular maintenance ranked 6th, and Demolition of buildings beyond repairs ranked 7th.

4.3 ANALYSIS OF THE COLLAPSED BUILDINGS

The causes of the various cases of building collapse were discussed according to the case-study method which was used in this research.

4.3.1 Collapsed building Site at Federal Girls Junction, Off Ugbowo Road, Benin City, Edo State. - Case 1

- Type of building – Public
- Purpose of building – Commercial
- No. of floors - 2
- Date of Collapse – 2020
- Calamities – Nil
- Type of building contractor – Indigenous

The experimental and structural analysis shows that the causes of collapse in case 1 includes; low compressive strength of blocks, faulty design specifications, and use of sub-standard construction materials.

The blocks harvested from the collapsed building site (case 1) gave a compressive strength of 14.04 N/mm^2 , and this indicates that the concrete is of a fairly low compressive strength and one of the vital factors responsible for low compressive strength is the usage of substandard construction materials; which is also one of the top causes of building collapse from the questionnaire results.

Result from the structural analysis indicates that the building was erected with a column of cross-sectional dimension 200mm x 260mm with 4 bars 10mm steel @ 120mm c/c as opposed to the standard minimum size; 225mm x 300mm with 4bars of 12mm with stirrups of 8mm steel rings at a distance of 150mm c/c; beam size of 200mm x 225mm, 2 bars of 10mm thickness bottom, 2 bars of 10mm top as opposed to 350mm x 350mm, 2 bars of 12mm thickness in the bottom and 2 bars of 10mm at the top of the beam; slab thickness of 97.5mm (3.8”) as opposed to 125mm (5”). Foundation met the minimum standard of 1m depth. The occurrence of wrong structural design is most common due to unprofessional and when incompetent workmen are being hired.

4.3.2 Collapsed Building Site at 30, Inu-Umuru Street, Auchi, Edo State - Case 2

- Type of building – Private
- Purpose of building – Residential
- Date of Collapse – 2012
- No. of floors - 1
- Calamities – 2
- Type of building contractor – Indigenous

Results gotten from this research indicate that the causes of collapse in case 2 include low compressive strength of blocks and poor structural design.

With a Compressive strength of 12.60 N/mm^2 , the harvested block from Case 2 was also recorded to have a low compressive strength, and this can be the cause or contributing factor to the cause of collapse.

However, from the design results it show that the building was erected using a shallow foundation, with 4m depth of footing, a column of cross-sectional dimension 225mm x 250mm

4 bars 10mm steel @120mm c/c as opposed to the standard minimum size; 225mm x 300mm with 4bars of 12mm with stirrups of 8mm steel rings at a distance of 150mm c/c; beam size of 300mm x 310mm, 2 bars of 8mm thickness bottom, 2 bars of 8mm top as opposed to 350mm x 350mm, 2 bars of 12mm thickness in the bottom and 2 bars of 10mm at the top of the beam; and this analysis says that the design specification are slightly off the minimum standard.

4.3.3 Collapsed Building Site at 10, Egbeadokhai Street, Off General Hospital Road, Auchi, Edo State - Case 3

- Type of building – Private
- Purpose of building – Residential
- No. of floors - 1
- Date of Collapse – 2008
- Calamities – Nil
- Type of building contractor – Indigenous

Analysis shows that the collapse in case 3 happened as a result of low compressive strength of blocks used during construction, which was most likely as a result of wrong mix-ratio of blocks and low quality of cement.

After experimental procedures, case 3 gave a result of 9.89 N/mm^2 compressive strength of blocks, which signifies that the blocks were not made with the right specifications, making this one of the possible reasons of collapse. As when the compressive strength of blocks or concrete blocks are low in compressive, it won't be able to hold the designed load for that structure.

The analysis of this case shows a column of dimension 225mm x 250mm with 4 bars 12mm steel with stirrups of 8mm steel rings @150mm c/c; beam size of 350mm x 320mm, 2 bars of 12mm

thickness bottom, 2 bars of 10mm top as opposed to 350mm x 350mm, 2 bars of 12mm thickness in the bottom and 2 bars of 10mm at the top of the beam. With depth of footing, 4.3m below ground level exceeding the minimum standard of 4m.

4.3.4 Collapsed Building Site at 24, Idonije Street, Off Up-garage Road Auchu, Edo State - Case 4

- Type of building – Private
- Purpose of building – Residential
- No. of floors - 1
- Date of Collapse – 2014.
- Calamities – Nil
- Type of building contractor – Indigenous

The cause of collapse in Case 3 was analyzed to be a result of faulty structural design of the building.

Block sample in Case 4 was tested to have a compressive strength of 16.58 N/mm^2 , exceeds standard minimum standard. So this factor couldn't have been the cause collapse of the building. Reviewing the structural detailing of this case, the building was constructed using a column of cross-sectional dimension 200mm x 260mm, 4 bars 10mm steel @120mm c/c; beam size of 290mm x 280mm, 2 bars of 8mm thickness bottom, 2 bars of 10mm top; and 3.8m foundation depth. From analysis, these design specifications do not meet the minimum standards for structural design, making it most likely the cause of collapse.

4.2.5 Collapsed Building Site at 22, Egbeadokhai Street, Auchu, Edo State - Case 5

- Type of building – Private
- Purpose of building – Residential
- No. of floors - 1
- Date of Collapse – 2010
- Calamities – Nil
- Type of building contractor – Indigenous

Wrong design of structural members and very low compressive strength of the blocks made are the reasons for collapse of the building.

