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Proferring Solutions to Building Collapse in Nigeria using PM Techniques

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Abstract

The primary objective of this study lies in identifying project management solutions to building collapse. It sought to unravel structural, regulatory and procedural factors as well as solutions and evidences to mitigate building collapse or loss of structural integrity which has been a recurrent menace in the Nigerian construction industry. It hinges on the theoretical framework of the project management theory which emphasises the triple importance of time, cost and scope of the project as determinants of project outcomes and deliverables.

The study utilised the analytical research design with a critical realism philosophy driving the deduction-induction reasoning analysis process. It utilised qualitative metrics around themes on project management types, causal factors and solutions to building collapse. It concurrently utilised a multi-method data collection by engaging a review of secondary sources in terms of global project management solutions and the primary data obtained through indepth interviews with a sample of six professionals who work in the construction industry.

The study dissects from the indepth interview, a number of causal factors in terms of of building collapse. The substandard structures, non-adherence to building codes, and weakened regulations are mentioned a few factors. Use of poor quality materials, violating building codes, derailed plans, poor soil survey and eroded foundation design while very low quality in terms of training, communication and skills are intervening variables. The study identified different project management protocols such as Building Information Modelling (BIM), Critical Path Method (CPM), Multi-stakeholder approach, Six Sigma, Agile/Lean management system and Earned Value Management (EVM). These project management solutions were elicited from case examples from different countries that have been utilised to mitigate building collapse in other countries.

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Sincere appreciation to God Almighty for the Grace to be alive to submit this thesis at this time. At commencement of the programme I developed serious pains and had a surgical Operation removing my womb. Getting over this was tough for me but now I have to appreciate everyone that stood by me and supported me this far. Engr OluwaSeun Adenigba PhD, MBA, MSc have been most supportive and every member of my family. God bless you all.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Since ancient times, building construction has been a fundamental aspect of human existence with the critical importance laid on the structure, stability, materials and methods employed in buildings as human habitation, has undergone significant transformations, progressing from the creation of pit-houses and grass shelters to the construction of more enduring structures (Edwards, 2024; Tobolczyk, 2020; Bowen and Gleeson, 2018). The last century has witnessed a shift from horizontal expansion of buildings to vertical transformations with the debate focused on sustainability. At the same time, in developing countries like Nigeria, there is still a systematic causality responsible for substantial losses of materials, health, and lives associated with building collapse (Hamma-adama, Iheukwumere, and Kouider, 2020).

Globally, the recurrent incidences of building collapse pose a significant threat to the national and local economy, impeding progress towards the United Nations Sustainable Development Goals (SDGs), particularly SDG11, which emphasises sustainable cities and communities (He and Njock, 2023). These incidents are documented annually, with an average of eight collapses each year and more than 300 fatalities annually (Keim, 2021). The ramifications of building collapse are far-reaching, affecting building occupants, investors, stakeholders, and the general public, thereby influencing the project's objectives (Akande *et al*., 2016). Despite ongoing advancements in construction technologies and regulations, the persistence of building collapse or failure remains a concern (Yin *et al*., 2019; Li, 2020). The challenges and hazards associated with building collapse are not confined to a specific region but are recurrent in various parts of the world, including Brazil, India, Egypt, China, and Nigeria. For instance, Chen *et al*. (2021) reported the collapse of a 30-year-old building in China, resulting in 17 deaths and 5 injuries. Zhou and Ma (2023) documented the collapse of a hotel in Quanzhou, China, claiming the lives of 29 people. In India a 35-year-old building was also reported to have collapsed causing the deaths of more than 36 people while injuring more than 24 people (Jha, 2020). Additionally, Ohenhen and Shirzaei (2022) reported a staggering total of 152 building collapses in Lagos in 2005, resulting in more than 200 casualties. These incidents underscore the grave consequences and menace posed by building collapse, despite efforts to address the issue.

In explaining what constitutes a project, Oladigbolu *et al*. (2022) defined it as an endeavour comprising a sequence of organized and regulated tasks with defined start and end dates, conducted to accomplish a particular objective while adhering to limitations in terms of time, cost, and resources. This description aligns with the description of a building by Odeyemi *et al*. (2019) as structures that are methodically conceptualized, designed, developed, and built with the primary goal of protecting individuals and their possessions. This connection suggests that buildings are also considered as projects since they have a specific objective with defined start and end dates. Kumar (2022) emphasized that one of the major characteristics of projects, including construction projects, is that there are stages in carrying out a construction project and that proper management of each stage of a construction project is necessary for its successful implementation while minimizing the risk of faults. Mawdesley and Michael (2007) similarly stated that the completion of a building project can follow either a path of optimism, guesswork, and luck, or one of systematic planning and control. The former approach is prone to unfavorable outcomes as all work is carried out without expert review and risk management. Additionally, Mawdesley and Michael (2007) noted that systematic planning and control offer a positive approach to building construction and risk management, although the prevention of failure cannot be guaranteed due to variations in the quality of the planning process. This statement characterizes the situation in the delivery of building projects in Nigeria. It is widely acknowledged that a significant number of building projects in Nigeria lack proper planning and scheduling of activities, often executed without input from a project manager with training in PM (PM). Even when projects are planned, the planners seldom employ appropriate scheduling techniques to logically sequence the planned activities constituting the building project, thus compromising effective project execution. However, the significance of thorough planning, scheduling, and monitoring of building project activities cannot be overstated, particularly in the context of preventing project abandonment, failure, building collapse, as well as cost and time overruns.

Mulvaney (2005) concurs with the aforementioned perspective, asserting that the purpose of planning is to generate a timetable for work, ensuring each task is assigned a start and finish date, along with the guarantee that essential resources for each task will be available as needed. However, in Nigeria, those responsible for executing public building projects often neglect the significance of scheduling building project activities. This is evidenced by the scarce utilization of scheduling plans in public building projects, and when used, bar charts are typically the preferred method, regardless of the project's complexity. Building

stakeholders in Nigeria are sceptical about the impact of PM techniques on the successful delivery of building projects. Evidently, when discussions about PM techniques arise with building project stakeholders, there is a noticeable lack of enthusiasm. Instead, they tend to emphasize that these techniques are ineffective in Nigeria, asserting that site workers lack comprehension, resulting in their non-utilization. They further argue that the adoption of such techniques is unnecessary (Barnisile, 2005).

To address the issue of building collapse and the related risks, the Nigerian government enacted laws at various points in time to direct building construction and reduce the threat and risks of building collapse. The Nigerian Urban and Regional Planning Act No. 88 of 1992 was enacted by the government in 1992 to facilitate the production and execution of development plans and planning schemes to create a better environment for living, work, and recreational activities. Aside from the above-mentioned general goal, the Act was intended to provide greater importance to development control, among other specific aims (Obodoh *et al*., 2019). Despite the regulations put in place by the government, the issue of building collapse still remains persistence in the country as indicated by recent incidents, therefore, it becomes necessary to understand the root cause of building collapse. There have been many causes that have been related to building collapse in Nigeria as suggested by various investigations, for example some studies have suggested that the use of sub-standard building materials is responsible for building collapse and failure (Dimuna, 2010; Ayedun *et al*., 2011; Ayodeji, 2011; Agwu, 2014), while others such as Ayininuola and Olalusi, 2004; Olajumoke *et al*., 2009 and Ede, 2014 have attributed building collapse to faulty design as well as lack of proper supervision. Hence, a majority of the challenges and issues can be traced back to the actions and omissions of the stakeholders involved, spanning from the design phase to the construction stage. These stakeholders encompass the client, designers, and constructors, involving professionals such as architects, civil/structural, mechanical, and electrical engineers, quantity surveyors, and builders. The central focus of many discussions and research findings pertains to deficiencies in building materials, design, construction supervision, and the oversight by local authorities responsible for design approvals and compliance monitoring (Agwu, 2014; Ede, 2014).

In light of the growing frequency of building collapses in Nigeria endangers human lives, property, and the country's socioeconomic fabric, this study will evaluate the causes of these recurring recurrence of these tragedies, despite existing legislation and government efforts, emphasises the necessity for a full knowledge of the underlying causes and effective

solutions. It dives into the various issues connected with building collapse, focusing on the long-term ramifications for communities, economies, and the pursuit of sustainable development goals. Despite the enactment of laws and regulations governing building construction, the frequency of these incidents of building collapse necessitates a thorough assessment of the underlying causes. Several researches have connected building collapse to variables such as substandard materials, poor design, and insufficient supervision. However, one common thread running across these problems is a lack of proper management throughout the construction process, which includes stakeholders from design to construction.

To address these issues, a paradigm change towards methodical planning and control is required, with PM techniques playing a key role. Thorough planning, scheduling, and monitoring of construction project activities are critical for avoiding project abandonment, failure, and, most significantly, building collapse. While stakeholders in Nigeria are sceptical of the effectiveness of PM techniques, this study aims to challenge this perception and demonstrate the critical role these techniques can play in ensuring the successful delivery of building projects and mitigating the risks of building collapse in Nigeria. This research aims to contribute to safer and more resilient construction practices by providing practical and realistic solutions based on PM techniques, ultimately fostering a built environment that prioritises the well-being of its occupants and the country's long-term development.

