HIERARCHICAL ASSESMENT OF FACTORS LEADING TO BUILDING COLLAPSE: A CASE STUDY OF BENIN CITY

BY

OKOYOMOH, OSHOLEAKHUE AYOMIKUN

ENG1905210

UNIVERSITY OF BENIN,

BENIN CITY

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A PROJECT SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.Eng) IN THE DEPARTMENT OF CIVIL ENGINEERING, FACULTY OF ENGINEERING.

SUPERVISOR: PROF. OGHENEALE U. ORIE

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PLAGIARISM

This work **HIERARCHICAL ASSESMENT OF FACTORS LEADING TO BUILDING COLLAPSE: A CASE STUDY OF BENIN CITY** by OKOYOMOH, Osholeakhue Ayomikun with matriculation number ENG1905210 of the Department of Civil Engineering, Faculty of Engineering, University of Benin City, Edo State, Nigeria, has PASSED the PLAGIARISM TEST.

PROJECT COORDINATOR:

Name: Engr. Ehi E. Oria-Usifo

Signature and Date: ----------

CERTIFICATION

This is to certify that this work was carried out by Okoyomoh, Osholeakhue Ayomikun, Mat. No. ENG1905210, of the Department of Civil Engineering, Faculty of Engineering, Faculty of Engineering, University of Benin City, Edo State, Nigeria

SUPERVISOR

Professor Ogheneale U. Orie

Signature and Date: ----------

HEAD OF DEPARTMENT:

Engr. Prof. Ngozi I. Ihimekpen

Signature and Date: ----------

DEDICATION

This work is dedicated to my parents, Mr. & Mrs. Okoyomoh for their unwavering and indefatigable support, to my course mates, for festering the spirit of solidarity in me, to all my lecturers, for their guidance throughout my time in this hallowed institution, to my time in this esteemed department and to God Almighty, for his watchful hand over me.

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ABSTRACT

Building collapse remains a persistent challenge in urban areas across Nigeria, with Benin City experiencing a notable frequency of structural failures. It is a devastating phenomenon that leads to the destruction and loss of property and lives This paper represents a study on the hierarchical assessment of the underlying factors causing building collapse in the city of Benin. Utilizing a multi-criteria decision-making approach, the research categorizes and ranks the causes based on expert interviews, field observations, and documented case studies. Key factor examined include poor construction practices, substandard materials, inadequate regulatory enforcement, design flaws, and environmental influences.

The hierarchical assessment process employs the use of structured questionnaire to gather data from professionals in the construction industry and ranks these causes based on the most voted factors into primary, secondary and tertiary factors revealing poor construction materials, inadequate supervision and regulation, corruption, poor workmanship and repurposing of buildings to be the most primary factors. Lack of proper engineering design, overloading, poor foundation work, weak enforcement of building codes and member failure to be secondary factors. Negligence and lack of maintenance, rapid urbanization and natural disasters to be tertiary factors.

Recommendations to curb or reduce the issue of building collapse in the city of Benin are strict enforcement of building codes and regulations, quality control and material testing, enhanced professional training and certification, combating corruption, public awareness campaign, urban planning and zoning regulation, promotion of preventive maintenance, establishment of a building collapse response task force, encouraging use of technology in construction.

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Relative Important Index (RII)

Ultrasonic Pulse Velocity Test (UPVT)

Nondestructive Test (NDT)

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Building collapse remains a significant issue globally, particularly in urban environments, due to rapid urbanization, aging infrastructure, and, at times, insufficient construction practices. The collapse of buildings can lead to loss of life, property, and economic damage. Over the years, various factors contributing to these collapses have been identified, ranging from material failure, structural design issues, poor construction practices, natural disasters, and inadequate maintenance.

The study of the causes of building collapse is crucial for improving safety standards, engineering practices, and urban planning. Understanding the hierarchical assessment of these factors helps in identifying the most influential causes and their interrelationships, thereby guiding effective preventive measures.

The theme of building collapse encompasses multiple disciplines, including engineering, architecture, construction management, urban planning, and materials science. Building collapse often involves complex interactions between structural, environmental, human, and economic factors. Various methods of assessment have been used to study the causes and impacts of building failures, including forensic analysis, safety audits, and risk assessments.

Building collapse can occur at any stage of a building's life cycle—during construction, at the point of occupancy, or even after years of use. The collapse can be partial or total, and its causes are often a combination of multiple factors. Hierarchical assessment seeks to analyze these factors in a structured manner to identify root causes and to rank them based on their severity and interdependencies.

1.2 Statement of the Problem

This project seeks to provide a hierarchical analysis of the factors leading to building collapse.by breaking down the contributing factors into primary, secondary and tertiary causes, this study aims to uncover the root causes, interactions, and cascading effects that ultimately result in structural failure.

1.3 Aim of the Study

The aim of this study is to determine the causes of building collapse using Hierarchical Analysis Method in order to proffer solutions to these factors causing the collapse.

The specific objectives of this study are to:

i. Identification of the underlying causes leading to the collapse of buildings.
ii. Assessment of the risks associated with the building collapse and their impact.
iii. Recommendations of strategies designed to prevent or minimize building collapse.

1.4 Scope of Study

The scope of this study includes:

i. Investigation of various reports of building collapse in Benin City.
ii. Identification of the various factors leading to collapse.
iii. Analysis of data gotten from Investigation using Hierarchical Analysis Method.
iv. Recommendations of solutions designed to curb the issue of building collapse in Benin City.

1.5 Justification of Study

Building collapses remain a significant global issue, resulting in loss of life, economic damage, and social disruptions. Despite advances in construction, there is still a need for a comprehensive understanding of the factors contributing to structural failure. This study offers a hierarchical assessment of these factors, focusing on the complex interaction between design flaws, material quality, human error, and environmental influences. By systematically analyzing these causes, the study provides a clear framework for prioritizing interventions to improve building safety.

The findings from this research will be instrumental for policymakers, engineers, and construction professionals, guiding better decision-making in design, construction, and maintenance practices. By identifying critical risk factors, the study will help prevent future collapses, saving lives, reducing economic losses, and ensuring that buildings meet higher safety standards. It will also inform regulatory bodies in updating building codes and enforcement measures, fostering a more proactive approach to preventing structural failures.

Ultimately, this study aims to address the current gaps in understanding the root causes of building collapses, offering practical solutions to mitigate risk. By improving building practices, raising public awareness, and providing data-driven recommendations, the research will contribute to safer, more resilient cities, reducing the human and financial costs of building failures in society

CHAPTERTWO

LITERATURE REVIEW

2.1 Fault Design/Construction/Structural Defects

Oseghale et al. (2015) carried out a study that looked into the causes of building failure and assessed how building failure impacts costs in Lagos State, Nigeria. To gather information, the researchers used questionnaires given to professionals in the construction sector and conducted case studies at different sites. They used purposive sampling to pick the sites visited and the professionals involved. For analysing the data, descriptive statistics like frequency distribution, percentages, and mean response analysis were applied. The research found that the main causes of building failure included poor design, bad construction practices, excessive loading, lack of approved drawings, not following approved drawings, and the involvement of unqualified individuals.

Olusola et al. (2011) wrote a paper that looked into both technological and non-technological factors leading to building collapse in South-Western Nigeria. Technological issues included design flaws, site errors, poor material use, and weak foundations. Non-technological factors were identified as lack of skilled labour, corruption, and more. The paper offered conclusions and recommendations aimed at helping the government apply current frameworks more effectively to reduce or eliminate building collapses.

Ebehikalu and Dawam (2014) looked into the issue of building collapse in Nigeria by reviewing related studies. Their research used both primary and secondary sources of data. Primary data was collected through on-site inspections and field investigations. The data were analysed using a mix of qualitative and quantitative techniques. The findings

showed that building collapses were caused by things like structural faults, poor supervision and workmanship, use of low-quality materials, bad or missing structural design, negligence, heavy rain, weak foundations, overloading, illegal modifications, failure to follow building regulations, rushed or poor construction, uninformed or greedy clients, and lack of drainage or dilapidated structures.