Sample 5 (Case 5) was recorded to have a compressive strength of 8.41 N/mm^2 , recording the lowest strength amongst all the samples. Also contributing to this, comparison of the results from the structural analysis indicates that the building was erected with a column of cross-sectional dimension 200mm x 250mm with 4 bars 8mm steel @130mm c/c as opposed to the standard minimum size and reinforcement; 225mm x 300mm with 4 bars of 12mm with stirrups of 8mm steel rings at a distance of 150mm c/c; beam size of 240mm x 285mm, 2 bars of 8mm thickness bottom, 2 bars of 18mm top as opposed to 350mm x 350mm, 2 bars of 12mm thickness in the bottom and 2 bars of 10mm at the top of the beam. The depth of footing was also found to be 3.8m below ground level.

CHAPTER FIVE

5.1 CONCLUSION AND RECOMMENDATION

In the preceding chapter, analysis and interpretation of data were presented. This chapter however deals with summary of findings and conclusions of this research. Recommendations are also provided which will be aimed at reducing the causes of building collapse.

5.2 SUMMARY OF FINDINGS

This research has posited various factors responsible for the incessant causes of building collapse in Edo state to be employment of incompetent workmen, use of substandard materials coupled with poor implementation of housing policies. Hence, examining the compressive strength of all the various samples tested, they are all relatively poor in quality and this is mostly as a result of wrong water-cement ratio, low cement strength, poor quality of concrete material, and lack of quality control during the production of concrete. It was also discovered that the structural design of most of the cases in this study were neglected, and this can play major role in the cause of collapse, as the right reinforcement and proper formation of structural members for the building will not be done.

This research also found out that the issue of lack of sub-soil investigation to determine the soil carrying capacity before erection of building has in no measure contributed to the continuous incidence of building collapse in the state. From the research conducted, most areas in Edo State is known to have well-compacted soil with high bearing capacity.

Data analysis revealed that these incidents of building collapse in Edo State has led to the horrors of destruction of properties, insecurity to affected persons, homelessness to affected persons and loss of lives.

5.3 CONCLUSIONS

Building development in all its ramification is more than shelter. It entails processes evolve in stages. The stages involved include; the planning, designing, costing, and execution of the project by professional in accordance with the legal provision, bye-laws, standards and specifications.

The urban space system is noted for its juxtaposition with urban development and activities. Although building collapse is less in Edo State, it is not uncommon to find decay and dilapidation of buildings in other major states in Nigeria. This trend extends not only to residential building but to other land uses. The level of decay and dilapidation is traceable to several factors ranging from poor planning, faulty designs, poor implementation, ineffective monitoring, high level of corruption, to lack of proper maintenance just to mention but a few.

From this research, it is clear that building failure in Edo State occur mainly due to the following reasons: Incompetent and untrained workmen, Lack of proper design, and Lack of proper construction procedures and observance of the necessary quality control measures required for construction works. And it is only the provision of quality physical development closely monitored effectively from the design stage by the appropriate proficient professional would provide good live ability, adequate safety as well as reduce the dilapidation, distress and eventual collapse.

5.4 RECOMMENDATION

From this research work it is my belief that the following will significantly help policy makers in their quest to finding lasting solutions to the menace of building collapse in Edo state.

- The development control department should be made of professionals with high degree of integrity who would place ethical standards above other considerations.
- Builders and developers should be kept abreast of recent developments in the building industry by attending workshops and forum also there is a need for re-certification and retraining of stakeholders in building environment.
- Proper structural design calculations and drawings should be presented to planning offices before approval for construction is given.
- Planning authorities should ensure a client employs a qualified engineer for the supervision of his project.
- All sectors of the building and construction industry should limit themselves to their areas of specialization to forestall occurrence of failure.
- Qualified engineers should be employed by planning authorities to properly check structural calculations and drawings to ensure proper design.
- Planning authorities should insist on soil investigation where there are doubts as regards the data used for the foundation design of a building.
- Professional societies in the building industry should produce training programme aimed at integrating young graduates into their various societies and sound professional practice.

REFERENCES

- Adewole, K., Oladejo, O. and Ajagbe, W. “Incessant Collapse of Buildings in Nigeria: The Possible Role of the Use of Inappropriate Cement Grade/Strength Class”, *International Journal of Civil and Environmental Engineering*, Vol. 8, Number 7, 2014, pp 832-837.
- Ayodeji, O. “An Examination of the Causes and Effects of Building collapse in Nigeria”, *Journal of Design and Built Environment*, Vol.9, 2011, pp 37–47.
- Barker, M. (2003). Assessing the “quality” in qualitative research: The case of text-audience relations. *European Journal of Communication*, 18, 315–335. Google Scholar | SAGE Journals | ISI
- Baskarada, S. (2014). Qualitative case study guidelines. *The Qualitative Report*, 19, 1–25.
- Baxter, P., Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report*, 13, 544–559.
- Bazeley, P. (2015). Mixed methods in management research: Implications for the field. *Electronic Journal of Business Research Methods*, 13, 27–35.
- Beverland, M., Lindgreen, A. (2010). What makes a good case study? A positivist review of qualitative case research published in *Industrial Marketing Management*, 1971–2006. *Industrial Marketing Management*, 39, 56–63.
- Building Collapse: Causes, prevention and remedies (pp. 88-94). The Nigerian Institute of Building, Ondo State.