1.2 Statement of Research Problem

Building collapse and related hazards constitute a unique research which borders on public safety and infrastructure integrity, there is a growing corpus of academic works on the research area in the 50 years of its recurrence in Nigeria albeit there is still a huge gap in understanding and implementing viable solutions. Building collapse has arisen as a critical and extensively debated topic in Nigeria's construction industry, attracting significant attention in recent years (Qurix and Doshu, 2020). According to Ayininuola and Olalusi (2004), Dimuna (2010), and Amadi *et al*. (2012), this long-standing problem is mostly caused by human-induced factors. The persistent difficulty of building collapses highlights the critical need for comprehensive steps to address these man-made vulnerabilities, improve construction methods, and promote industry safety standards, particularly in areas where the risk is higher. It stands out as one of the most distressing types of construction catastrophes on a global scale. Instances of building collapses have become a regular occurrence worldwide in recent decades, leading to numerous casualties and substantial property losses

(He and Atangana Njock, 2023). The persistence and escalation of building failure and collapse in Nigeria over the last decade have had a substantial and far-reaching impact, both in terms of human lives and economic implications (Hamman-Adama and Kouider, 2017). This phenomenon has been a source of concern for three decades, during which Nigeria has had an alarming frequency of building failures and collapses. Between 1974 and 2011, a staggering 64 buildings were reported to have collapsed in Nigeria, resulting in approximately 300 fatalities (Tanko *et al*., 2013). The gravity of the situation became even more pronounced in the subsequent decade. Between 2010 and 2020, an alarming total of 48 buildings collapsed in urban cities across Nigeria, marking a troubling surge in such incidents (Qurix and Doshu, 2020).

This disturbing trend reflects not only a quantitative increase but also a qualitative intensification in the impact of building collapses, with each event leaving a lasting imprint on the affected communities. An example of the human toll and damage caused by a building collapse happened in 2016 in Uyo, Akwa Ibom State, when a single catastrophe claimed the lives of around 200 people (Punch, 2016). Lagos, Nigeria' s thriving metropolis and the world's third most populous coastal city, has been especially prone to the scourge of building collapse over the last 50 years. With a population of almost 15 million, Lagos has seen an unending sequence of such incidents, emphasising the vital need for effective intervention. According to existing research, roughly 300 structures collapsed in Lagos between 1978 and 2022 (Ebehikhalu and Dawam, 2014; Okunola, 2021). The human toll has been terrible, with over 400 documented deaths, 6,000 displaced homes, and an estimated property damage of US$ 3.2 trillion (Okunola, 2020, Okunola, 2021, 2022).

The loss of lives and disruption in communities necessitates an emphasis on a comprehensive understanding of the underlying factors responsible for building collapse and remedies (Okunola, 2020). The economic impact is significant, with the costs of rescue, rebuilding, and compensation adding to the financial strain. Unfortunately, the regular occurrence of building collapses, poses significant research enquiry. It is pertinent to understand that when a building collapse occurs, the structure fails to fulfil its intended purpose (Allen and Jano, 2019; Love and Matthews, 2024; Adedokun and Egbelakin, 2024). In Nigeria, the Council for the Regulation of Engineering in Nigeria (COREN) and the Nigerian Institute of Architects put the incident count for collapsed buildings above 135 buildings and over 500 human casualties for 2024 (Adaji, 2024). These losses occur at various stages, encompassing on-site

construction health and safety concerns to the post-construction phase which are attributed to negligence to the safety, serviceability, and economy (Awoyera et al., 2021).

Notably, four major cases of building collapse in Lagos alone resulted in the terrible loss of 191 lives (Ohenhen and Shirzaei, 2022). The various consequences of building collapse, as elucidated in numerous research studies, indicate that the issue transcends its immediate impact, extending beyond physical damages to structures. The repercussions of building collapse profoundly affect various aspects of Nigerian society, influencing the lives of citizens through fatalities and displacement, impacting the economy, and posing a hindrance to the pursuit of sustainable development goals. These effects contribute to a complex web that affects the socio-economic fabric of the nation (Okunola, 2021, 2022; He and Njock, 2023).

Furthermore, the repeated occurrence of these incidents has called into question; the effectiveness of existing regulatory frameworks, construction practices, and building standard enforcement. The lack of comprehensive PM procedures geared to the specific constraints of the Nigerian construction scene impedes the avoidance of building collapses, resulting in enormous human and economic losses (Ogundipe, 2024). Hence, This study seeks to analyse and use realistic PM techniques to reduce the constant and reoccurring hazards associated with building collapse in Nigeria.

1.3 Research Questions

The following research questions are to be answered at the end of this research:

1. What are the causal factors in terms of structural, regulatory and work procedures that significantly contribute to the occurrence of building collapse in Nigeria?
2. What are the PM techniques that are currently been employed in Nigeria construction industry?
3. How can PM techniques be effectively utilized in mitigating the issue of building collapse in Nigeria?

1.4 Aim of the study

This study aims to provide effective solutions to the prevalent issue of building collapse in Nigeria through the strategic application of PM techniques.

1.5 Specific objectives of the research

The specific objectives of the study are to

- Identify the causal factors contributing to building collapse in Nigeria, taking congnisance to primarily structural, regulatory and procedural aspects.
- Analyse PM techniques employable to deter building collapse within Nigeria construction industry
- Present evidences on PM techniques and solutions deployed in other countries that are viable for considerations for effectively mitigating the issue of building collapse in Nigeria.

1.6 Theoretical Framework

Considering building construction as a project and acknowledging the need for comprehensive management of every stage involved in carrying out the project, this thesis adopts the 'PM Theory' framework to evaluate the effectiveness of PM techniques in addressing building collapse in Nigeria.

The objective of PM theory is to explain and guide the planning, implementation, and control of projects, ensuring their goals are met while adhering to limitations in terms of time, cost, and quality (Kerzner, 2017). The PM theory consists key concepts, they are the project life cycle and the triple constraint or iron triangle. According to PMI (2017), a project life cycle entails the sequence of stages a project progresses through from initiation to conclusion. Each project phase comprises a set of interconnected activities leading to the fulfilment of one or multiple deliverables. The life cycle of a project in regards of its size or complexity consist od constants stages or phases that can be measured and evaluated at each interval or at the end of each stage to evaluated the progress of the projects. These phases include: starting the project, organizing and preparing, carrying out the activities and closing the projects.

Another significant concept within PM theory is the triple constraint or iron triangle or the PM Triangle, which denotes the interconnected aspects of time, cost, and scope that dictate project performance and achievement (Whitman *et al*., 2023). The Iron Triangle serves as a fundamental framework for evaluating project success, gauging whether the project is completed on time, within budget, and meeting predetermined quality, performance, or scope criteria. It has become the standard for regularly assessing project performance. The Iron Triangle concept provides a clear method of illustrating the connections among these core success factors. It is commonly represented as a triangle with each criterion at its vertex.

Changes in one criterion, such as due to client requests or resource constraints, can impact the other criteria. If one constraint fails, it is likely to exert adverse pressure on one or both of the remaining two (Pollack *et al*., 2018).

1.7 Justification of the study

The importance of "Preferring Solutions to Building Collapse in Nigeria Using PM Techniques" derives from the urgent necessity to address a pervasive hazard to public safety and economic stability. Building collapses in Nigeria have caused considerable human casualties and economic losses, emphasising the urgent need for comprehensive solutions. The use of PM methodologies provides a systematic and proactive approach to identifying, assessing, and mitigating the underlying causes of building failures. This study aims to give valuable insights to the construction sector by emphasising organised planning, risk management, and adherence to quality standards, to foster safer, and more resilient infrastructure in Nigeria.

1.8 Scope of the Study

The incidence of building collapse is widespread across various regions of the country, but statistics reveal that the majority of these collapses are concentrated in Lagos state, a bustling metropolitan area in Nigeria. Data indicates that approximately 300 building collapses have occurred in the city between 1978 and 2020, solidifying its reputation as a hotspot for such incidents (Ebehikhalu and Dawam, 2014; Okunola, 2021). Given this stark reality, the objective of this project is to assess Lagos as a representative case study in Nigeria, aiming to evaluate the efficacy of implementing PM techniques to address the issue of building collapse.

1.9 Structure of the Thesis

The present thesis is organized into five chapters. The first chapter encompasses the background, justification, statement of the research problem, and the aims and specific objectives of the study. Chapter two provides an empirical and conceptual assessment of building collapse in Nigeria, along with the associated factors and mitigation methods proposed based on various established investigations in the country. Chapter three outlines the detailed methodology, procedures, and research tools utilized in addressing the research problem. Chapter four presents the findings and results of the research. Finally, chapter five delves into the discussion of the research's findings in connection to prior research. This chapter also includes the research's contribution to knowledge, the conclusion of the study,

limitations encountered during the course of the study, and recommendations derived from the research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter conducts a thorough analysis of existing research, concentrating on the persistent problem of building collapse in Nigeria. It dives into the numerous elements that contribute to construction failures and proposes realistic strategies for addressing this ongoing problem. The chapter begins with a thorough examination of building collapse accidents in Nigeria and an investigation into their underlying causes. Furthermore, it critically evaluates project and risk management within the context of construction projects, highlighting best practices in construction PM and explaining the present regulatory framework that governs the construction industry in Nigeria. The chapter's ensuing sections provide a thorough assessment of the challenges confronting construction management in Nigeria, shedding light on both historical and contemporary issues. Furthermore, it highlights past solutions and interventions that have been used over time. The chapter also examines the relevance of PM approaches in the Nigerian environment, providing insights into the problems and opportunities connected with their implementation. It also includes case studies of building collapse accidents in Nigeria, which provide real-world examples to highlight crucial aspects. Finally, the chapter examines the theoretical framework in construction management, which contributes to a comprehensive understanding of the subject.