George et al. (2020) carried out a case study on a one-story building that had partially collapsed, focusing on identifying the exact cause through technical assessment in order to suggest repair solutions. This involved a thorough engineering analysis of the structural parts of the building and consideration of possible repair methods. Field inspections were done by digging around the building's foundation to check its condition, collecting soil samples for lab analysis, and performing non-destructive tests. Observations from the inspections showed that the construction lacked proper supervision, and the building was under-reinforced, which led to major cracks and bending. The study highlighted how crucial it is to have proper supervision and quality checks during the construction of framed buildings. The proposed solution was to bring in professionals to redesign the structure following building standards, followed by cracking, chiselling, and excavation to reconstruct the building with strict supervision.

Kumalasari and Fabian (2003) analysed 225 building failure cases in the United States from 1989 to 2000. They found that 63% of these failures occurred in low-rise buildings. The most common causes were external events and poor construction or maintenance. A comparison with earlier studies revealed an increasing trend in failures involving both low-rise and multistorey buildings. The authors suggested the development of comprehensive databases and better sharing of building failure information to prevent similar incidents in the future.

Moses et al. (2015) looked into the specific reasons for the collapse of a three-story building in Ile-Ife. The analysis included reviewing the initial building design and construction work. Findings showed the structure was poorly designed in critical areas such as beams and columns, and the construction quality was low due to inexperience or negligence by the contractor. Despite having enough reinforcement in some parts, the design failed to consider critical factors like cantilevers, leading to the building's failure. The study concluded that under-design, bad concrete mix, and lack of supervision were major contributors.

Cynthia and Norbert (2005) reviewed a building collapse in London caused by a gas explosion. Investigation revealed major flaws in the tower's design and construction, especially the lack of a structural frame and alternate load paths. The precast concrete panels were poorly connected, which made the building vulnerable. These flaws led to updates in building codes across several countries, incorporating stronger “robustness” or structural integrity provisions.

Obiora et al. (2022) reviewed a study that investigated what caused the collapse of an unfinished three-story building in Oko, Anambra State, Nigeria. The study used a qualitative approach that involved subsoil and geotechnical tests, along with destructive testing of structural components like concrete, reinforcement bars, and blocks. These tests were done to understand soil quality and material strength. The CPT results showed that the subsoil was very weak and that the sand used was not suitable for concrete. The findings indicated that the collapse was due to a poor foundation, improper concrete mix, and use of low-quality materials.

Claude and Cautier (2015) reviewed various building collapse cases in Cameroon and explored the reasons behind them. They gathered data through questionnaires given to

building professionals, as well as site visits and case studies. The study found that common causes of collapse included lack of soil investigation, poor foundation and structural designs, environmental wear and tear, and the use of low-grade materials and concrete mixing techniques.

Katkukah and Mije (2023**)** assessed the causes of frequent building collapses in Jos town by visiting sites shortly after incidents and reviewing secondary data. Their findings pointed to poor concrete quality, reduced sizes of structural components, inadequate design, and the absence of professional supervision. The study highlighted that many private developers bypass experts to save costs, leading to catastrophic results.

Miodray et al. (2017) detailed the process of determining the causes behind a specific building collapse. The investigation pointed to a mix of poor design, faulty execution, and disregard for proper permitting and supervision. Structural issues in rebar detailing and failure to follow building codes were noted. The study used documentation analysis, site inspections, interviews, and regulation reviews to reach its conclusions and highlighted that safety margins in the structure were insufficient.

Timothy et al. (2021**)** evaluated the collapsed Nigerian Medical Association Hall/office complex using the Ultrasonic Pulse Velocity Test (UPVT). The findings showed substandard concrete quality in beams and slabs, and questionable structural integrity of underground columns, pointing to these as the likely causes of the collapse.

Obi et al. (2021) studied five collapsed buildings in Anambra State, using both destructive and non-destructive testing methods. The research identified use of unqualified workers, lack of proper quality control, and poor detailing and specifications as major causes. A sensitivity analysis was applied to assess which factors most affected

the structural performance, enabling the researchers to offer informed engineering recommendations.

Daniel et al. (1992) presented a detailed summary of a lift-slab collapse investigation, which included background details, on-site observations, laboratory tests, computational analyses, and conclusions. The study identified the likely cause of collapse as instability in steel wedges at a specific column, which led to slab support failure and triggered a progressive collapse. Recommendations were made to prevent similar failures in future lift-slab constructions.

Renan and Ramani (2018) analysed the 2011 collapse of the Real Class residential building in Belem, Brazil. They used structural and architectural plans alongside site data to assess the failure. The study concluded that the building's columns and foundations could not withstand local wind loads, and the structure experienced excessive displacements, ultimately resulting in collapse.

2.2 Use of Substandard Materials

Adebowale et al. (2016) wrote a paper that explored the causes and effects of building collapse on Nigeria's economy. The goal was to provide useful information that could help prevent such incidents, both in the study area and in other developing countries. The causes of building failure were linked to both natural and human-related factors. Surveys in Nigeria pointed to reasons like the use of poor-quality materials, unskilled labour, hiring of non-professionals, lack of enforcement of building codes, and corruption in the construction sector. These issues have largely contributed to many building failures. The consequences include building collapses that negatively impact lives and investments. In 2014 alone, over 120 deaths due to building collapse were recorded in Lagos. Similar

cases happened in Port Harcourt and Abuja. The study suggested that stakeholders in the construction field should follow building codes strictly, the Standard Organization of Nigeria (SON) should make sure only certified materials are sold, and the government should actively monitor construction sites by enforcing relevant laws to improve the industry.

Ayedin et al. (2012) conducted a study aimed at finding out the main causes of building failure and collapse from the views of key stakeholders, including building professionals, contractors, and property owners or developers. The study intended to provide practical suggestions to help prevent future incidents. Lagos State was chosen as the focus due to the high number of building collapses reported there. To meet the goal of the research, questionnaires were randomly distributed to professional Estate Surveyors, Structural and Civil Engineers, contractors, and landlords/developers in the study area to gather their opinions on building collapse issues. The study found several causes such as poor-quality materials, bad workmanship, hiring unqualified contractors, wrong construction methods, heavy rainfall, developers and contractors not following standards, lack of proper supervision, and unauthorized modifications to buildings. It suggested that all stakeholders, including professionals and developers, should be properly educated on the dangers of building collapse and the importance of safety when constructing buildings.

Hillary and Chinedu (2021) used a survey research method to look into why residential buildings collapse in Nigeria and the implications this has on technical education. The study involved a few selected members of the Builders' Institute in Port-Harcourt, with data gathered through questionnaires and analyzed using mean and standard deviation. The study found that one of the key reasons for frequent building collapse is the presence

of unqualified individuals in the industry. They recommended strict adherence to the National Building Code for all residential construction activities.

Paul (2020) explored the primary causes, effects, and preventive strategies related to building failure and collapse, focusing on Port-Harcourt. Both primary and secondary data were used, with questionnaires administered to professionals and key stakeholders. The findings, analyzed using the Relative Importance Index (RII), highlighted the use of substandard materials, lack of qualified professionals, flawed designs, and poor maintenance as leading causes. Recommendations included awareness campaigns, stricter laws, enforcement of building codes, and the adoption of sustainable practices, particularly for high-rise constructions.

Joseph (2022) carried out a research project aimed at identifying the causes, effects, and solutions to building collapse in Rivers State. Stakeholders in the construction industry were given questionnaires to capture their insights. The results, analysed using mean scores, indicated that building collapses were mainly due to foundation and structural failures, use of poor materials and equipment, unskilled labour, and other factors like explosions and impact events.

Anthony et al. (2018) discussed the importance of non-destructive testing (NDT) in evaluating the structural integrity of concrete columns. Using tools like the Profoscope rebar locator, the study successfully identified one column that failed the reliability test, demonstrating the effectiveness of NDT in preventing building failures due to hidden defects.

Abiodun and Timothy (2018) presented a paper that brought together insights from past literature, field research, and personal observations to examine why buildings continue to

collapse in Nigeria. They discovered that most collapses were caused by poor design, outdated buildings that had not been maintained, low-quality materials, and lack of supervision. The authors argued that unless urgent actions are taken, achieving sustainable development in Nigeria will remain difficult. They proposed several well-reasoned recommendations to improve the quality and safety of buildings nationwide.