- Chinwokwu, G. (2000). The role of professionals in averting building collapse. Proceedings of a workshop on Building collapse: Causes, prevention and remedies (pp. 12-28). The Nigerian Institute of Building, Lagos State.
- Dare, S. (2002). Building design, build ability and site production. In D.R. Ogunsemi (Ed.), Building Collapse: Causes, prevention and remedies (pp. 74-87). The Nigerian Institute of Building, Ondo State.
- Fadamiro, J.A. (2002). An assessment of building regulations and standards and the implication for building collapse in Nigeria. In D.R. Ogunsemi (Ed.), Building Collapse: Causes, prevention and remedies (pp. 2839). The Nigerian Institute of Building, Ondo State.
- Fakere, A., Fadairo, G. and Fakere, R. “Assessment of Building Collapse in Nigeria: A Case of Naval Building, Abuja, Nigeria”, International Journal of Engineering and Technology, Vol. 2, Number4, pp 584-591.
- Famoroti, F. (2006, March 30). Before the next building collapse. The Punch (p. 9).
- Hassan, I. O., Abeku, D. M. Salihu, C. and Maxwell, S. S. “Buildings Collapse and Socio-Economic Development of People in the Federal Capital Territory, Abuja, Nigeria”, International Journal of Economic Development Research and Investment, vol. 7, Number 2, 2016, pp 51- 64.
- Obot. I. D. and Archibong, A.E. “Collapsed Buildings in Nigeria”. Global journal of engineering research, Vol. 15, 2016, pp 11-15.

- Odulami, A.A. (2002). Building materials specification and enforcement on site. In D.R. Ogunsemi (Ed.), *Building Collapse: Causes, prevention and remedies* (pp. 222-7). The Nigerian Institute of Building, Ondo State.
- Ogunsemi, D.R. (2002). Cost control and quality standard of building projects. In D.R. Ogunsemi (Ed.).
- Okonko, E. (2001). *Quantitative Techniques in Urban Analysis*. Ibadan; Kraft Books Limited.
- Oloyede, S. A., Omoogun, C. B. and Akinjare, O. A. “Tackling Causes of Frequent Building Collapse in Nigeria”, *Journal of Sustainable Development*, Vol. 3, Number 3, 2010, pp 127-132
- Olusola, K. O., Ojambati T. S. and Lawal, A. F. “Technological and Non–Technological Factors Responsible for the Occurrence of Collapse Buildings in South –Western Nigeria”, *Journal of Emerging Trends in Engineering and Applied Sciences*, Vol. 2, Number 3, 2011, pp 462-469.
- Olusola, K.O. (2002). Structural stability of building structures. In D.R. Ogunsemi (Ed.), *Building Collapse: Causes, prevention and remedies* (pp. 50-73). The Nigerian Institute of Building, Ondo State.
- Olusola, K.O., Ata, O. & Ayangade, J.A. (2002). Quality and Structural Strength of concrete Blocks produced in Ile-Ife: A preliminary Investigation. *Journal of Environmental Technology*, Federal University of Technology, Akure, 1(1&2): 136-142.

Omenihu, F. C., Onundi, L. O. and Alkali, M. A. “An Analysis of Building Collapse in Nigeria (1971-2016)”, Challenges for Stakeholders. University of Maiduguri Annals of Borno, Vol, 26, 2016, pp 113-140.

Oxford Advanced Learner Dictionary. (2002). Jonathan, C., Kathryn, K. & Michael, A. (Ed.). Oxford University Press, 5, (p. 219).

Yunusa, A. and Sada, B. “Appraisal of Residential Building Collapse, Causes and Solution in Sokoto State Nigeria”, Journal of Mechanical and Civil Engineering, Vol.6, Number 4, 2017, pp 44-63.