2.2 Construction Industry in Nigeria

The construction sector holds a prominent position as one of the world's largest industries. As of 2023, global construction market value, as reported by The Business Research Company, reached $14,393.6 billion in 2022, representing 14.2% of the global GDP, it is among major determinants of any developing country' s economy. It is the second highest employer of labour after agriculture in an emerging economy like Nigeria. The construction businesses in Nigeria have an input of 4.09% in the real gross domestic product (GDP) of the country (National Bureau of Statistics (NBS), 2019). In recent statistics, the construction industry in Nigeria contributed N8.33 trillion to the Nigerian treasury in the first quarter of 2023. Although this figure was slightly lower than the N9 trillion generated in the last quarter of 2022 (Aina, 2023), it still represents a substantial amount generated from the industry. The construction industry in Nigeria faces various challenges. According to Ezeokoli *et al*. (2021),

among the numerous challenges confronting the industry, the more prominent ones, as identified by construction stakeholders in the southeast of the country, include corruption issues among project procurers and engineers, constraints in project finance and capital supply, inflation in construction resource prices, inadequate project planning and quality control, and a scarcity of skilled labour. These challenges, either individually or collectively, may be responsible for the significant menace of building collapse that has plagued the nation's building industry. Investigations have suggested that factors associated with building collapse in Nigeria, such as structural failure, faulty design, the use of unqualified personnel, poor workmanship, inappropriate foundation, and substandard materials (Aribilola *et al*., 2023), are consequences of the challenges facing the construction industry in Nigeria.

2.3 Building Collapse in Nigeria

Odeyemi *et al.* (2019) explains the multifaceted nature of building, identifying them not only as physical structures but also as meticulously designed structures with the primary goal of protecting individuals and their possessions. These structures are methodically conceptualized, developed, and built with the ultimate purpose of creating a comfortable environment. The emphasis in this definition is on the recognition that structures meet the fundamental human need for shelter, which extends beyond persons to include their belongings, animals, and the essential mechanical and electrical equipment required for modern living. Within the Nigerian context, the construction landscape has witnessed remarkable advancement over the years, as articulated by reports from the Real Estate Developers Association of Nigeria (REDAN). This progress is exemplified by the construction of at least 300,000 new building units annually (Nairametrics, 2023), emphasizing the significant role that building construction plays as a major endeavour in the country. This exponential rise demonstrates the construction sector's dynamism and pivotal role in the nation's infrastructure development. However, despite this progress, the possibility of building collapse remains as a critical concern. Odeyemi *et al*. (2019) defines building collapse as a state of complete failure, an eventuality that transpires when a structure has effectively given way, with most structural parts succumbing to the forces acting on them. In such cases, the building undergoes a severe state of failure, rendering it incapable of standing as originally intended. This description emphasizes the gravity of building collapses, underlining the need for comprehensive steps to prevent and mitigate such catastrophic accidents in the construction industry.

In recent years, the issue of building collapse has emerged as a paramount concern within the Nigerian construction industry, particularly over the last two decades. This surge in concern is attributable to the escalating incidence of building collapses, predominantly witnessed in numerous urban areas (Qurix and Doshu, 2020). This period has been marked by a series of devastating events, as Nigeria has witnessed the collapse of various structures, resulting in the loss of lives and substantial damage to properties valued at millions of Naira (Odeyemi *et al*., 2019). While building collapses are not unique to Nigeria and occur all over the world, the rate at which they occur in Nigeria has sparked particular concern (Ibrahim *et al*., 2018) as the country has been ranked top in the frequency and intensity of building collapse in Africa, with Lagos been at the forefront of this unfortunate incident (Ugwu, 2023). The frequency and severity of building collapses in the country have highlighted the critical need for a concentrated and coordinated effort to identify, prevent, and mitigate the elements that contribute to this widespread problem.

In a bid to highlight the severity of the building collapse issue in Nigeria, a research effort was undertaken by Okoye *et al*. in 2023. Their study aimed to quantify the number of building collapses across five decades, spanning from 1973 to 2022. According to the findings, a total of 177 buildings were reported to have collapsed during this period. The breakdown revealed that there were 9 building collapses reported between 1973 and 1982, 22 between 1983 and 1992, 27 between 1993 and 2002, 64 between 2003 and 2012, and 55 between 2013 and 2022. These figures, based on reported incidents, shed light on the escalating trend of building collapses in the country over the decades (Okoye *et al*., 2023). In year 2023, Nigerian Institute of Civil Engineering recorded a total of 32 building collapse across the nation and a partial building collapse in 2024. It is important to note that the statistics provided by Okoye *et al*. (2023) are derived from reported numbers in academic articles, potentially indicating a discrepancy with the actual number of building collapses in the country. A different perspective was provided by Ogundeji (2023), who reported that Nigeria has witnessed a total of 553 building collapses between 1974 and April 13, 2023, spanning 49 years. This data was based on the records of the Building Collapse Prevention Guild, revealing a significant gap between the evaluated cases in research articles and the actual recorded instances by the guild. The report by Ogundeji (2023) also stated that the highest number of building collapses occurred in the year 2022, with 62 recorded nationwide. By the time the report was published in April 2023, 12 building collapses had already been documented. The report from Ogundeji (2023) also indicated that building collapses were not

recorded in only three years: 1971, 1975, and 1981, spanning 49 years in the country. These statistics points to the fact that building collapse is a menace in the country. While admitting probable differences in reported numbers, Okoye *et al*.'s (2023) data indicate an alarming increase in the frequency of building collapses in Nigeria per decade. This increase persists despite advances in technology, building materials, and construction practices, necessitating a thorough assessment of the underlying reasons for this widespread problem. The compelling need for a thorough examination of the elements that contribute to building collapses in Nigeria is clear, emphasizing the importance of effective interventions and preventive measures in the construction industry.

Over the years, incidents of building collapse have been documented in various parts of the country. According to Nicholas *et al*. (2021), notable occurrences of building collapses have been recorded in prominent cities such as Abuja, Lagos, Port-Harcourt, Ibadan, Enugu, and Kaduna. Additionally, Ogundeji (2023) reported instances of building collapse in Taraba, Bayelsa, Gombe, Yobe, and Zamfara, underscoring the widespread nature of this issue. The frequency of building collapses varies across regions in the country. Qurix and Doshu (2020) highlighted that, when comparing four major locations known for building collapses, Lagos exhibits the highest rate, followed by Abuja, Kaduna, and Ibadan. These cities are recognized for their population density and urban lifestyle, contributing to the challenges in maintaining structural integrity. Supporting the assertion that Lagos has the highest rate of building collapse, Ogundeji (2023) disclosed that Lagos reported over 326 building collapses in the last 49 years, constituting 59.05% of the total 553 reported cases nationwide during this period. In the year 2022, which recorded the highest rate of building collapses with 62 incidents nationwide, Lagos alone accounted for 20 cases, representing 31.7% of the total incidents. These statistics underscore the prominence of Lagos, a major metropolis in the country, as the most notable location for the occurrence of building collapses. Despite incidents being reported in various areas across the country, Lagos stands out as a significant hotspot for this unfortunate phenomenon. Collapsed buildings in Nigeria have been predominantly grouped into three major categories: Residential, Commercial, and Institutional buildings. However, the frequency of building collapse incidents varies across these categories. Okunola (2020) identified that among the 152 building collapses that occurred in Lagos between 2005 and 2020, 9% were institutional buildings, 13% were commercial buildings, while residential buildings accounted for the majority, at 78%.

The occurrence of building collapses in the country has led to various consequences, including loss of life, property destruction, and considerable financial and resource loss. Obodoh *et al*. (2019) assessed the effects of building collapse in Nigeria, categorizing them as economic/financial risks, sociopolitical risks, human-related risks, environmental risks, and physical hazards. The most significant repercussions were the loss of life, property, and economic/financial hazards. According to an article published by Nwannekanma (2022), over 1,090 deaths and numerous injuries were recorded from 461 collapsed buildings between 1974 and July 2021. Additionally, the Building Collapse Prevention Guild reported that out of the 62 building collapse catastrophes recorded in 2022, 84 deaths and 114 injuries were documented (PUNCH, 2023). Apart from these tragic outcomes, building collapse in the country has resulted in the loss of livelihoods and the displacement of families, with over 6,000 households affected (Okunola, 2022). In terms of property and financial losses, Okunola (2022) highlighted that the frequent occurrence of this catastrophe has led to a total loss of approximately $3.2 trillion worth of property over the last two decades. In Lagos, which is known to be at the forefront of these incidents, up to N66.37 billion was lost to building collapse in 2022 alone (Nwannekanma, 2022). These various effects of building collapse in the country further underscore the significant menace posed by this phenomenon.