Suzanne and Norbert (2004**)** reported on the partial collapse of a 16-story apartment building, caused by low concrete strength due to cold weather exposure. The investigation revealed serious lapses in quality control, supervision, and accountability, with no clear responsibility assigned for structural safety.

2.3 Professionalism, Supervision and Stakeholder Responsibility

Adenuga (2014) studied the role of professionals in building collapses in Lagos State. The research used a survey approach, distributing 65 questionnaires to professionals in the construction industry, with 50 returned and analysed. The sampling was done randomly. Results showed that many unqualified and inexperienced contractors operate in the industry. Additionally, weak leadership and poor site management by engineers and builders contributed to building failures. The study suggested that only certified and licensed engineers and builders should be allowed to design and supervise construction work. It also emphasized the need to enforce the professional code of conduct strictly to prevent unethical practices.

Olasunkanmi (2022) carried out a study that explored how professionals in government agencies and other public and private organizations understand the causes of building collapse, and the steps taken by Lagos State to prevent and respond to such disasters. The study used purposive snowball sampling to select 42 participants for detailed interviews.

The research found that building collapse is a common issue in the area and is mainly driven by failures in the system and human mistakes. It also revealed that most of the collapsed structures were older residential buildings. Additionally, it was found that the disaster management strategies in place were not complete or effective. The study recommended ongoing public awareness for building developers and called for the government to provide modern tools like drones and GPS devices to help monitor construction projects in the state more effectively.

Olumide et al. (2022) conducted a study to explore how internal stakeholders contribute to building collapse in Lagos and how their challenges can be addressed. A survey method was used, targeting professionals in the construction industry. Data analysis using both descriptive and inferential statistics revealed several issues, such as neglecting life cycle costs of utilities, poor coordination during design, lack of consideration for maintenance, and failure to inspect materials or supervise properly. The study suggested that identifying these internal issues could help shape strategies to reduce building failures in the region.

Oluwadure (2021) examined construction supervision challenges in southwestern Nigeria, including issues like poor funding, lack of skilled manpower, and flawed government policies. Using structured interviews and literature review, the study concluded that better enforcement of project timelines, budgeting, and material procurement procedures are vital to reduce building collapses.

Chimezie and Kzgsztof (2021) studied the causes of building collapse from the perspective of project management in real estate. The aim was to show how effective project management can help prevent structural failures. They gathered data using questionnaires given to 100 professionals in the building industry. Findings confirmed

that key causes included weak foundations, poor material handling, bypassing of professionals, insufficient site assessments, and hiring unskilled labour.

Nwabueze (2021) focused on understanding what construction professionals—seen as key players—think about the causes of building collapse and how the issue can be resolved. The study was based in Owerri Municipal Council, Imo State, Nigeria. A four-point Likert scale questionnaire was carefully prepared and given to 250 randomly chosen participants to collect data. Out of these, 193 valid responses (77%) were returned and used in the analysis. The results indicated that all major construction stakeholders contributed in some way to building collapse incidents. Among the study's suggestions was that the government, professionals, and other stakeholders must stick to their official responsibilities to reduce building collapses in Nigeria.

Falana and Ipindola (2020) led a study to better understand the root causes of building collapses and to propose long-term solutions. They examined perceptions from stakeholders in Lagos State using structured questionnaires and informal interviews. The data were analysed using the Relative Importance Index (RII), which ranked the top ten causes of collapse in the region. Based on the rankings, the authors made several recommendations to help reduce the risk of future collapses.

Olayinka et al. (2017) examined how poor property management after construction can contribute to building collapse in Nigeria. Data were collected via questionnaires distributed to residents of residential and commercial buildings in Lagos. The findings revealed misuse of property management roles, high levels of dissatisfaction with property maintenance, and a lack of routine integrity assessments. The study recommended that professional property managers oversee building maintenance and that mandatory integrity tests be conducted regularly.

Theodore and Jean (2019) examined the reasons for building failures in urban areas of Cameroon. Using both personal observations and secondary data like journals, media sources, and earlier research, they identified several causes. These included the use of poor-quality materials, exposure to environmental conditions like wet-dry cycles, unqualified workers, no approved designs, and weak foundations. The paper ended by offering recommendations aimed at minimizing or avoiding building-related accidents in the country.

2.4 Regulatory, Policy and Legal Failures

Adesanya and Olarewaju (2014) reviewed research aimed at identifying the major factors behind building collapse and the level of impact each factor has, with the goal of creating effective strategies to reduce or eliminate such incidents in the state. The research used both primary and secondary data sources. The primary data was collected through structured questionnaires given to stakeholders in the construction sector within the state. The data was analysed using inferential statistics like agreement index and chi-square test of associations. The results pointed out five major factors that urgently need to be addressed to prevent building failure: lack of enforcement of building codes, unauthorized changes to approved plans, use of substandard materials, poor workmanship, and hiring of unqualified personnel. The study highlighted the importance of passing the building code into law in Lagos State to guide policy-making.

Hilary et al. (2018) did a systematic review by combining different findings from research papers listed in the Scopus database and made recommendations. The review pointed out that the main causes of building collapse in Nigeria include the use of low-quality materials, natural or environmental factors, structural issues, poor management of construction processes, construction errors, corruption, and breaking of legal rules in the

building sector. The study ended by highlighting potential areas for future research on building failure and collapse in the Nigerian context.

Innocent (2018) emphasized the urgent need for an effective national building code in Nigeria to ensure safety and quality in the construction industry. The paper also reviewed existing literature on building collapses to summarize the key causes, which include absence of regulatory oversight, lack of respect for professional roles, and negligence. The study proposed several suggestions to help improve the Nigerian construction industry and reduce the frequency of collapses.

Abimbola and James (2017) examined current challenges in building collapse and how they affect sustainable development in Nigeria. The research asked whether construction industry players are applying sustainable development ideas, considering how often building collapses happen in the country. The motivation behind the study was based on scholars' opinions that the industry often ignores long-term consequences in their current practices. The findings confirmed that construction approaches used by stakeholders are not aligned with sustainability principles and have contributed to poor building performance. The authors recommended revising current planning and implementation systems for building rules and regulations. They urged the Nigerian government to take the lead in enforcing sustainable practices in the construction sector.

Alabi and Ahmad (2013) investigated the causes of building collapse and reviewed related court cases to determine what legal claims may come up when buildings collapse. They used descriptive analysis on a set of selected legal decisions. The findings showed that both contractual and tortious claims are commonly made following a building collapse. The study concluded that owners of collapsed buildings who had legal contracts

with professionals or contractors could make claims based on both contract and tort law, especially when they experienced financial losses due to the collapse.

Nnadi Ejiofor (2018) pointed out that despite the frequent collapse of buildings in different Nigerian cities like Abuja, Lagos, and Onitsha, regulatory systems have not been effectively updated. Although reliable building codes exist, they are often not followed, leading to structural failures. The study used questionnaires and interviews to gather data, which were analysed using tools like Spearman's ranking and T-tests. The findings showed that top causes of building collapse include using unapproved materials, poor designs, and hiring unqualified workers. The study also listed the effects of building collapse such as loss of life, property damage, and harm to the country's reputation, while offering solutions to prevent future incidents.

Alastair (2016) wrote about the widespread issue of building collapses in developing countries, which often result in numerous deaths and injuries. The paper argues that reducing such incidents requires focused government intervention in areas like pre-construction planning, contractor selection, and ongoing building maintenance. He recommended that knowledge transfer from more developed countries could help improve standards through shared experiences and best practices.

2.5 Environmental, Site and Natural Causes

Emmanuel (2023**)** investigated the impact of climate change on building collapse in Lagos State by analysing a decade-long trend in temperature and precipitation. The study found that although the number of rainy days decreased, rainfall intensity increased, leading to more frequent flooding. This change has had a detrimental effect on buildings and infrastructure, resulting in a rise in flood-induced building collapses in recent years.

Ayotunde (2010) examined incidents of building collapse in Lagos over a thirty-year span using time series analysis to understand trends and predict future occurrences. The study also reviewed past investigation reports to identify root causes of building failures. Spatial analysis revealed that many collapses occurred in areas with swampy land that had been reclaimed. One of the key recommendations was the need for thorough geophysical investigation of such areas to help mitigate future building failures.