APPENDICES

A. Case 1: Federal Girls Junction, Off Ugbowo Road, Benin City, Edo State.

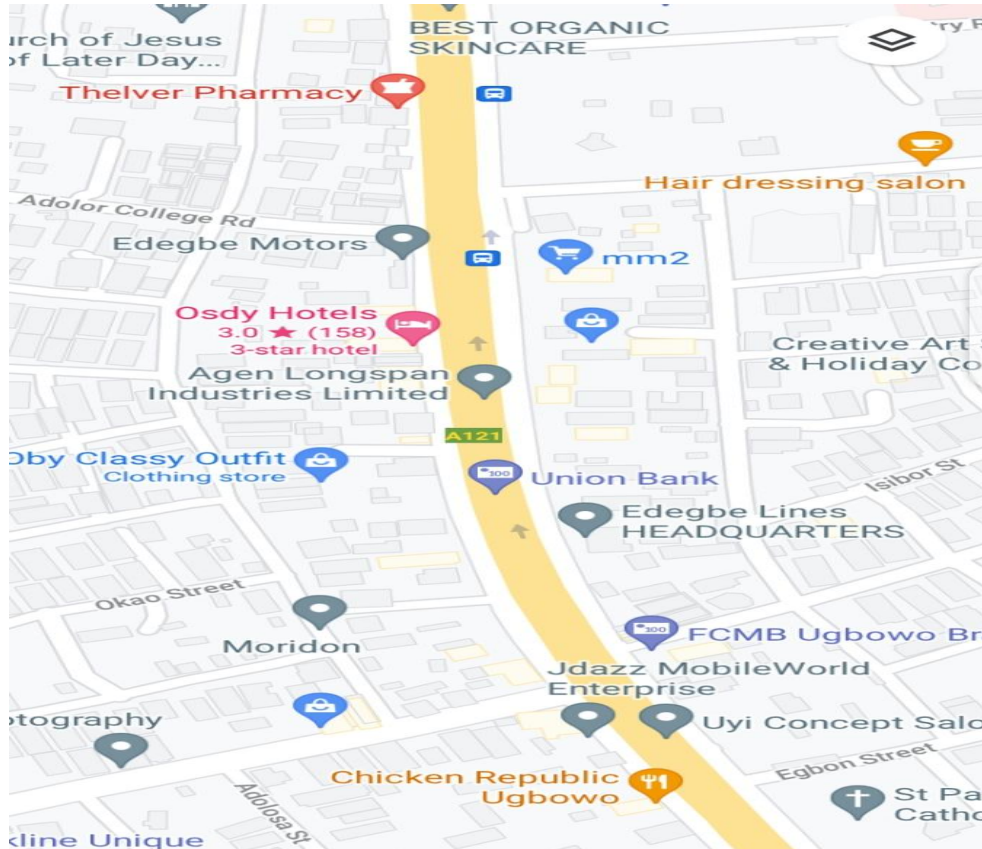


Figure A-1: Map showing location of case 1



Figure A-2: Building before collapse



Plate A-3: Building after collapse

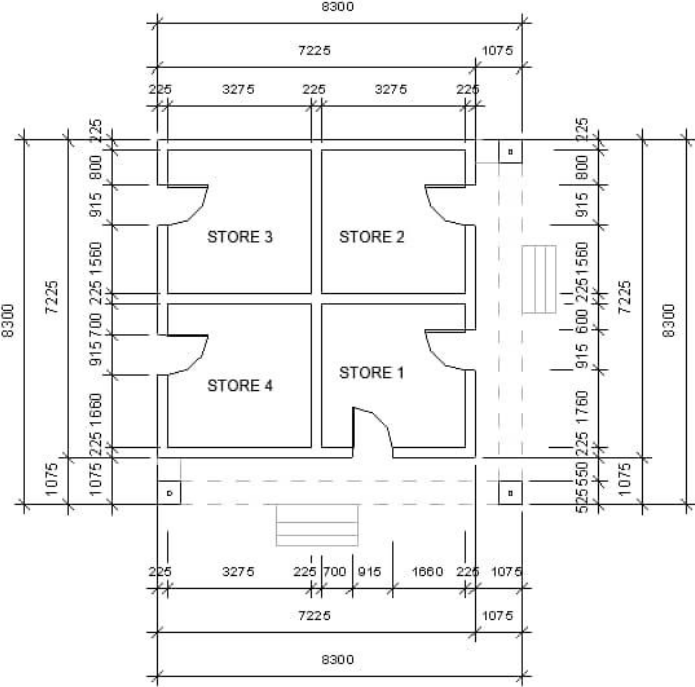


Figure A-4: Building plan

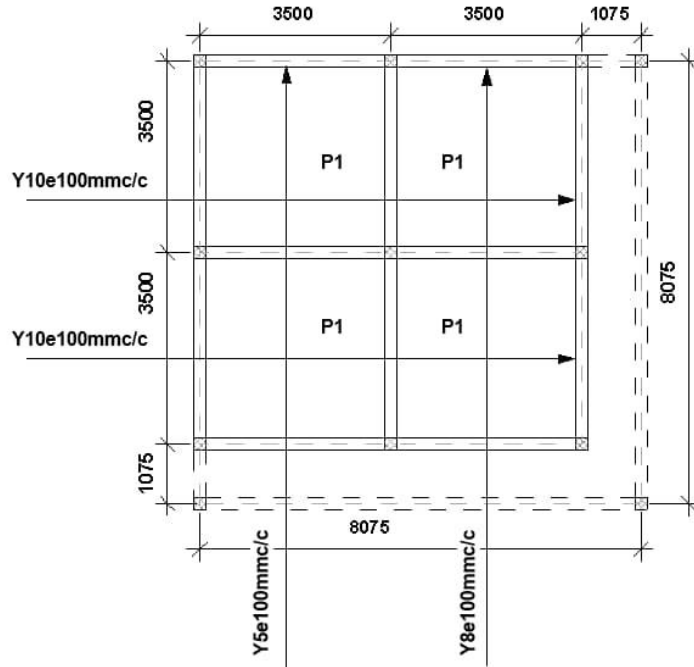


Figure A-5: Slab detailing

B. Case 2: No. 30 Inu-Umuru Street, Auchi, Edo State.

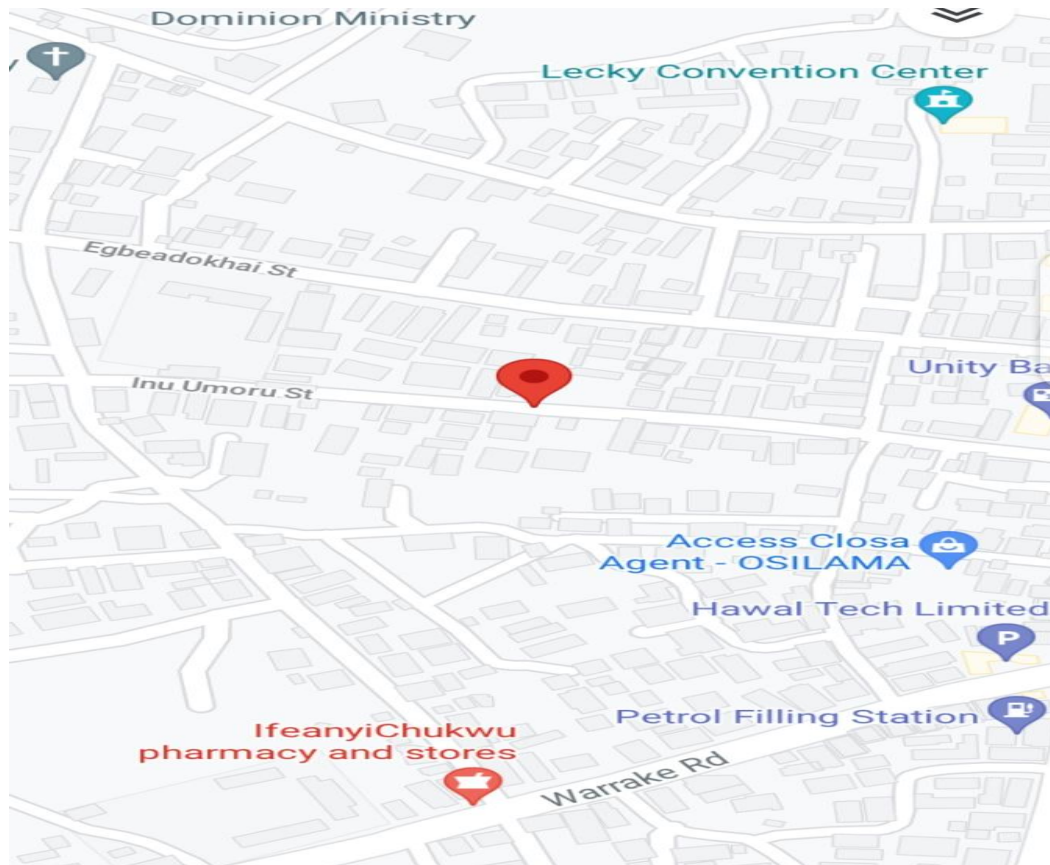


Figure B-1: Map showing location of case 2



Plate B-2: Building before collapse



Plate B-3: Building after collapse

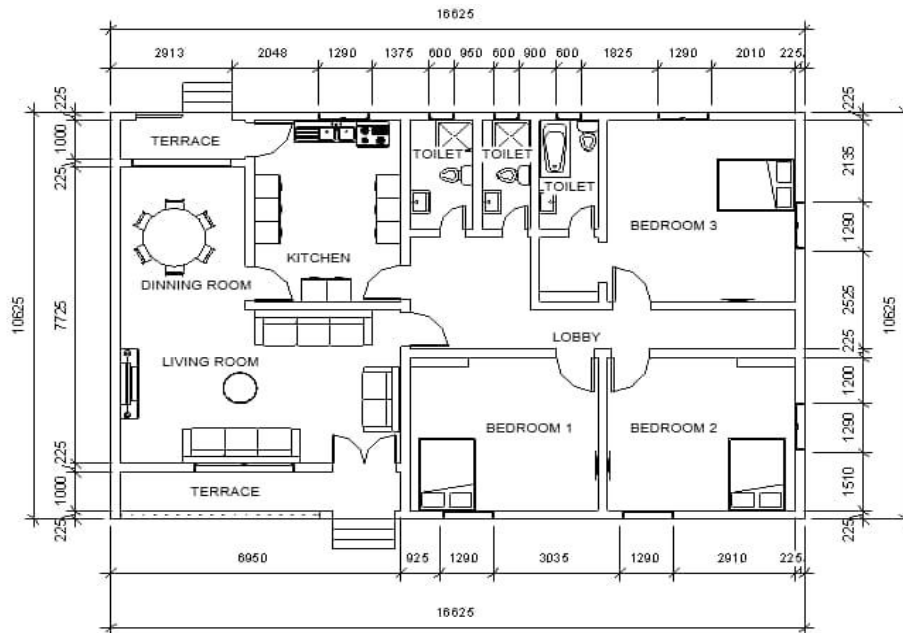


Figure B-4: Building plan

C. Case 3: No. 10 Egbeadokhai Street, Off General Hospital Road, Auchi, Edo State.

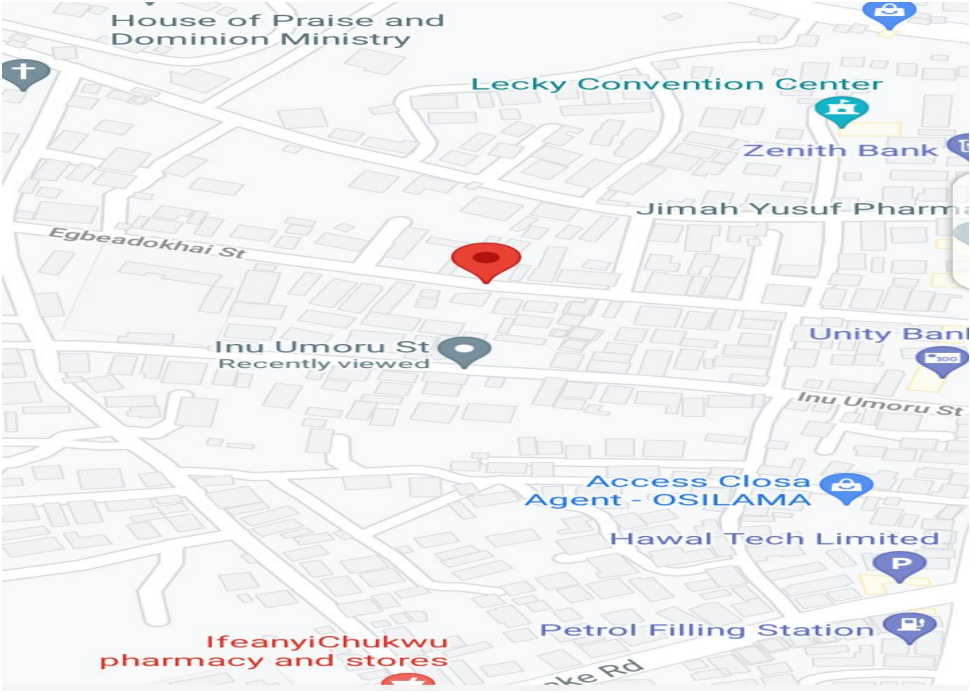


Figure C-1: Map showing location of case 3



Plate C-2: Building before collapse



Plate C-3: Building after collapse

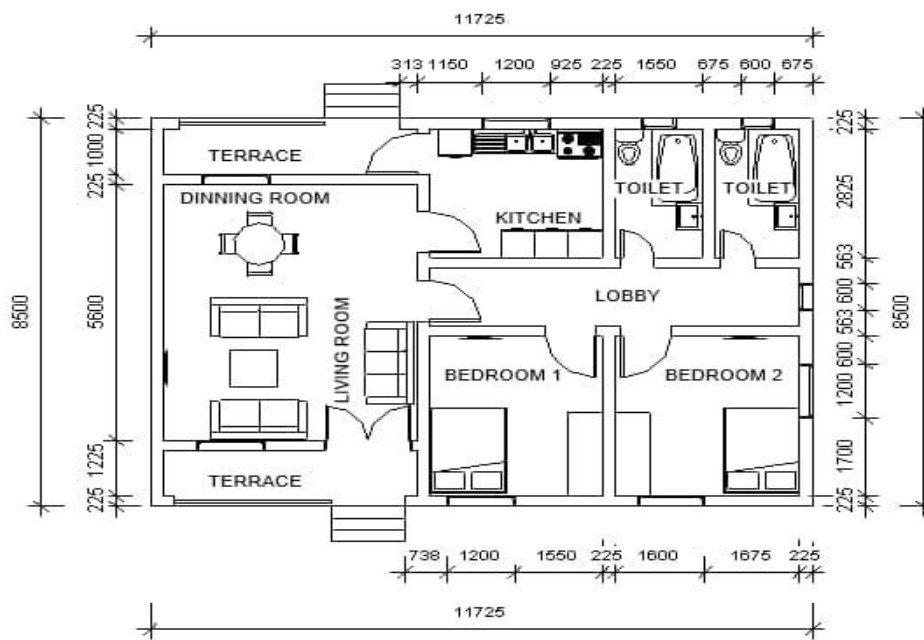


Figure C-4: Building plan

D. Case 4: No. 24 Idonije Street, Off Up-garage Road Auchi, Edo State.