2.4 Causes of Building Collapse

There is no occurrence without a cause; the phenomenon of building collapse has been attributed to various causes, which have been broadly categorized into two main groups: natural causes and man-made causes (Ma'aruf *et al*., 2023). Instances of building collapse resulting from natural causes have been recorded, such as cases triggered by earthquakes in Taiwan (Nicholas *et al*., 2022) and instances in Nigeria caused by heavy downpours and flooding (Okoye *et al*., 2023). However, investigations into the causes of building collapses in Nigeria have predominantly pointed to human errors, with only a few attributed to natural disasters. Researchers have conducted various investigations to identify probable causes of building collapse in Nigeria, soliciting opinions from stakeholders. Nicholas *et al*. (2022) conducted research to determine the causes of 56 building collapse cases in Nigeria between 2009 and 2019. From their investigations, various factors were identified as responsible for building failure and collapse in the country. The use of substandard materials accounted for 25%, structural failure due to years of existence accounted for 23.9%, poor supervision, poor workmanship, and the use of unqualified personnel accounted for 14.8%, non-adherence to statutory regulations/warnings and compliance with approved building plans accounted for

6.8%, and natural disasters accounted for only 3.4%. Furthermore, Hamma-Adama *et al.* (2020) classified the investigated causes of building collapse in Nigeria into primary and secondary causes to assess their causal effects. Primary causes included substandard building materials, poor workmanship/faults on the construction site, faulty design, quackery, illegal conversion/alteration/excessive loading, inadequate or lack of supervision, geotechnical issues, and non-consultation of professionals. Secondary factors, such as poor maintenance culture, corruption, and fire incidents, were considered to have indirect contributions to building collapse.

Qurix and Doshu (2020) conducted an examination into the frequency with which certain factors have the potential to lead to building collapse by conducting primary research among 50 building professionals in three states of the country: Lagos, Abuja, and Kaduna. From the results obtained from the study, certain factors were identified as contributing more significantly to building collapse. These factors include corruption among contractors, inappropriate foundation, cost-cutting by clients due to expensive building materials, lack of monitoring and compromise from government regulatory agencies, faulty architectural and engineering designs, use of substandard materials, and poor supervision or the absence of supervision by qualified professionals. Other researchers have also conducted reviews of various causes identified as contributing to building collapses in the country. Nwoyiri *et al.* (2023) highlighted in their review that professional bodies in the building industry attribute the causes of building collapse to deficiencies in structural drawings, lack of proper supervision, alteration of approved drawings, approval of technically deficient drawings, illegal alterations to existing buildings, clients' over-reliance on contractors for decision-making on sites, use of unqualified personnel, and absence of town planning inspection and supervision on sites. Odeyemi *et al*. (2019) also identified an array of factors such as hasty construction, overloading, old age, poor construction, poor quality materials, and structural defects as being responsible for building collapse in Nigeria. Finally, Imafidon and Ogbu (2020), in their analysis of the causes of building collapse, grouped the factors into clusters and identified that the causative factors fall under clusters relating to design and construction, policy-related causes, or quality management-related causes.

Apart from the causative factors, studies have also delved into the underlying reasons that might have contributed to these factors. Okunola (2020) employed a qualitative method (interview) to understand the underlying reasons for the occurrence of building collapse in Lagos State. The results of the study revealed that individual errors and governmental errors

are primarily responsible for collapse incidents in Lagos. According to the study, the individual errors that have led to building collapse are rooted in the ambiguity and uncertainty surrounding the issue of land tenure, which is the primary way people gain access to land ownership in Lagos State. Some respondents from Okunola's (2020) study indicated that the main way of acquiring or deriving benefits from land is to obtain it from land grabbers (Omo Onile), which can easily be hijacked at any point in time. Therefore, the fear of uncertainty to a certain degree is one of the reasons why developers are hasty with construction and thereby fail to follow the required processes in building construction as stipulated by the government and governing bodies. Another underlying factor related to individual errors is greed and the pursuit of unwarranted profits. From Okunola's (2020) study, it was gleaned that developers, in an attempt to maximize profits, resort to using substandard or sometimes cheap materials, bypass basic professional procedures for obtaining building plan approval, engage unqualified personnel in the construction of buildings, and partake in illegal conversions or alterations to existing and/or dilapidated structures. Okunola (2020) further elaborated that this issue could be attributed to the fact that developers are constantly under immense pressure to recoup the capital invested in the project promptly, allowing them to quickly move on to the next project.

Okunola (2020) determined that on the government's part, underlying situations such as ineffective monitoring of building development due to inadequate staff capacity and insufficient tools to operate, the use of inefficient technical staff in local authorities, unwarranted delays in the approval process, and the deployment of incompetent staff in inappropriate positions are all associated with building collapse in the state. Additionally, corruption among government officials responsible for building plan approval and monitoring of the construction process was another major factor associated with building collapse in the state. The level of corruption within the government has led to the approval of building plans that violate city plan layouts, such as constructing in inappropriate places like flood-prone areas, which can eventually result in building collapse due to natural phenomena such as floods and storms.

In addition to these factors, another group of factors relates to the management of construction projects and the insufficient use of PM methodologies and techniques. Ezeokoli *et al*. (2021), in their investigation of modern construction approaches in Nigeria's south-eastern region, identified poor project planning, inadequate quality control, and corruption as significant challenges encountered in construction in that area. These identified constraints

have been demonstrated to result in the underutilization of project managers, resulting in reduced operational efficiency. As a result, projects lacking proficient PM practices are at greater risk of encountering delays and exceeding budgetary constraints which can result into the use sub-standard materials and unqualified professionals. Adagba *et al*. (2023) examined the factors behind the failures and desertion of construction projects in Kaduna state, Nigeria. Their results emphasized corruption as a significant problem, particularly in kickback practices, evident in forms like bribery, which undermines the regulatory framework overseeing contract bidding. Moreover, shifts in government leadership were found to result in the introduction of new policies, disrupting ongoing projects and reducing the effectiveness of project managers. Political pressures also compound PM difficulties by intervening in project oversight and administration, consequently impacting project requirements.

The collapse of buildings in Nigeria and other regions is a dramatic example of the complex interplay of different causes, including natural forces, human activities, and systemic weaknesses. While it is true that events such as excessive rainfall and flooding can contribute to specific collapses, it is critical to recognise that the majority of building collapse in Nigeria are caused by human fallibility, ineffective procedures, and flaws in regulatory frameworks. When the core causes of these collapses are examined, it is clear that human errors and lapses in judgement play a substantial role. Substandard practices, caused by a range of variables such as cost-cutting efforts, a lack of competence, and shortcuts in construction procedures, frequently result in reduced structural integrity. Regulatory failures worsen these difficulties by permitting bad construction methods to continue unabated. Substandard building materials are a common problem, contributing significantly to building failures. Furthermore, relying on default construction designs without considering site conditions or not following recognized safety measures poses substantial risks. Furthermore, modifications to building designs and requirements, whether due to budget constraints or changes in project scope, might jeopardize structural stability if not handled properly. Finally, these difficulties share a common denominator: inadequate management throughout the whole building project lifecycle. Inadequate oversight, insufficient quality control procedures, and a disregard for established building codes and standards all lead to an increased risk of structural failure. Hence, all of these challenges can be mitigated through diligent management and rigorous supervision of building projects.

2.5 Regulatory Framework in Nigeria Construction Industry

The construction sector stands out as one of the most intricate and diverse parts of any nation's economy. It engages a broad range of participants (Osuizugbo and Ojelabi, 2020). Okeke *et al*. (2020) expanded on the idea that the intricate nature of the construction industry stems from the participation of various entities, both domestic and international, including professionals, materials, labour, and machinery, all of which collaborate, interact, and operate together to complete construction projects. This includes individuals such as design experts (architects, engineers), financial analysts (quantity surveyors), construction crews (builders, contractors), urban planners, surveyors, and auxiliary personnel (government officials, developers, financial institutions). To manage this, the government has established town planning and approval authorities tasked with overseeing the approval process for all construction projects within specific geographical areas. Numerous legislations, standards, and regulations are in place to govern the operations of the construction industry, aimed at ensuring a safe and conducive working environment necessary for the creation of structurally sound buildings. Throughout the construction phase, permits, approvals, or certifications are typically mandated as prerequisites for advancing to subsequent stages of the work. Compliance with these permits or approvals is legally required, necessitating careful attention to meet the established criteria; failure to do so may lead to liability for those involved in the construction process.

The major legal/policy guiding building and construction in Nigeria are The Nigerian Urban and Regional Planning (NURP) Law (decree 88 of 1992) and National Urban Development (2006). The Constitution of the Federal Republic of Nigeria (CFRN) 1999 delegates the responsibility for setting standards for building and construction projects to the concurrent legislative list. This means that building standards are established by all levels of government: federal, state, and local. However, in cases of conflict, federal standards take precedence over those at lower levels. As a result, building codes, regulations, and bye-laws are enforced at the federal, state, and local government levels in Nigeria. While building standards in Nigeria have evolved over time, drawing from customs, practices, and available materials, the best practices in building design, material usage, safety protocols, labour regulations, professional standards, monitoring, and management are continuously updated to align with the changing dynamics of various stages of construction projects (Onyema, 2017). Emerging from various legislative frameworks that govern building standards in Nigeria are both statutory regulations, which establish minimum compliance requirements, and non-statutory guidelines,

such as the national building code and codes of conduct or ethics for industry professionals. These elements work in harmony to uphold the integrity of building projects, ensure the welfare and safety of workers, and promote practices that safeguard public and environmental health. Among the legislative enactments pertinent to the industry are the Standard Organization of Nigeria Act (SON Act), the Land Use Act of 1978 as amended in 2004, the Factories Act of 2004, the National Building Code of 2006 (NBC), the Labour Act of 2004, the Industrial Training Fund Act of 2011, and numerous state laws.