Masoud et al. (2023**)** explored how earthquakes affect steel buildings by gathering expert opinions through a structured questionnaire and analysing the data using hierarchical analysis. The findings revealed that column damage is the most critical factor in complete collapse during an earthquake, highlighting the need for improved vertical structural member design.

Gwang (2015) analysed two major building collapses in South Korea using hierarchical analysis to evaluate causative factors. Faulty construction practices and inadequate inspection were identified as high-priority contributors. The study emphasized the need for systematic construction oversight to prevent structural failures.

Colin (2008) described how earthquakes can cause building collapse through mechanisms such as sway and the failure of critical supports like corner columns. He recommended that earthquake engineering must address progressive collapse by designing for ductility and accounting for "double-span" scenarios where supports are lost.

Akaninyene and Sahad (2017) conducted a study focused on understanding the reasons behind the high rate of building collapse in Nigeria and how to prevent them. They collected data by distributing questionnaires to professionals in the construction industry.

The results were analysed using statistical tools like frequency distributions, percentages, and mean response. Major causes identified included weak foundations, poor quality control, lack of proper site checks, avoidance of professional services, and unskilled labour. The study suggested measures like having qualified professionals on-site, getting approvals before starting construction, and ensuring structural engineers are involved in multi-story projects.

Kaushal Lad (2024) reviewed literature on natural disasters, particularly earthquakes, and how they affect buildings. The study pointed out that many structures collapse during earthquakes because they are not designed with seismic resistance in mind. It also explored methods to make buildings more earthquake-resistant, including the use of shear walls, base isolators, and bearings to help structures handle seismic forces and reduce collapse risks.

Liaping et al. (2010) analysed factors influencing the collapse resistance of reinforced concrete frames during the 2008 Wenchuan earthquake. The study focused on three key areas: global strength, redundancy, and integration of the structural system. It proposed strategies for collapse prevention and highlighted areas needing further research.

Cody and Abbic (2016) studied the effects of vertical ground motion on building structures, particularly those with cantilevered components. Using Incremental Dynamic Analyses (IDA), the study showed that vertical shaking exerts far greater load effects than typically accounted for in U.S. building codes, making certain structural types especially vulnerable.

Sodiya (2024) led a study to assess causes and effects of building collapse using a survey design. The study involved 120 randomly selected buildings, with data collected through

questionnaires and assessment charts. Findings showed that many buildings had undergone changes in use—most notably the addition of heavy equipment like generators—which put stress on already weak structures. The study identified this as a key factor and recommended urban renewal programs, enforcement of planning laws, revamping building certification processes, and strict adherence to zoning regulations.

Caicedo et al. (2019) investigated the collapse of the 24-story "Space" building in Medellin, Colombia. The study identified uneven pile settlement and resulting load redistribution as the main causes. The research was based on field inspections, lab tests, and analysis of the building's structural design and construction process.

2.6 Analytical and Predictive Modelling Approaches

Olushina et al. (2024) conducted a study that presented a short structural report on building collapses in Nigeria between 2020 and 2021, using Lagos State as the case study. The study also used five supervised machine learning models—Robust Linear Model (RLM), Support Vector Machine (SVM), Random Forest (RF), and Decision Tree (DT)—to predict casualty rates from building collapses. They performed a feature importance analysis to figure out which factors most contributed to collapse-related casualties. The findings showed that the SVM model had the best predictive accuracy among the tested algorithms. According to the feature importance analysis, location was the most critical factor leading to casualties from building collapse. The study advised that proper geotechnical investigations should be done at building sites before construction starts in Nigeria.

Caredda et al. (2023) conducted a literature review of efforts made in structural engineering to create buildings that are less prone to collapse. The review looked at

various forensic engineering studies and noted the development of several databases that track the causes and risks associated with structural failures. One major contribution was a new database that organizes information on hazards, the initial point of failure, and how that failure spreads through a structure.

Imafidon and Ogho (2020) reviewed literature and used unsupervised methods to group the causes of building collapse in Lagos State based on data collected from construction professionals. They applied hierarchical cluster analysis and mean score techniques. The analysis showed that the causes could be grouped into design and construction issues, policy failures, and quality-related problems. The key factors under each group were identified as poor maintenance culture, changing building use without approval, and the use of substandard materials. The study suggested that the government should work harder to improve both design and construction practices, beginning with better building policy development. It also recommended a strong strategy to stop the spread and use of fake or low-quality construction materials.

Okeola et al. (2014) directed their research towards identifying core factors responsible for building collapse with the intention of developing proactive solutions. A major difficulty faced in tackling this problem is the lack of a detailed analysis of past collapse incidents. Their study provided a data-driven evaluation by analysing records of building failures in Lagos. The results pointed to poor workmanship, low-quality materials, flawed design, and overloading as leading causes. Recommendations were made to help prevent future collapses, both immediately and in the long term.

Yagob et al. (2009) provided a thorough review of progressive collapse in buildings, noting its growing relevance in structural engineering. Although progress has been made,

the study called for more work to develop efficient and cost-effective design methods to safeguard buildings from this type of failure.

2.7 Progressive Collapse and Seismic/Extreme Load Response

Mahorkar et al. (2024) studied the concept of progressive collapse, which is when damage starts at one point of a building and spreads, leading to a complete failure. This can happen due to accidents, explosions, or natural disasters, especially when key structural parts like columns are affected. The main concern with progressive collapse is how much worse the final damage can be compared to the initial one. The study suggested methods to limit the damage, including strengthening important parts of the building and improving design layouts. A technique called the Alternative Path Method (APM) was recommended to test how well buildings can handle the loss of one structural element.

Trapani et al. (2023) examined how reinforced concrete frame buildings react to extreme events like explosions or impacts that cause sudden failure of key structural parts. The study explored how masonry infill walls affect a building's response when a column is lost unexpectedly. Case study tests showed that masonry infills significantly influence how the structure responds to these events by altering its resistance pattern and limiting further collapse in many situations.

Michael et al. (2014) summarized significant progressive collapse events to better understand structural weaknesses when subjected to localized damage. The paper reviewed current engineering practices and guidelines, highlighting the use of fully non-linear dynamic methods. It concluded that steel-framed structures are particularly vulnerable, especially at the connections. The paper also discussed pros and cons of

different modelling techniques used to evaluate these connections during collapse analysis.

Roberto (2007) reviewed existing analytical methods for assessing how buildings respond to earthquakes, including their limitations and the outcomes of past experimental tests. He emphasized that while significant progress has been made, more research is needed before earthquake collapse capacity and safety margins of buildings can be confidently evaluated.

2.8 Effects, Legal Consequences and Remedies

Umeora (2013) researched the causes of building collapse in Nigeria and assessed the extent of damage caused. The study also examined how capable the country is in handling such emergencies. Using secondary data, the research focused on incidents between 1997 and 2009 to determine how many lives were lost. The analysis, supported by a modeling tool, showed a high number of casualties and identified gaps in emergency response. The study recommended raising public awareness and improving emergency management systems in the country.

Olagunju et al. (2013) discussed the problem of building collapse in Nigeria and its impact on society, highlighting several notable cases. The frequent incidents of collapsed structures are not only a concern to professionals in the construction industry but also to clients and users. The paper explored some common causes like poor design, faulty construction, issues with the foundation, and fire hazards. It also offered corrective measures. In conclusion, the study suggested practical steps that could help ensure better implementation of these solutions.

Solymon et al. (2019) examined the frequency and spread of building collapse incidents across Nigeria from 2013 to 2017. Data were collected from print and digital media, as well as conversations with fellow professionals. Based on the damage and loss of lives recorded during this period, the study emphasized the need for all construction professionals to adopt preventive approaches. A major recommendation was that all buildings should undergo structural integrity assessments, and any found unsafe should be demolished.

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CHAPTER THREE

METHODOLOGY

3.1 Study Area

Benin City, located in southern Nigeria, is the capital of Edo state. Known for its rich history as the former seat of the Benin Kingdom, it is a cultural and commercial hub. However, like many urban centers in Nigeria, Benin City has faced significant challenges related to rapid urbanization, infrastructural development and building safety.

The rapid population growth and urban expansion have led to a rise in the construction of residential, commercial, and industrial buildings, regulatory enforcement or attention to building safety standards leading to a series of building collapse incidents in recent years.