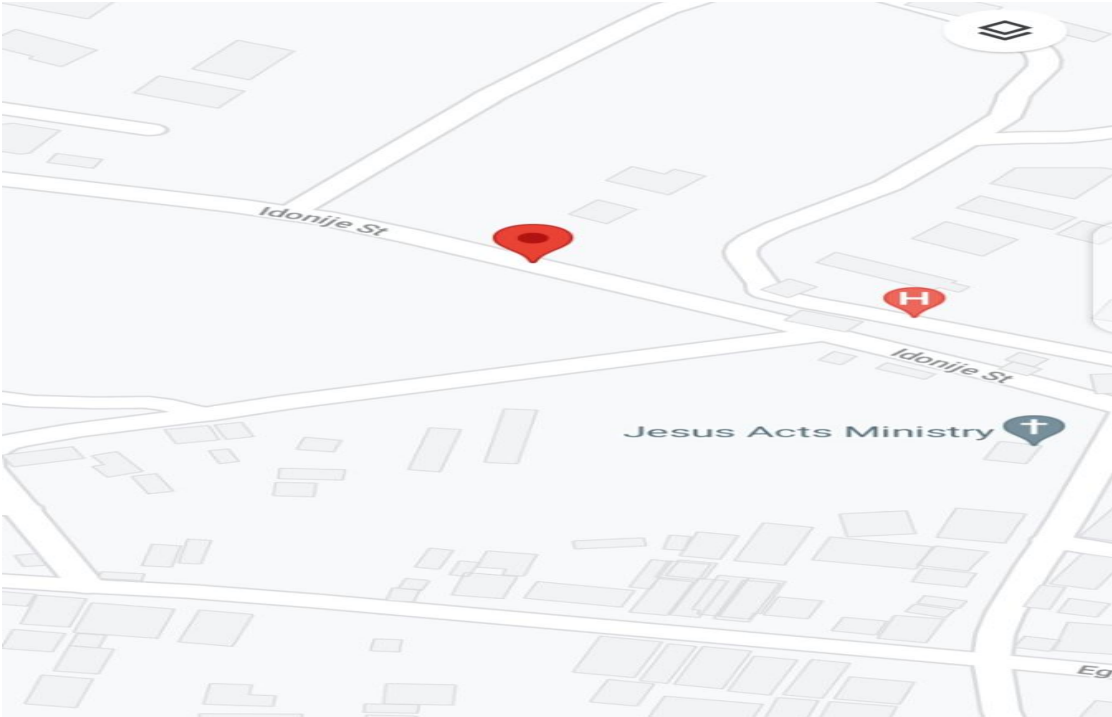


Figure D-1: Map showing location of case 4



Plate D-2: Building before collapse



Plate D-3: Building after collapse

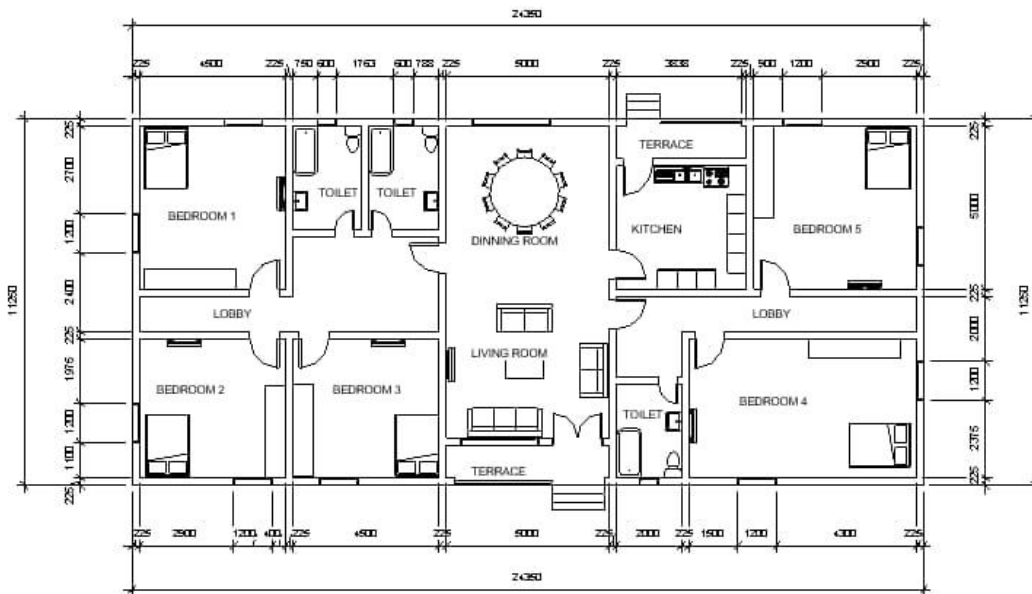


Figure D-4: Building plan

E. Case 5: No. 22 Egbeadokhai Street, Auchi, Edo State.

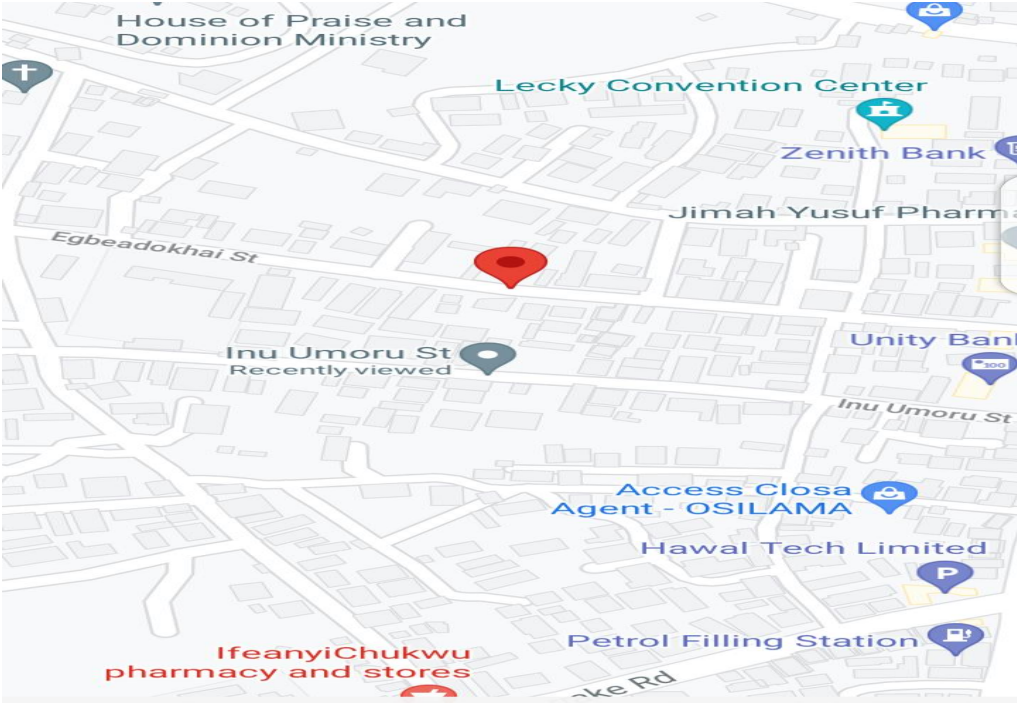


Figure E-1: Map showing location of case 5



Plate E-2: Building before collapse



Plate E-3: Building after collapse

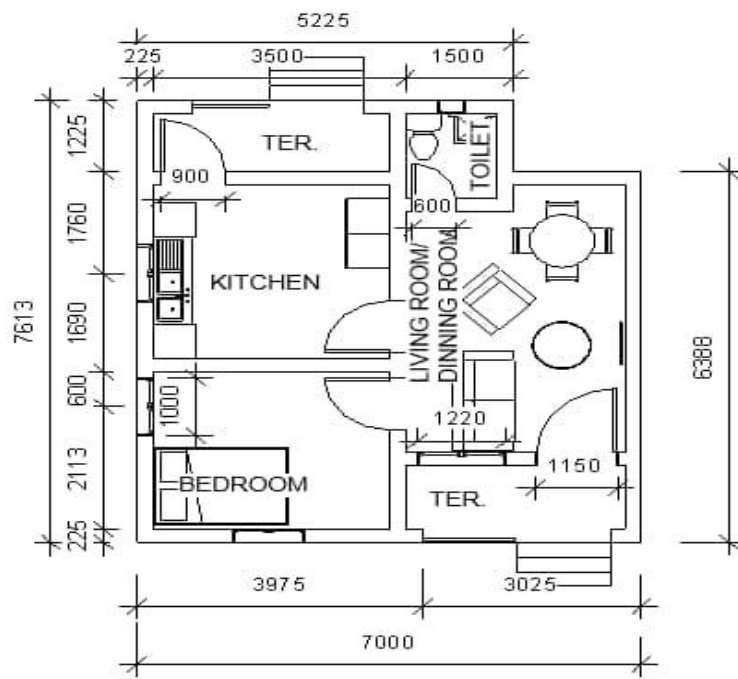


Figure E-4: Building plan

F. QUESTIONNAIRE

Please tick () as appropriate

1. Organization type
(a) Client [] (b) Contractor [] (c) Consultancy [] (d) others (specify)
2. Company or firm size
(a) Small [] (b) Medium [] (c) Large [] (d) other (specify)
3. Category of projects undertaken
(a) Building project [] (b) Civil Engineering project [] (c) Heavy Engineering project [] (d) other (specify)
4. Respondents years of experience
(a) 1-5 years [] (b) 6-10years [] (c) 11-15 years [] (d) 16-20 years [] (e) above 20 years []