According to Okeke *et al*. (2020), the Nigerian Urban and Regional Planning Decree (NURP), numbered 88 of 1992, governs physical and developmental activities in the country and facilitates the decentralization of planning and control activities by establishing institutions at three tiers of government. At the federal level, the Urban and Regional Planning Commission is responsible, while at the state level, the Urban Development Boards oversee these activities, and at the local government level, the Local Planning Authorities are tasked with similar responsibilities. These agencies are mandated not only to enforce the provisions of the NURP law 1992 but also to implement the National Physical Development Plan (NUDP), initially introduced in 1997, along with other policies, programs, and activities aimed at advancing urban and city planning and enhancing the quality of life for the populace. Following this, Section 7.4 of the Nigerian National Building Code 2006 provides detailed explanations regarding the statutory documentation prerequisites for obtaining building plan approval in Nigeria. It outlines the conditions that must be met concerning the regulation of physical planning as mandated by the relevant planning authorities within their respective jurisdictions. Among these documentary requirements, the following are strictly important to building construction:

- Site Analysis Report and Plan: This document, compiled by a certified urban planner, ensures that the proposed development aligns with the standards set for the surrounding area. All planned building developments must adhere to the existing Urban Design Plan and zoning regulations (Okeke *et al*., 2020). The process involves comprehending and analysing various elements, including positive, negative, and neutral factors observed on the project site, as well as its natural and environmental surroundings, both natural and man-made. This understanding informs decision-making to support the architectural design process (Abou Ouf and Makram, 2018).
- Design Drawings: Depending on the geographical context, acquiring a development permit typically necessitates the submission of a minimum of three sets of building

plans. These sets include architectural working drawings, structural engineering designs, and mechanical and electrical engineering plans. The architectural drawings must encompass detailed floor plans outlining the utilization and dimensions of each space, as well as schedules for doors, handles, and windows. Sections and gridlines should also be included. Moreover, these drawings must align with the location, type of building, and applicable zoning regulations. Structural drawings should outline the intended load of the building and depict structural elements such as beams, columns, and slabs designed to withstand these loads. Additionally, material specifications and finishing schedules must adhere to building standards and codes. The service drawings should indicate the placement of electrical, mechanical, plumbing, and communication conduits, pipes, and systems. Furthermore, these plans should delineate the materials and techniques employed to ensure structural integrity, fire resistance ratings, and fire-stopping measures.

Apart from the main agencies established for building management and control at the federal level, states have also established their own agencies to oversee building construction within their respective jurisdictions. Lagos State, which has faced challenges with building collapses, has implemented such an agency. The Lagos State Building Control Agency, established under the Lagos State Urban and Regional Planning and Development Law in 2010 and operational since August 12, 2012, is tasked with ensuring that fundamental minimum standards are upheld in building construction and renovation projects. These standards aim to guarantee the safety, healthiness, accessibility, and habitability of both existing and newly constructed buildings for present and future generations. The agency's responsibilities include comprehensive building control, granting approval for construction following the acquisition of development permits, and conducting inspections and certification at various stages of building construction. (LASBCA, 2024).

These various agencies, laws, and documents were established with the aim of facilitating the construction of essential and suitable buildings. While these legislative measures were implemented to guarantee sufficient protection for both humans and the environment, their effectiveness in addressing the escalating incidents of building collapses nationwide remains limited. The escalating occurrences of building collapses persist unabated, despite concerted efforts to address them. This issue can be ascribed to a multitude of factors hindering the effective implementation of relevant policies. For instance, a notable case in Lagos, particularly the collapse of a 21-storey building along Gerrad Road in the Ikoyi area on

November 1st, 2021, sheds light on these challenges. According to Ogundeji (2023), the coroner overseeing the investigation attributed the collapse to the irresponsibility and negligence of government agencies tasked with upholding best practices in project approval and supervision. The coroner highlighted that the building's density and setback violated the Lagos State Building Regulations significantly. In response to the coroner's findings, the Chairman of the Lagos State Branch of the Nigeria Institute of Architects cited the understaffing of essential agencies responsible for overseeing building constructions. This shortage of manpower impedes effective monitoring across over 48,000 construction sites in the state.

A member of the Nigerian Institute of Builders echoed this sentiment, attributing the issue of building collapses in the state to inadequate regulations. Expanding on this, it was noted that while there are existing policies governing building construction, their effective implementation is impeded by the insufficient staffing of building control agencies relative to the extensive scope of the state. Consequently, government agencies often find themselves unable to adequately monitor or supervise building construction activities after the approval of building plans, thus allowing unqualified individuals referred to as 'quacks' by Ogundeji (2023) to engage in construction projects. Additionally, Ogundeji (2023) highlighted that the prevalence of 'quackery' is further fuelled by the reluctance or inability of regulatory bodies and relevant governmental authorities to prosecute and convict individuals found responsible for professional negligence in cases of building collapses.

The combined influence of these factors primarily accounts for the ineffectiveness of the diverse legislations and policies. This pinpoints the realization that while policies can be established, their successful implementation and achievement of intended objectives also hinge on human efforts.

2.6 Proposed Solutions to Building Collapse in Nigeria

The issue of building collapse in Nigeria has been persistence for a while now, with records indicating over 533 building collapse in the country over 49 years which is quite alarming. Many articles have investigated the causes of building collapse in the country and also some have provided recommendations for mediate the issue of building collapse in the country.

The study from Qurix and Doshu (2020) proposed interventions for building collapse can be implemented in two ways, proposing the effective roles of professionals, policy makers/government control agency, while the second intervention method involves the use of

technology in mitigating building collapse. Laying emphasis on the role of professionals, Qurix and Doshu (2020) suggested that continuous mandatory education is needed to ensure up to date competencies in order to bring about professional competency while also emphasising on the fact that design and supervision of buildings should by handled by competent and certified professionals and a professional who designs or supervises a building that collapses should be appropriately held responsible for the case of the collapse. According to the study, policy makers and government regulatory agencies have elaborate regulations regarding planning, but these regulations are not effectively enforced. Additionally, investigations following identified cases of collapse are typically inconclusive. Therefore, the control agencies should perform their role effectively, development control units should guarantee that all individuals responsible for sealing drawings are officially certified. All drawings submitted for planning approval must include a letter of engagement for supervision from the client and an undertaking from relevant professionals in the building industry to oversee construction. Furthermore, the Bureau for Public Procurement should ensure that no company undertakes a construction project without qualified Engineers and Builders. Supporting this Awoyera *et al*. (2021) stated that government control agencies have important role to play in construction industry as they are responsible for regulating the code guiding building construction, therefore they should be responsible for enforcing penalties on violators, while also ensuring that all codes for building construction in the country is followed to the letter as this will prevent inconsistent and irresponsible designs from contractors and designers. This can be done by instituting effective taskforce to monitor the process of building construction as suggested by Wordu and Kanu (2021).

The second mode of intervention as proposed by Ourix and Doshu (2020) involve the use of technology to mitigate building collapse. This involves the use of Building Information Modelling (BIM) and other technological concepts such as digital fabrication. As the combination of these concepts would certainly improve the knowledge of the professionals on building behaviours and advanced building concepts. Also, the study emphasize that the government control agency can also make the knowledge and use of technology compulsory as this ascertain the efficiency and knowledgeability of builders and designers. Building Information Modelling (BIM) is a cutting-edge technology and method for virtually designing and overseeing construction projects. BIM can be employed to tackle various challenges within the building industry, including but not limited to, enhancing productivity, improving quality standards, reducing costs, minimizing construction waste, mitigating

delays, and facilitating information exchange among project stakeholders (Ullah *et al*., 2019). It can also be utilized to promote building sustainability by simulating environmental conditions. This simulation provides valuable insights for design, allowing designers to anticipate environmental patterns such as flooding patterns over time. The data obtained from these simulations can inform design and planning decisions, leveraging technology to significantly reduce uncertainty in the design process (Qurix and Doshu, 2019). Other technologies that can be employed in building construction include the digital fabrication technology which is a computer aided design process that manipulates materials through subtractive and additive methods leading to the production of a physical object using a machine known as 3D printer (Mehendarto and Adityo, 2019).

Awoyera *et al*. (2021) proposed that mitigating building collapse in Nigeria necessitates the presence of quality assurance and quality control personnel at construction sites. These personnel serve as a vital check on construction processes, materials, and workers, enabling the detection of faults or potential errors. Additionally, Awoyera *et al*. (2021) recommended the implementation of regulations by control agencies and contractors to limit client interference. The study highlighted that client interference can contribute to building collapse, as contractors may prioritize fulfilling client instructions over ensuring safety in order to retain contracts, ultimately resulting in the construction of faulty buildings.

Okunola (2022) highlighted the necessity to mitigate building collapse in Nigeria, particularly in Lagos, which holds the record for the highest number of collapsed buildings in the country. A crucial step in this regard involves conducting integrity tests on all high-rise buildings. Awoyera *et al*. (2021) raised concerns about the collapse of high-rise buildings, noting that most collapses between 2009 and 2019 occurred in buildings with 2 to 7 floors, indicating a significant risk among these structures. Okunola (2022) emphasized the urgent need for frequent integrity tests on all high-rise buildings in Lagos, especially those constructed more than five years ago. Structural integrity tests are essential to confirm the stability of buildings and ensure their suitability for habitation. Additionally, Okunola (2022) stressed that the government must take action to either strengthen or demolish buildings that are deemed structurally unfit for habitation.