3.2 Steps Involved in Hierarchical Analysis

Hierarchical analysis of factors leading to building collapse typically involves identifying and organizing the various factors that contribute to building failures and categorizing them into different levels. The hierarchical analysis process can be used to perform structured assessments, prioritize interventions and implement effective mitigation strategies.

3.2.1 Problem Identification

The scope of this analysis concerns the city of Benin and the number of building collapse incidents that have occurred over the years such as

i. 2016 Benin City Building Collapse
ii. 2020 Collapse at Etsako East Local Government Area
iii. November,2019- Ugbowo, Benin City
iv. 2021- Benin City High-Rise Construction Collapse
v. 2020-Residential Building Collapse

3.2.2 Factor Identification

There is no shortage of factors that lead to building collapse, even in the state of Benin. These factors may include: Poor site selection, Inadequate Supervision, Illegal modifications, Substandard materials, Corruption in the construction industry, Urbanization and population growth, etc. The building collapse incidents listed in the problem identification step above where as a result of certain factors as well, namely:

i. 2016 Benin City Building Collapse: This collapse was attributed to poor building practices, such as use of substandard materials and lack of proper supervision.
ii. 2020 collapse at Etsako East LGA: This was also a result of poor construction practices there by weakening the structure.
iii. November 2019- Ugbowo, Benin City: Reports indicated that a weak foundation and inadequate materials were factors in the collapse.
iv. 2020- Residential Building Collapse: Structural weakness in the building had been noted by some of the residents before it collapsed.
v. 2021-Benin City High-Rise Construction Collapse: The collapse was attributed to improper reinforcement and substandard materials being used by the construction company.

3.2.3 Hierarchical Structure

Building collapse, especially in developing cities like Benin City, Nigeria are caused by a combination of multiple factors. These factors interact in complex ways. Below is a hierarchical structure outlining these factors:

Primary Factors

i. Poor construction practices such as: use of substandard materials, inadequate structural design, improper workmanship.

ii. Corruption and Regulatory failures like bribery and negligence, weak enforcement of building codes, illegal modifications.

iii. Lack of Proper Planning and Site Selection: inadequate site evaluation, lack of zoning laws and urban planning.

Secondary Factors

i. Economic Pressure: cost-cutting measures, increased demand for housing

ii. Inadequate Supervision and Inspections: lack of proper monitoring during construction, rushed inspections and inadequate inspection procedures

iii. Environmental Factors: weather conditions, seismic activity.

Tertiary Factors

i. Structural Failures: weak foundations, overloading, deterioration over time.

ii. Human Error: improper execution of designs, unauthorized additions.

iii. Maintenance and Usage Issues: lack of maintenance, misuse of the building.

Immediate Triggers

These are specific triggers that lead directly to the collapse once all the underlying factors have built up.

i. Sudden Environmental Stresses: heavy rain/storms, flooding.

ii. Vibration or Movement: nearby construction or traffic

iii. Catastrophic Failures: complete structural breakdown.

3.2.4 Data Collection and Evaluation

i. Data will be collected from previous building collapse incidents as well as expert opinions from construction experts or the factors that could lead to building collapse via an administered questionnaire.

ii. An analysis on the frequency and impact of each identified factor will be carried out to assess their significance.

3.2.5 Prioritize Factors

The relative importance of factors identified will be assessed using methods like:

i. Expert Judgement: Gathering insights from engineers, architects and other professionals.

ii. Risk Assessment: Evaluations on each factor based on likelihood and potential safety.

3.2.6 Intervention Design

Strategies based on the identified causal factors such as structural deficiencies, regulatory failures, and professional misconduct as well as insights derived from the comprehensive data collected through the administered questionnaires, will be carefully developed and tailored to address the recurring challenges associated with building collapse, with the aim of informing policy, guiding professional practice, and enhancing construction standards

3.2.7 Implementation and Monitoring

i. The mitigation strategies will be implemented based on the priorities derived from the hierarchical analysis.

ii. The buildings will have to be regularly monitored to ensure the effectiveness of those interventions.

3.2.8 Continuous Feedback and Improvement

Building collapse and near-miss events will be used as feedback for continuous improvement of mitigation strategies. Regular updates on the hierarchical analysis model data and case studies to refine the understanding of risk factors will be advised.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Hierarchical Structure

In this chapter the results of the hierarchical analysis of factors contributing to building collapse in Benin City are discussed in detail. Using a systematic approach, various factors have been identified, categorized and ranked according to their relative importance. The analysis employs a combination of expert opinions and data-driven insights to assess the impact of each factor in the occurrence of building failures. The findings offer a comprehensive understanding of the interrelationships among these factors and provide a clearer view of the key drivers behind structural collapses. This chapter aims to highlight the most critical variables and offer recommendations for improving building safety and mitigating collapse risks.

For the process of data collection, a structured questionnaire was administered to professionals in the construction industry in Benin City and the responses gotten from this questionnaire informed the hierarchical structure presented below.

1. Primary Factors (Root Causes)

   These are the most significant and direct causes that lead to building collapses.

   i. Poor Construction Materials: Use of substandard cement, poor quality steel, and inadequate concrete mix weaken structural integrity.
   ii. Inadequate Supervision and Regulation: Lack of proper inspection and enforcement of building codes and safety regulations by relevant authorities.

iii. Corruption: Bribery and unethical practices within the construction and regulatory sectors, allowing builders to bypass safety standards.

iv. Poor workmanship: Employment of unqualified and inexperienced personnel as a part of the construction work force.

v. Repurposing of buildings without following proper protocol: Home owners often use their buildings for purposes other than what they were designed for without consulting professionals in the industry.

2. Secondary Factors (Contributing Causes)

These are factors that indirectly influence building collapse, often stemming from negligence, lack of resources, or failure to enforce standards.

i. Lack of Proper Engineering Design: Construction without certified plans or structural engineering input, leading to unsound buildings.

ii. Overloading: Converting buildings for purposes beyond their design capacity (e.g., residential buildings being used for commercial purposes)

iii. Poor Foundation Work: Inadequate foundation construction, especially on weak or unstable soil, contributes to structural failure.

iv. Weak enforcement of building codes: Construction without supervision from the necessary government officials.

v. Member failure: the failure of structural members like beams, columns and slabs.

3. Tertiary Factors (Peripheral Causes)

These are indirect or additional factors that amplify or trigger the collapse but are not primary contributors.

i. Negligence and Lack of Maintenance: Ignoring minor structural problems (cracks, leaks) that grow over time and compromise the safety of the building.

ii. Rapid Urbanization: Increased demand for space leading to hurried construction in unregulated areas or on land that may not be structurally sound.

iii. Natural Disasters: While infrequent, environmental factors such as heavy rainfall, flooding, or occasional seismic activity can exacerbate weak construction.

4.2 Data Supporting Credibility of Analysis

The necessary data gotten from the administered questionnaire to justify its credibility is as presented below:

S/N	Profession	Number of Respondents
1	Architecture	9
2	Building Owner	7
3	Project Management	6
4	Civil Engineering	23
5	Site Engineer	25
6	Quantity Surveying	11
	TOTAL	81

Table. 4.1 Table showing Frequency of Respondents

Site Engineers and Civil Engineers had the most respondents.

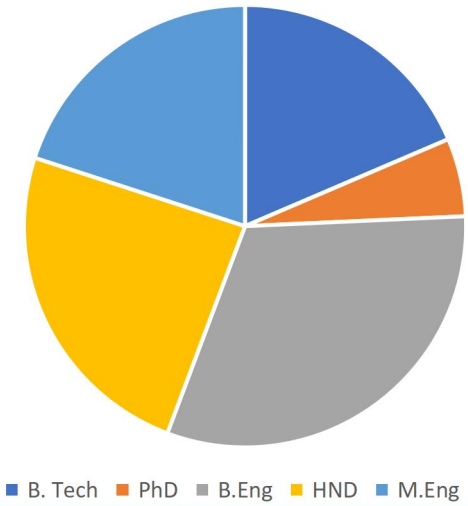

Fig 4.1 A Pie Chart showing the Academic Qualification of the Respondents

Majority of the respondents have a B.Eng., which increases the credibility of the data and the outcome of the evaluation.