5. For how long has your firm been in operation?
(a) 1-5 years [] (b) 6-10 years [] (c) 11-15 years [] (d)16-20 years [] (e) above 20 years []
6. Number of construction project handled?
(a) 1-5 [] (b) 6-10 [] (c) 11-15 [] (d) 16-20 [] (e) above 20 years[]
7. Discipline of Respondents
(a) Architect [] (b) Engineer [] (c) Quantity Surveyor [] (d) Builder [] (e) others (specify)
8. Academic qualifications of respondents
(a) HND [] (b) B.sc/B.Tech/PED [] (c) M.sc/M.phi [] (d) PHD [] (e) others (specify)
9. Professional qualification of respondents
(a) Probation member [] (b) Corporate member [] (c) Fellow member [] (d) others (specify)
10. Have you been involved in any construction project? (a) Yes [] (b) No []
11. Numbers of construction projects executed by your firm since the inception (a) 1-5 [] (b) 6-10 [] (c) 11-15 [] (d) 16-20 [] (e) over 20 []

SECTION B

Kindly rate on a scale of frequency, the frequency of building collapse in Edo State Nigeria.

1. Do building collapse occur frequently in Edo State? (a) Yes [] (b) No []
2. Do you agree that building collapse have been a major concern in Nigeria and is a threat to human lives and properties in Edo State? (a) Yes [] (b) No []
3. The following have been identified as the causes of building collapse in Edo State Nigeria. Rank the various causes in order of severity using the scale below: 5 = very severe; 4= severe; 3= neutral; 2 = low and 1 = very low.

S/N	Identified Causes of Building Collapse in Edo State Nigeria	Ranking				
		5	4	3	2	1
i	Unprofessional conduct					
ii	Poor Implementation of Housing Policies					
iii	Faulty Design					
iv	Faulty Construction					
v	Use of Substandard Construction Materials					
vi	Lack of Maintenance					
vii	Employment of Incompetent Workmen					
viii	Ineffective Implementation of Building Regulations					
ix	Lack of Proper Soil Test					

4. The following have been identified as the effects of building collapse in Edo State Nigeria. Rank the various effects according to the order of severity using the scale below: 5 = very severe; 4= severe; 3= neutral; 2 = low and 1 = very low.

S/N	Identified Effects Of Building Collapse in Edo State Nigeria	Ranking				
		5	4	3	2	1
i	Loss of Lives					
ii	Destruction of Properties					
iii	Homelessness to Affected Persons					
iv	Insecurity to Affected Persons					
v	Loss of Huge Investments					
vi	Environmental Pollution					

5. The following have been identified as the measures to mitigate the occurrence of building collapse in Edo State Nigeria. Rank the identified measures in order of relevance using the scale below: 5 = very relevant; 4= relevant; 3= moderate; 2 = low and 1 = very low.

S/N	Identified Measures To Mitigate the Occurrence Of Building Collapse in Edo State Nigeria	Ranking				
		5	4	3	2	1
i	Regular Maintenance.					
ii	Buildings must Conform to Specification.					
iii	The Use of Quality Materials.					
iv	Thorough Supervision					
v	Engaging of Competent professionals					
vi	Demolition of Buildings that had gone beyond repairs.					
vii	Clients should be Sensitive of Quality Construction.					
viii	The Building Regulations should be adhered to.					