Government interventions have been implemented to address the issue of building collapse in Nigeria, notably through the enforcement of Executive Order No. 05. This order focuses on

enhancing the planning and execution of projects, promoting Nigerian content in contracts, and advancing science, engineering, and technology through the declaration scheme under the Nigerian Building and Road Research Institute (NBRRI). The objective of these interventions is to prevent building and bridge collapses in the country while also fostering desired growth and sustainability in the nation's economy (Issac, 2023).

Despite the suggested recommendations and interventions that have been put forth and implemented, there seems to be a lack of effectiveness in addressing the problem of building collapse, as indicated by the number of collapses recorded in 2023 (32 buildings). Certain factors have been proposed as possible reasons for this lack of effectiveness. According to Ogundeji (2023), there is a neglect of responsibilities by staff and members of control agencies such as the Nigerian Institute of Building and the Building Collapse Prevention Guild. Many individuals have exploited these responsibilities for personal gain, allowing bribery and overlooking faulty plans and buildings without enforcing penalties for non-compliance with building codes. These truncate efforts aimed at mitigating the frequent occurrence of building collapse. Additionally, Okunola (2022) highlighted the issue of 'lip service' to building safety, suggesting that the government often fails to implement recommendations from previous integrity tests of buildings, possibly due to a lack of political will to uphold fundamental standards.

Various challenges have been identified as responsible for the ineffectiveness of employing digital technologies in building construction in Nigeria. Studies by Ikuabe *et al*. (2020) and Idowu *et al*. (2023) have shown that the adoption of digitalization in the Nigerian construction industry remains relatively low, with a predominant reliance on paper documentation. These studies have highlighted challenges such as stakeholder resistance to technology, the high cost of digital technology, inadequate power supply, difficulties in adapting to change, insufficient digital facilities, and concerns about potential job losses as major barriers to the implementation of digitalization in the Nigerian construction industry. Furthermore, organizational culture and structure, data insecurity, limited availability of the right digital skills and capabilities, complexity of the construction industry, lack of awareness about digitalization, shortage of trained personnel, lack of collaboration, lack of government support, technology challenges, absence of a clear strategy, competing priorities, increased complexity of data, and fear of digital technologies are among the additional barriers identified in these studies.

The proposed solutions and recommendations aimed at mitigating the issue of building collapse in Nigeria, although they have fallen short in their effectiveness, emphasis the critical need for collaborative efforts among professionals, government agencies, and stakeholders within the construction industry. Achieving this collaborative effort demands a systematic approach that encompasses monitoring of construction projects from inception to completion, prioritizing safety, efficiency, and adherence to established standards and regulations. In this regard, the implementation of PM techniques emerges as a pivotal factor. PM techniques play a pivotal role in overseeing the execution of projects, ensuring adherence to established standards and regulations, and fostering effective communication, coordination and collaboration among all project stakeholders, while also adhering to project objectives, timelines and fulfilling the necessary responsibilities.

2.7 PM and Techniques in Building Construction

A project is an endeavour comprising a sequence of organized and regulated tasks with defined start and end dates, conducted to accomplish a particular objective while adhering to limitations in terms of time, cost, and resources (Oladigbolu *et al*., 2022). This definition of 'a project' can also be applied to building construction, as it involves a sequence of organized and regulated stages with a specific timeframe. It entails the utilization of various resources within a specific budget to achieve its goals. PM was defined by Association for PM (2022) as the application of various processes, methods, skills, knowledge and expertise to accomplish specific objectives according to the project acceptance criteria within agreed parameters which is always embedded in definite timescale and certain budget. While PM techniques are framework, tools or methodologies that helps to plan, organize and execute a project (Tarver, 2023). Unegbu *et al*. (2022) asserted that for PM to achieve the aims and objectives of a project, there is a need for a thorough understanding of the dynamics of PM practices by PM personnel. According to Nwachukwu and Nzotta (2010), the poor performance of construction projects in many developing economies can be attributed to the inadequate utilization of PM techniques, best practices, project performance measures, and critical success factors. These factors constitute the multivariate that influences construction projects, and the lack of understanding of the relationships among these variables can lead to issues in project completion, which may not be readily apparent. Chen *et al*. (2012) highlighted that many of these variables, often neglected in construction projects, are interconnected and mutually influential. Understanding the dynamics of these relationships is

imperative for effective management, resource allocation, and control to ensure the successful completion of projects.

Over the years, management science has witnessed various advancements, evolving into a comprehensive knowledge system that plays a crucial role in PM, particularly within the construction sector (Isik *et al*., 2008). The foundation of PM and its techniques can be found in the PM Body of Knowledge (PMBOK), an initiative by the PM Institute (PMI, 2017). The PMBOK encompasses a wide range of knowledge, methodologies, processes, tools, and skills essential for the effective and efficient management of projects. The strategic application of these knowledge areas to construction projects has been shown to enhance project outcomes (Unegbu *et al*., 2022). Within the PMBOK, there are ten knowledge areas, including integration management, scope management, time management, cost management, quality management, risk management, human resource management, communication management, procurement management, and stakeholder management, along with over seventy-six practices (Chou and Yang, 2012; PMI, 2017). The proficiency of a construction company in PM and its ability to maintain a competitive edge in the industry are gauged by the adeptness of project teams in employing standard PM best practices (Chou and Yang, 2012), which ultimately enhances project performance and mitigates the risk of failure.According to Kumar (2022), PM and its techniques can be applied at every stage of a project's life cycle, beginning from the organizational structure of the company to the project's closure. Kumar (2022) explained the utilization of PM, PM techniques, and tools during project execution. In the initial phase of projects, known as the "start of projects", various PM techniques and tools such as Project Charter and Project Prioritization Models play a crucial role. They ensure proper coordination of all projects and prioritize strategic goals appropriately. Moreover, these techniques aid in project portfolio management, which provides essential information enabling informed business decisions. Given that projects can typically surpass available resources in terms of funds and personnel if not properly managed, it becomes imperative to adhere to a systematic and well-defined process for selecting projects to be executed. In the second stage of project execution, known as "Project Planning," Kumar (2020) highlighted several essential PM tools. The study identified tools such as the 'Project Priority Matrix' and 'Work Breakdown Structure' (WBS). The Project Priority Matrix serves to establish project priorities by identifying which project criteria are constrained and which are more flexible. It was emphasized that establishing the Project Priority Matrix early in the project, in collaboration with the client and sponsors, facilitates decision-making when changes occur

later in the project. Regarding the WBS, it serves six purposes in project planning: enhancing project objectives, aiding in the project organization chart, establishing the logic for tracking costs, time, and performance, facilitating communication of project status, improving global communications, and delineating how the project will be contracted.

In the third phase, "Project Execution," Kumar (2020) outlined several tools and techniques used at this stage, including the 'Information System for PM (PMIS) model,' the 'communication matrix,' and 'team building.' PMIS software packages assist project managers in making necessary decisions regarding project planning, organization, and control, thereby enhancing their efficiency and effectiveness. These software tools also contribute to project success by improving budgetary control, meeting deadlines, and ensuring compliance with technical specifications. The communication matrix is essential for mitigating project problems and ensuring that clients, team members, and other stakeholders have the necessary information to fulfil their roles. Team building enhances technical performance by improving effectiveness, efficiency, and innovation, while also fostering better management, cooperation, communication, and clarity of objectives among all project stakeholders. The next phase is the "Project control" phase, during which techniques and tools such as the 'Gantt chart', 'Project Evaluation Review Technique (PERT)', 'Critical Path Method', and 'Earned Value Management (EVM)' methodology is utilized (Kumar, 2020). The Gantt chart, a fundamental tool used across various PM contexts, illustrates the various phases, tasks, and activities scheduled within a project or displays a timeline encompassing the project activities, thereby enhancing the efficiency of the method. Other tools, including PERT, CPM, and EVM, are essential for managing projects, as they monitor project progress by identifying stages that require more attention, thus aiding in performance improvement during project execution (Kumar, 2020).

In the final stage, known as the "Project Closure" phase, several tools are highlighted, including 'Closing audits,' 'ExPost evaluation,' and 'Project closure checklist.' These tools are essential for evaluating the completed project, assessing each step and stage, and documenting the process. They aid in identifying successes and areas for improvement throughout the project's duration and documenting the lessons learned. Lessons learned entail the knowledge acquired from a process or multiple experiences, which is constructed through reflection and critical analysis of outcomes that could have impacted either failure or success and can be applied to other projects.

Kumar (2020) provided a comprehensive overview of the utilization of diverse PM techniques and tools, elucidating their significance in facilitating project execution and ensuring successful project completion. These techniques assist in steering the project in the planned direction and aid the company in achieving the aims and objectives of the project.

2.7.1 PM methodology (PMM)

PM methodologies refer to established organizational or strategic-level processes and procedures employed for project execution. They differ from tools and techniques like quality control and scope management, which are utilized at the operational level to oversee individual project delivery (Biggins *et al*., 2016). There have been various PMM that have been put together over the years, examples of these PMM include "the Association for PM Body of Knowledge (APM BOK)", "Projects in Controlled Environments (PRINCE2)", "A Guidebook of Project and Program Management for Enterprise Innovation (P2M)", "A Guide to the PM Body of Knowledge (PMBOK)", "International Organization for Standards 21500 (ISO 21500)", and "British Standard 6079-1 (BS 6079)" (Biggins *et al*., 2016) which are mostly the traditional PMM. These PMM have been applied in several countries of the world and some of the most common PMM are the PMBOK and PRINCE2 (Sidney, 2018).