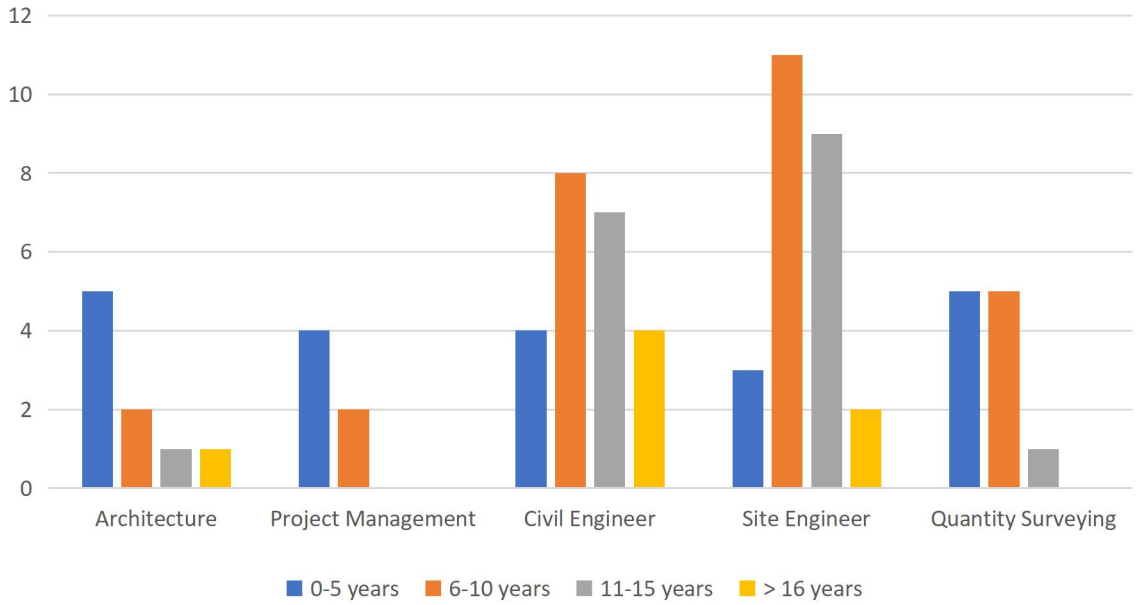

Fig.4.2 Bar Chart showing Years of Working Experience of the Respondents

The professions with the most respondents; Civil Engineering and Site Engineering have most of their respondents with a 6-10 year work experience, thus increasing the accuracy of the result.

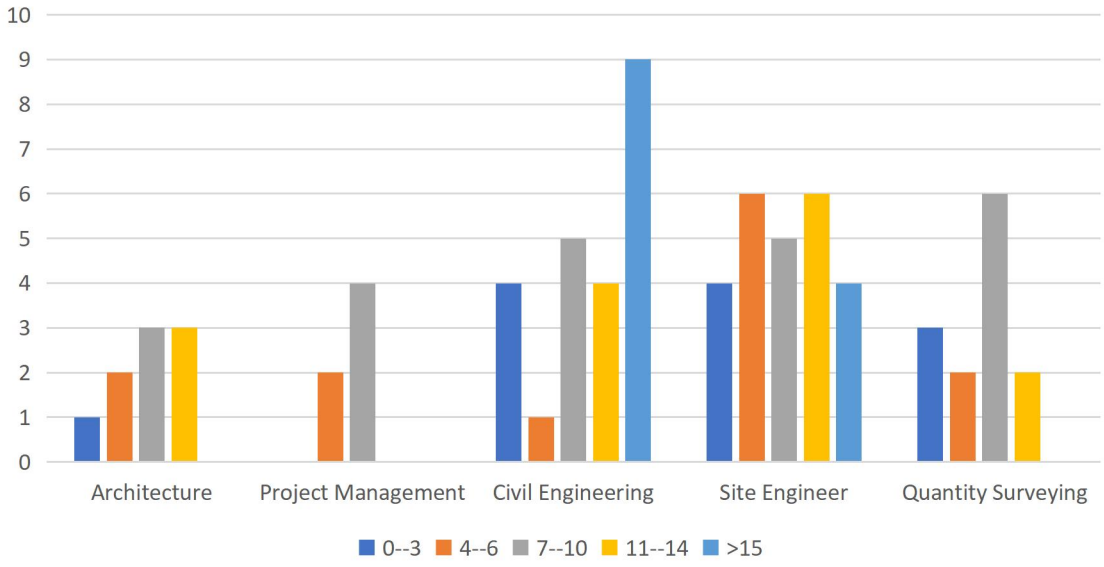

Fig.4.3 Bar Chart showing the Number of Projects Worked On

Fig.1.3 Bar Chart showing the number of construction projects participated in.

The Civil Engineers and Site Engineers which are the professions with the most respondents, have participated in a large number of construction projects. Although other professions like Project Management and Architecture are lacking in comparison, the credibility of the result still stands due to the sheer number of responses from the most experienced professions.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The hierarchical analysis of the factors leading to building collapse in Benin City, Nigeria, reveals a complex interplay of primary, secondary, and tertiary causes that contribute to the persistent issue of structural failure. At the root of the problem lie poor construction materials, inadequate supervision and regulation, and corruption within the construction and regulatory sectors. These primary factors directly undermine the integrity of buildings and the enforcement of safety standards.

The secondary factors, such as lack of proper engineering design, overloading of buildings, and poor foundation work, further exacerbate the problem. These issues typically arise due to negligence or insufficient technical knowledge in the construction process. Additionally, tertiary factors, including negligence and lack of maintenance, rapid urbanization, and natural disasters, create an environment where even minor structural issues can escalate into catastrophic failures.

Addressing building collapse in Benin City requires a comprehensive approach that tackles these issues at every level, from stricter enforcement of building codes to improving public awareness and community involvement in construction practices.

5.2 Recommendations

To curb the issue of building collapse in Benin City, the following measures are recommended:

- **Strict Enforcement of Building Codes and Regulations:**

Authorities should enforce existing building codes and safety standards more rigorously. This includes thorough inspections during construction and after completion to ensure compliance with safety norms.

ii **Quality Control and Material Testing:**

Ensure that construction materials are sourced from reputable suppliers and undergo testing to meet quality standards. Establish regular audits and random inspections to verify material quality at construction sites.

iii **Enhance Professional Training and Certification:**

Architects, engineers, and construction workers should undergo proper certification and training. This will improve technical knowledge and skills, particularly in designing and constructing safe buildings.

iv **Combating Corruption:**

Government and regulatory bodies must work to eliminate corruption by establishing transparent processes for construction permits and inspections. This could involve the creation of a public database of construction projects for increased transparency.

v **Public Awareness Campaigns:**

Conduct awareness programs for property owners, contractors, and the general public about the dangers of using substandard materials, neglecting maintenance, and overloading buildings. These campaigns should emphasize the importance of safety in construction.

vi **Urban Planning and Zoning Regulations:**

Implement proper urban planning and zoning regulations that prevent the construction of buildings in areas prone to flooding, soil erosion, or other natural hazards. Ensure that land use policies align with the structural requirements for safe construction.

vii **Promote Preventive Maintenance:**

Encourage building owners to invest in regular inspections and maintenance to detect and repair minor structural issues before they escalate. This could be incentivized through tax breaks or subsidies for maintenance work.

viii **Establishment of a Building Collapse Response Task Force**:

Set up a dedicated team responsible for investigating building collapses, providing real-time responses to emergency situations, and disseminating findings to improve future building safety standards.

ix **Encouraging Use of Technology in Construction:**

Adopt modern technologies, such as Building Information Modeling (BIM), to assist in designing more stable and safer buildings. BIM can help architects and engineers simulate real-world conditions and identify potential structural weaknesses early.

In conclusion, the fight against building collapse in Benin City requires a multifaceted approach that addresses the root causes, such as poor materials, lack of supervision, and corruption, while also tackling contributing factors like urbanization and maintenance neglect. By implementing stricter regulations, improving professional training, and promoting community awareness, we can significantly reduce the frequency of building collapses and create a safer built environment for the residents of Benin City.

REFERENCES

Abimbola, O. W. and James O. R. (2012) Contemporary issues in building collapse and. its implications for sustainable development; Journal of Buildings. Vol. 2, No. 3, Pg. 283-299.