- ***PRINCE2 methodology***

  PRINCE2 stands as a PM methodology commonly applied in both public and private sectors. It offers a structured approach for effective PM across various project types, with a notable emphasis on information systems. PRINCE2, short for PRojects IN Controlled Environments, version 2, sets the standard utilized by the UK government in project commissioning (Newton, 2015). The idea originated in 1989 under the Central Computer and Telecommunication Agency (CCTA). Initially stemming from PROMTII, a PM methodology by Simpact System Limited (SSL) in 1975, PRINCE2 underwent extensive development by the Office of Government (formerly CCTA) in the following years. By 1996, PRINCE2 was fully developed and gained international recognition as a leading PM approach (Singh and Lano, 2014). PRINCE2 is described as a "process-oriented method for PM, offering a flexible and adaptable framework for overseeing various project types." Similar to the PMBoK, PRINCE2 offers guidelines and best practices for effectively managing projects across different domains (Karaman and Kurt, 2015).

  PRINCE2, however, has several shortcomings. These include challenges in effectively engaging with stakeholders and contractors involved in a project. Additionally, adapting

PRINCE2 for smaller or medium-sized projects can be complex. Furthermore, this methodology may lack flexibility in managing the process of change effectively (Karaman and Kurt, 2015; Newton, 2015; Rutford, 2015).

- ***The PMBOK Guide***

The PMBOK Guide is a compilation of well-established PM practices, terminology, and procedures. It emphasizes a process-oriented approach to PM (Vaskimo, 2015). The PMBOK guide adopts an approach that categorizes projects into product-oriented processes and PM processes, allowing for its application across projects of varying sizes, natures, and contexts. This guide is linked with PMI certification programs, which recognize individuals' knowledge and expertise, starting from the CAPM certification and progressing to PMP and PfMP certifications. Additionally, PMI offers specialized certifications such as "PMI Agile Certified Practitioner (PMI-ACP)", "PMI Risk Management Professional (PMIRMP)", "PMI Scheduling Professional (PMI-SP)", and "Organizational PM Maturity Model (OPM3)" Professional Certification (Vaskimo, 2015). The PMBOK guide is widely accepted as a national standard in the United States and other countries, emphasizing the importance of tools and techniques unique to PM (Sidney, 2018).

The primary factors associated with traditional PMMs such as PRINCE2 and PMBOK are their strict and rigid approach and their somewhat limited ability to accommodate or manage software and IT projects which are getting into the mainstreams of projects in the recent years (Sidney, 2018). Due to this, there have been development of new PMM framework such as "Agile PM (APM)".

- ***Agile PM***

Agility refers to the proactive ability to navigate an unpredictable, dynamic, and constantly changing environment. An organization's agility signifies its capacity to adjust to evolving environments or circumstances without being compelled to change. Agile PM amalgamates traditional PM principles with flexibility, collaboration, and adaptability to ongoing changes while maintaining discipline. The Agile concept and its methods have been influenced by agile software approaches such as Scrum, Lean, and Extreme Programming, all guided by a set of principles emphasizing adaptability and collaboration rather than rigid rules. These principles, embeded in the Agile Guide, dictate the

relationships, roles, and activities within software development processes among project managers, teams, and clients (Salameh, 2014; Sidney, 2018).

The Agile PM method facilitates stakeholder participation throughout the project, from inception to completion, which has been lauded as a cost and time-saving approach, enabling clients to test and approve the product at each development stage—a departure from traditional PM methods (Sague, 2015). However, while this approach prioritizes stakeholder satisfaction, Sohi *et al*. (2016) argue that it may compromise project timelines, as constant evaluation of project progress could lead to delays, especially in large-scale endeavours like construction projects. Another drawback is the diminished authority of project managers over the project process, as constant stakeholder approval is required for each phase (Dave *et al*., 2016; Streule *et al*., 2016).

2.7.2 PM techniques in construction

PM planning tools and techniques are generally utilized to facilitate the efficient planning required for the successful execution of projects (Kumar, 2022). According to Ayodele *et al*. (2014), the following PM techniques are very useful in bringing about successful implementation of projects in the construction industry:

a. **Work Breakdown Structure (WBS):** A Work Breakdown Structure (WBS) is a plan or inventory that outlines the project's deliverables by categorizing its work into smaller tasks or groups of tasks. A project Work Breakdown Structure (WBS) is a systematic arrangement of project tasks that categorizes and defines the entirety of the project scope. It's structured in multiple levels, illustrating work elements in logical relationships. Each lower level offers more detailed descriptions of project components. The WBS serves as a framework that integrates and links all project activities (technical, scheduling, and budgetary) and is utilized across the project's lifecycle to identify, assign, and monitor specific work packages. It's developed with sufficient detail to ensure each control account has a unique WBS element (Pelumi *et al*., 2022). By visually breaking down the project scope into manageable segments, the WBS aids project teams in comprehending the project's tasks, with each successive level providing greater definition and granularity (Oyedele, 2018).
b. **Decomposition Technique:** Decomposition, according to PM Body of Knowledge (PMBOK), is the process of dividing project deliverables into smaller, easier-to-manage components up until the point at which the work and deliverables are

precisely specified at the work package level (Institute, PM, 2017). This technique, known as decomposition, is utilized to develop the Work Breakdown Structure (WBS) by dividing project deliverables into smaller, manageable tasks or work components known as work packages. Additionally, decomposition is applied in the activity definition process to further divide work packages into smaller, more manageable components referred to as schedule activities (Ayodele *et al*., 2014).

c. **Expert Judgment Technique:** This pertains to informed opinions given based on proficiency in a specific application area, knowledge domain, field, industry, etc., as deemed suitable for the task at hand. Such expertise can be offered by any individual or group possessing specialized education, knowledge, skills, experience, or training, and can be sourced from various outlets, including: other departments within the performing organization; external consultants; stakeholders, including clients; professional and technical organizations, as well as industry associations. For instance, project team members or other proficient experts familiar with crafting detailed project scope statements, Work Breakdown Structures (WBSs), and project schedules can provide valuable insights into defining activities (PMI, 2003).
d. **Modular Approach:** Also known as 'Bottom-up estimating,' this process entails calculating the expenses or labour for every single work element (or activity) specified in the work breakdown structure, then combining these estimates to produce an all-inclusive estimate (APM, 2006). This strategy is used when it is difficult to correctly forecast a schedule. It entails calculating the resource requirements for each more detailed component of work and then adding these estimates to calculate the total resource quantity for each scheduling activity. If there are interdependencies across schedule activities, the resource usage pattern is factored into the projected requirements for each activity and reported accordingly (PMI, 2003)
e. **Benchmark Job Technique:** This technique, also known as comparative or analogous estimating, uses past data from similar projects to get the most appropriate cost and time estimates. It uses the values of previous similar activities' parameters, such as scope, cost, budget, duration, or scale metrics, such as size, weight, and complexity, as a reference to estimate the corresponding parameter or metric for a future activity (PMI, 2003; APM, 2006).
f. **Parametric Estimating Techniques:** This is an estimating technique that relies on the statistical correlation between past data and other variables of consideration, such as square footage in construction, to estimate project parameters such as scope, cost,

budget, and timeframe. This technique is particularly useful in statistical modelling (PMI, 2003; APM, 2006).

g. **Gantt chart:** This is a type of bar chart commonly used in PM to illustrate the relationship between planned activities and time. It serves as a time-phased graphic display of activities duration. The chart lists activities on the left side with time intervals depicted above the bars. Activity durations are represented by horizontal bars (APM, 2006).

h. **Linked Bar Chart:** This is an improved version of the Cantt chart which specifically shows the dependency links between project activities (APM, 2006). The major aspect of this chart is that there is a vertical link between the completion of one activity and the start of another (Rahman, 2022).

i. **Project Network Diagrams:** It is a presentation of project data in which the project logic is the main determinant of the placements of the activities in the diagram. It usually used in Project Evaluation Review Technique (PERT) and Critical Path Method (CPM) (Bagshaw, 2021).

j. **Project Evaluation Review Technique (PERT):** This method is utilized in PM to reduce the overall cost and duration of a project. Typically, this involves breaking down large, intricate projects into smaller sub-activities, assigning resources, and overseeing the project's cycles (Bagshaw, 2021).

k. **Critical Path Method (CPM) and Critical Path Analysis:** Critical path analysis is an analysis technique used for analysing the project network diagram to determine the flow of activities that must be completed on time to ensure the project's timely completion (APM, 2006), while Critical Path Method depends on the outcome of critical path analysis to create project schedule that outlines flow of process from start to finish of each activity on the project (Bagshaw, 2021).

l. **Line of Balance:** This is a graphical device that allows a project manager to see at a glance which activities of an operation are in balance. The line of balance chart illustrates the current status of operations, given that the necessary resources remain consistent. The chart is advanced by plotting both the completed work and the anticipated rate of completion for different activity, allowing for comparison with the actual progress. By assessing the rate of work completion, it is possible to forecast the probable completion date (Oladigbolu *et al*., 2022).

m. **Spreadsheets and other simulation/statistical tools:** These are computerized tools used for optimal cost-time scheduling and outcome forecasting. They are beneficial

for cost control and tracking costs and schedules. Additionally, they can be utilized to assess and predict project outcomes with varying task durations (Deborah *et al*., 2013; Valenko and Klanšek, 2017).