Abiodun, R. O. and Timothy, O. A. (2018) Impacts of building collapse on sustainable development in Nigeria; Civil and Environmental Research. Vol. 10, No. 11, Pg. 15-32.

Adebowale, A., Gambo, D., Ankeli, A., and Daniel, I. D. (2016) A review on Building collapse in Nigeria: Issues and Challenges; Journal of Arts & Sciences Vol. 9, No. 01, Pg. 99-108

Adenuga, O. A. (2012) Professionals in the bult environment and the incidence of building collapse in Nigeria; Journal of Organization, technology & management in Construction. Vol. 4, No. 2, Pg. 461-473.

Adesanya, A.T. and Olanrewaju, D. O. (2014) A study of factors responsible for Incessant collapse of buildings in Lagos State; Journal of Engineering Trends in Economics and Management Sciences Vol. 5, No.7, Pg. 57-61

Akaninyene, E. and Saheed, A. (2017) The underlying causes of building collapse in the Nigerian Construction Industry; Journal of Scientific & Engineering Research. Vol. 8, No.7, Pg. 347-353.

Alabi, O.M. and Ahmad, R. R, (2013) The study of claims arising from building collapses: case studies from Malaysia, Nigeria, Singapore and Thailand; Journal of Civil and Environmental Research. Vol. 3, No. 11, Pg. 113-129.

Alastair, S. (2018) Learning from experienced to avoid collapse; Proceedings of the Institute of Civil Engineers-Forensic Engineering. Vol. 109, No. 4, Pg. 127-132.

Anthony, N.E., Oluwarotimi, N.O., Olatokunbo, M.O., Opeyemi, J and Oluwadamilola, A. (2018) Use of non-destructive test to avert the risk of building collapse; International Journal of Civil Engineering and Technology. Vol. 9, No.7, Pg. 2028-2035.

Ayedun, C. A., Durodola, O. D. and Akinjure, O. A. (2012) An empirical ascertainment of the causes of building failure and collapse in Nigeria; Journal of Social Sciences Vol. 3, No. 2, Pg.313-322.

Ayotunde, O.O. (2010) Analysis of Incidences of Collapsed buildings in Lagos Metropolis, Nigeria; International Journal of Strategic Property Management. Vol. 14, No. 4, Pg. 332-346.

Caicedo, B., Alonso, E., Mendoza, C. and Alcoverro, J. (2019) The collapse of Space Building; Geotechnique Journal. Vol. 69, No. 3, Pg. 260-273.

Caredda, G., Nirvan, M., Manuel, B., Juan, S., Maries, C. and Jose, M. A. (2023) Learning from the progressive collapse of Building; Journal of Development in the Built Environment. Vol. 15, No. 1, Pg. 1-19.

Chimezie, C. N. and Krzysztof, Z. (2021) Identification of the Key Causes and Measures to Prevent Building Collapses in Nigeria; Civil and Environmental Engineering Reports. Vol. 31, No. 4, Pg. 55-75.

Cody, C. H. and Abbie, B. L. (2016) Collapse assessment of moment frame buildings, considering vertical ground shaking; Earthquake Engineering & Structural Dynamics. Vol. 45, No. 15, Pg. 2475-2493.

Colin, G. (2008) Progressive Collapse and Earthquake resistance; Practice Periodical on Structural Design and Construction. Vol. 13, No. 1, Pg. 19-23.

Cynthia, P. and Norbert, D. (2005) Ronan point apartment tower collapse and its effects on building codes; Journal of Performance of Constructed Facilities. Vol. 19, No. 2, Pg. 172-177.

Daniel, A. C., David, B.P. and Thomas, Z.S. (1992) Investigation of LAmbiance Plaza building collapse; Journal of performance of constructed facilities. Vol. 6, No.4, Pg. 211-231.

Ebehikale, N. and Dawom, P. (2014) A review on Spatial Analysis of building collapse in Nigeria: a study of the causes and problems; Journal of Economics and Sustainable Development Vol. 5, No. 25, Pg. 95-107.

Emmanuel, T. T. (2023) Evaluation of the effect of climate change on building collapse in Lagos state; International Journal of Advanced Academic Research. Vol. 9, No. 11, Pg. 112-123.

Falana, J. N. and Ipindola, O.O. (2020) Stakeholders' Perspective on the perceived causes of building collapse in Lagos State, Nigeria; International Journal of Advanced Science and Technology. Vol. 29, No. 3, Pg. 120-127.

George, U. A., Gregory, C. E. and Elvis, M. M. (2020) Failure analysis of a partially-collapsed building using analytical hierarchical process; Journal of Reliability Engineering and Resilience. Vol.2, No.1, Pg. 1-20.

Gwang, H. K. (2015) Collapse Accident Factors of Pungyo vents by Analyzing AHP; Journal of the Korean Society of Hazard Mitigation. Vol. 15, No. 6, Pg. 1-8.

Hilary, I. O., Chukwuemeka, O. I., Nkulika, J. P., James, D. O., Patience, I. A., Aboidun, A. O, (2018) SYSTEMATIC review of building failure and collapse in Nigeria; Journal of Civil Engineering and Technology Vol. 9, No. 10, Pg.1391-1401.

Hillary, W. and Chinedu, M.K. (2021) Residential Building Collapse in Nigeria; incidence, causes, effects, solution, and implication for technical education; International Journal of Innovative Education Research. Vol. 9, No. 2, Pg. 153-162.

Imafidon, M. O. and Ogbu, C. P. (2020) A taxonomy of building collapse causes in Lagos state, Nigeria; Journal of Technology Vol. 39, No.1, Pg. 74-86.

Innocent, C. O. (2018) Builder's view on the incessant building failures and collapse in Nigeria: A call for an effective national building code; American Journal of Engineering Research. Vol. 7, No.10, Pg. 173-180.

Jean, C. T. and Theodore, G. L. J. B. (2015) Failure and collapse of Building Structures in the cities of Yaounde and Doulala, Cameroon from 2010 to 2014; Journal of Modern Applied Sciences. Vol. 10, No. 1, Pg.23.

Joseph, C. O. (2022) Investigating the Causes, Effects, and Remedies to Building Collapses in Rivers State, Nigeria; International Journal of Engineering and Modern Technology, Vol. 8, No. 2, Pg. 53-71.

Katkukah, T. S. and Mije, F. G. (2023) Assessment of Building Collapses in Jos town, Plateau State Nigeria (2016-2022) ; DIDA International Journal of Sustainable Development. Vol. 16, No. 5, Pg. 11-18

Kaushal, L. (2024) Earthquake Resisting Building by using Base Isolation; International Journal for Research on Applied Science and Engineering Technology. Vol. 12, No. 4, Pg. 1126-1131.

Kayode, K. E. (2023) Building Collapse in Nigeria: Causes, Impacts and Solutions. Vol.1, No.1, Pg. 83-85

Kumalasari, W. and Fabian, C. H. (2003) Study of recent building failures in the United States; Journal of performance of Constructed Facilities. Vol. 17, No. 3, Pg. 151-158.

Lieping, Y., Xinzheng, L. and Yi, L. (2010) Design Objectives and collapse prevention for building structures in mega-earthquake; Earthquake Engineering and Engineering Vibration. Vol. 9, No.2, Pg. 189-199.

Mahourkar, P. and Mahondia U. (2024) Progressive collapse of RC structure; Journal of Structural Technology. Vol. 9, No. 2, Pg. 14-23.

Masoud, M., Abbas, B. and Seyyed Reza, H. (2023) Evaluation of Structural Factors Causing Complete Collapse of Steel Buildings during an Earthquake; Advance Researches in Civil Engineering. Vol. 5, No. 3, Pg. 20-32.

Michael, B., Wjesundara, M., Colin, M. and Evan, S. (2014) A review of progressive collapse research and regulations; Proceedings of the Institution of Civil Engineers-Structures and Buildings. Vol. 167, No. 8, Pg. 447-456.

Miodray, R.G., Neda, D. and Milan, T. G. (2017) Investigation of the Collapse of a Building in the final stage of its construction; Structural Engineering International. Vol. 27, No. 3, Pg. 429-434.

Moses, A. O., Olawale, S.O., Olayiwola, T.B. and Bomgboye, O. A. (2015) Analysis of the causes of a 3-storey building in Ile-Ife, Osun State, Nigeria; International Journal of Scientific & Engineering Research, Vol. 6, No.12, Pg. 1093- 1105.

Nnadi, E. (2018) The requisite to avoid risk of probable building collapse in Nigeria; International Journal of Energy and Environmental Science. Vol. 3, No.4, Pg. 82-88.

Nwubueze, M. A. (2021) Views of construction professionals on the causes and remedies of building collapse in Nigeria; Journal of Engineering Technologies and Management Research. Vol. 8, No. 6, Pg. 68-85.

Obi, W. D., Aginam, C. H. and Ezeagu (2021) Sensitivity analysis on selected collapsed building structures in Anambra State; Journal of Inventive Engineering and Technology. Vol. 1, No. 4, Pg. 1-17.

Obiora, C. O., Ezennia, I. S., Bert-Okonkwo, C. B. N., Chukwuemene; O. E. (2022) Assessment of Constructive factors of building collapse using Physical Analysis Tests: The case of Oko, Anambra State, Nigeria; Journal of Engineering Research and Reports. Vol. 22, No. 1, Pg. 1-11.

Okeola, O. G., Okeola, A. A. and Ameen, M. G. (2014) An empirical Assessment of Causes of Building Collapse in Lagos State, Nigeria; Epistemics in Science, Engineering and Technology. Vol. 4, No.1, Pg. 344-352.

Olagunju, R. E., Aremu, S.C. and Ogundele, J. (2013) Incessant collapse of buildings in Nigeria: an architect's view; Journal of Civil and Environmental Research. Vol. 3, No. 4, Pg. 49-54.

Olasunkanmi, H. O. (2022) Survival of the fittest: Assessing incidents of building collapse and reduction practices in Lagos, Nigeria; Journal of Environmental Quality Management. Vol. 31, No. 4, Pg. 141-150.

Olayinka, C.O., Abiodun, S. O., Ayodeji, O., Opeyemi, J. and Daniel, O. B. (2017) Incessant building collapse in Nigeria: a framework for post-development Management Control; Developing Country Studies. Vol. 7, No.3, Pg. 114-127.

Olumide, A. A., Innocent, C. O. and Ikhela, B. I. (2022) International Stakeholders' Contribution to Building Collapse in Lagos State, Nigeria: A Perceptional Survey; Civil and Sustainable Urban Engineering, Vol.2, No. 2, Pg. 67-81.

Olushina, O. A., Emmanuel, O. A., Michael, O. A., Ann, P. M. and Esther, O. O. (2024) Assessing the factors affecting building collapse casualty using machine learning techniques: A case of Lagos, Nigeria; Journal of Construction Management Vol. 24, No. 3, Pg. 261-269.

Olusola, K. O., Ojambati, T. S. and Lawal, A. F. (2011) 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, No. 3, Pg. 462-469.

Oluwadare, J. O. (2021) Assessment of Approval Process and Government Policies: Special Approach for Combating Building Collapse in Nigeria; Journal of Construction Engineering, Technology & Management. Vol. 11, No. 2, Pg.29-36.

Oseghale, G.E., Ime, J.I. and Ajayi, O.D. (2015) A review on the Causes and Effects of building collapse in Lagos state, Nigeria; Journal of Civil and Environmental Research Vol.7, No.4, Pg. 34-43.

Paul, K. N. (2020) Causes, Effects and Precautionary Measures to the Collapse of Buildings in Port-Harcourt, Rivers State, Nigeria; Journal of Environmental Science, Toxicology Food Technology. Vol. 8, No. 2, Pg. 53-71.

Renan, J. C.R. and Ramam, D. C. O, (2018) The collapse of Real Class building; Revista ibracun de estruturas e materiais. Vol.11, No. 2, Pg. 357- 388.

Roberto, V. (2007) Methods to Assess the seismic collapse capacity of building Structures: State of the art; Journal of Structural Engineering. Vol. 133, No. 1, Pg. 57-66.

Sodiya, O. (2024) Causes and Effects of Building Collapse in Urban Transitioned Zone of Ebute-Metta, Lagos State; International Journal of Women in Technical Education and Employment. Vol. 5, No.2, PG. 32-41.

Sulyman, N. A., Bello, T., Dahunsi, B. I.O. and Nwaigwe, D. N. (2019) Empirical Analysis of Building Collapse in Nigeria between 2013 and 2017; Adeleke University Journal of Engineering and TECHNOLOGY. Vol. 2, No. 2, Pg. 66-78.

Suzanne, K. and Norbert, J. D. (2004) Collapse of 2000 commonwealth avenue: Punching shear case study; Journal of Performance of constructed facilities, Vol. 18, No. 1, Pg. 54-61.

Theodore, G. L.J. and Jean, C. T. (2019) Causes of Failure and Collapse of Building Structures in Cameroonian Cities; Academic Journal of Civil Engineering. Vol. 37, No.1, Pg. 347-353.

Timothy, D., Aliyuda, Y. A., Mbimba, A. M. and Benjamin, Y.M. (2021) Assessment of Concrete Elements of A Collapsed Building Using Ultrasonic Pulse Velocity Test; International Journal of Recent Engineering Science. Vol. 8, No. 2, Pg.16-19.

Trapani, D. F., Antonio, P. S., Marilisa, D. B. and Giuseppe, C. M. (2023) Dynamic progressive collapse response of multi-story frame structures with Masonry infills. Vol. 54, No. 1, Pg. 1336-1349.

Umeora, C. O. (2013) The incidence of building collapse and emergency management in Nigeria; Journal of environmental sciences and resources management. Vol. 5, No.2, Pg. 73-79.

Yayobi, O., Galal, K. and Naumoski, N. (2009) Progressive collapse of reinforced concrete structures; Structural Engineering and Mechanics. Vol. 32, No.6, Pg.771-786.

APPENDIX

QUESTIONNAIRE ITEMS

PROJECT TOPIC: HIERARCHICAL ASSESSMENT OF FACTORS LEADING TO BUILDING COLLAPSE: A CASE STUDY OF BENIN CITY

STUDENT'S NAME: OKOYOMOH OSHOLEAKHUE AYOMIKUN

DEPARTMENT OF CIVIL ENGINEERING

UNIVERSITY OF BENIN

(After Kayode, 2023)

SECTION A: GENERAL INFORMATION

Please complete the following by checking (√) in the spaces provided as appropriate.

1. Which is your area of study in building profession?

Architecture ( )

Building Owner (Client) ( )

Project Management ( )

Civil Engineering ( )

Site Engineer ( )

Quantity Surveying ( )

2. What is your highest qualification?

B. Tech. ( )

PhD ( )

B. Eng. ( )

HND ( )

M. Eng. ( )

3. How many years of working experience do you have?

0 – 5 ( )

6 – 10 ( )

11 – 15 ( )

16 above ( )

4. How many building construction projects have you participated in?

0 – 3 ( )

4 – 6 ( )

7 – 10 ( )

11 – 14 ( )

15 above ( )

SECTION B

This section is concerned with the superstructure and substructure factors that can cause collapse in buildings.

What are the factors that cause collapse in a building?

Please check (√) appropriately the responses that suit the items provided below. The response categories are as follows; SA=Strongly Agree, A=Agree, D=Disagree, SD=

S/N	ITEM STATEMENT	SA	A	D	SD	U
1	Member failure (beam, column, slab, wall)					
2	Overloading					
3	Lack of proper engineering design					
4	Unqualified iron benders					
5	Unqualified masons					
6	Unqualified carpenters					
7	Natural disasters (Erosion/flooding)					
8	Poor foundation work					
9	Poor construction materials					

Strongly Disagree, U=Undecided.

SECTION C

This section is concerned with the construction project management factors that can cause collapse in buildings. What are the construction project management factors that cause collapse in a building? Please check (√) appropriately the responses that suit the items provided below. The response categories are as follows; SA=Strongly Agree, A=Agree, D=Disagree, SD= Strongly Disagree, U=Undecided.

S/N	ITEM STATEMENT	SA	A	D	SD	U
1	Inadequate supervision and regulation					
2	Corruption					
3	Negligence and lack of maintenance					
4	Rapid urbanization					

6	Weak enforcement of building codes					
7	Repurposing of building without following proper protocol					