n. **Cost-Benefit Analysis (CBA):** Cost-benefit analysis (CBA) is a structured method for assessing the economic feasibility of a project by estimating and comparing its associated costs and benefits (Boardman *et al*., 2020). The majority of the analysis involves identifying, quantifying, and assigning monetary value to all pertinent costs and benefits, covering both direct and indirect, tangible and intangible aspects, and then computing the net present value (NPV) or benefit-cost ration (BCR). The main goal of CBA is to enhance rational decision-making, resource allocation, and performance evaluation by maximizing social welfare, guided by principles of efficiency, transparency, and accountability (Whitman *et al*., 2023).

o. **Benchmarking:** Benchmarking basically involves evaluating current or intended project activities against those of other projects in order to bring about improvement in the project activity and to establish a standard for assessing performance (Sabri, 2023).

p. **Flow-charting:** These are diagrams used to indicate the relationship among various elements of a system. Common flow-charting techniques include cause-and-effect diagrams for illustrating how various factors might be linked to potential problems or effects, while system or process flowcharts show how the various elements in a system interrelate. Flow-charting is particularly important in risk management as it can help project teams anticipate potential problems and their locations, allowing them to implement appropriate mitigation procedures (Ayodele *et al*., 2014).

q. **Cost of Quality:** It concerns the overall cost incurred in ensuring the quality of a project, encompassing all activities aimed at meeting specified requirements and addressing any deviations from those requirements. This encompasses three categories of costs: prevention costs, appraisal costs, and failure costs, with the latter further divided into internal and external costs (Ayodele *et al*., 2014).

2.7.3 Best Practices in Construction PM

The use of effective PM practices is crucial within the construction sector, as it offers a systematic framework for organizing, implementing, and overseeing construction projects. These practices aid in establishing precise goals, defining project scopes, optimizing resource allocation, and proficiently managing risks (Shah *et al*., 2023). In project planning and

execution, there are various phases, including the initiation phase, planning phase, execution phase, monitoring and control phase, and finally, the closure phase. At every phase, distinct challenges are encountered, as indicated in Figure 2.1. For example, unclear project objectives and scopes can result in stakeholder misalignment, leading to increased costs and delays. Additionally, unplanned project duration and resource needs can result in conflicts during project execution. The lack of or insufficient feasibility plan can lead to unrealistic goals and resource shortages (Borthakur and Govind, 2017; Lin *et al*., 2018).

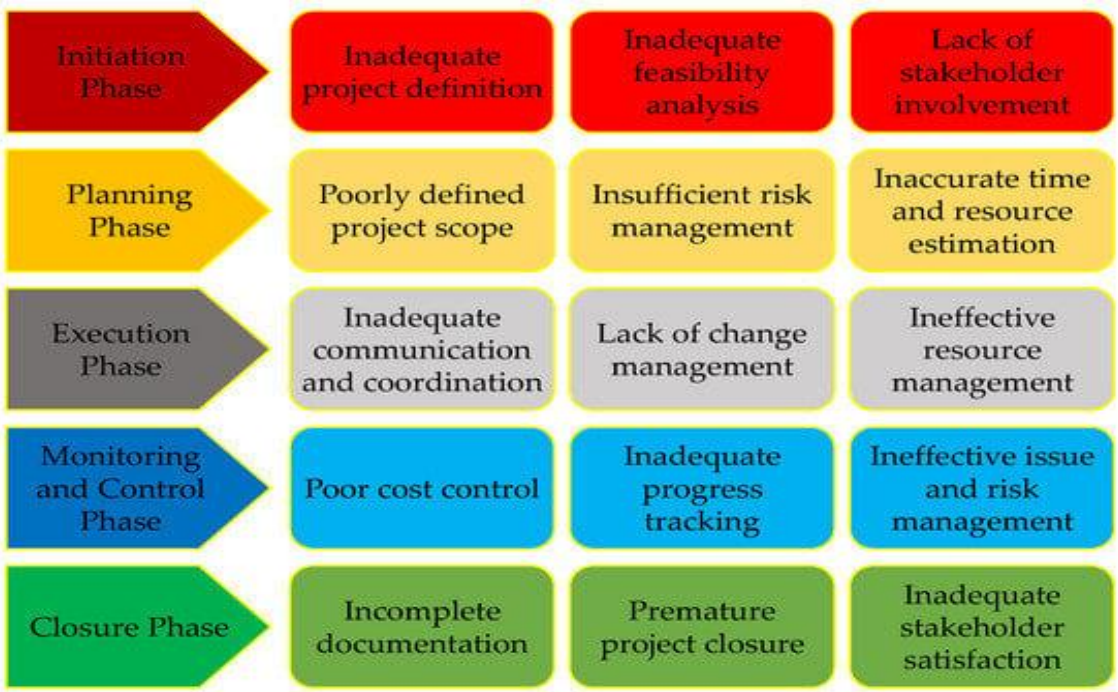


Figure 2.1 Challenges related to PM at various phases of a project

Source: Shah *et al*. (2023).

Therefore, proactive engagement of certain practices in PM such as clear project planning, effective communication, risk management, quality assurance and control, stakeholder engagement, resource management, project monitoring and reporting, change management, safety management and continuous improvement (Shah *et al*., 2023). Figure 2.2 indicates the flow of effective management practices employed in construction project for successful execution. Also, aside employing best PM practices, embracing innovative and new technologies alongside the construction industry best practices enhances project success and customer's satisfaction (Nizetic *et al*., 2019).

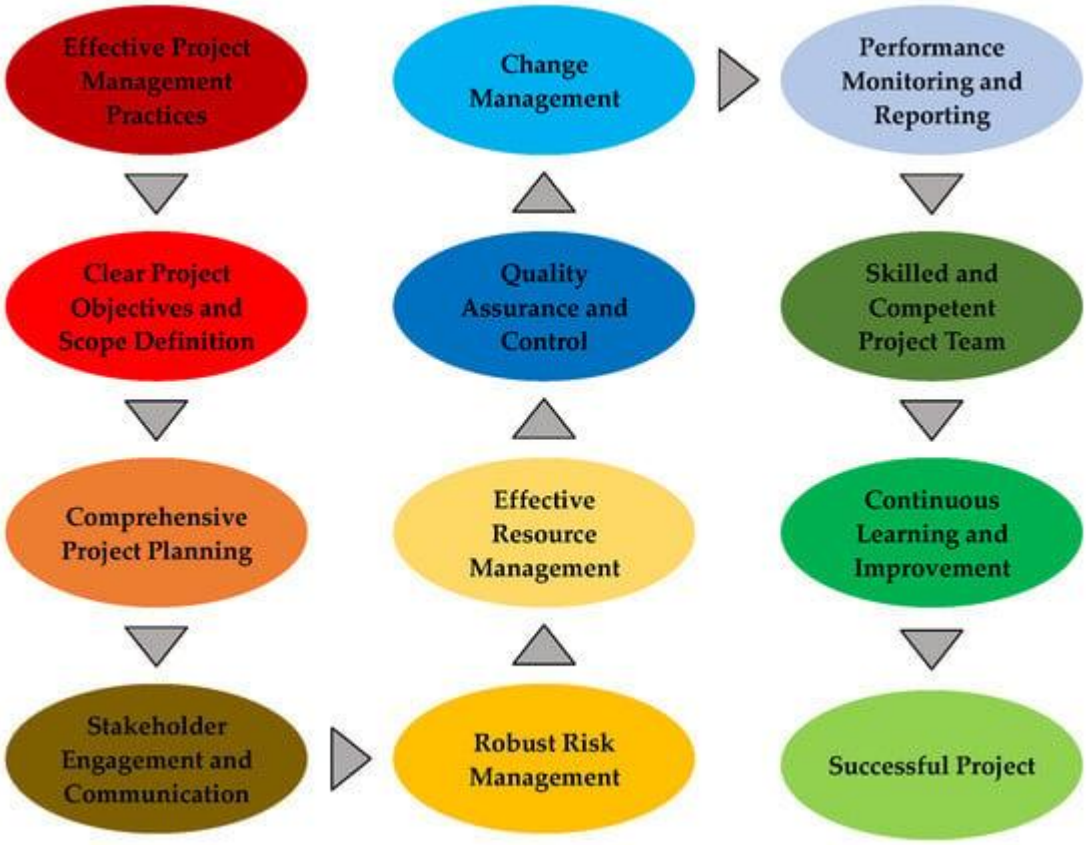


Figure 2.2 Flow of effective management practices employed in construction project for successful execution.

Source: Shah *et al*. (2023).

2.7.4 Application of PM techniques in construction

Several studies have been conducted on professionals in the construction industry to either assess their understanding of PM techniques or evaluate their effectiveness when implemented in the construction industry. In an effort to understand the utilization of PM methods and techniques in Nigeria's construction industry, Oyedele (2019) undertook a research study involving 200 key stakeholders from 20 construction firms in the country, comprising Managing Directors/Chief Executive Officers (MD/CEOs), Directors, and Managers. The findings revealed that PM methodologies (PMMs) such as PMBOK, Agile, Lean Six Sigma, and Waterfall were utilized in only 5 out of the 20 surveyed companies. However, concerning PM techniques, all 20 companies implemented various methods, including Gantt Chart, Microsoft Project, PERT Master, Primavera, and Work Breakdown Structure. Oladigbolu *et al*. (2022) conducted a study on 55 professionals in the construction industry to determine their knowledge of PM techniques and assess the effectiveness of these

techniques. The study revealed the professionals are familiar with the PM techniques, with the majority being acquainted with the Gantt chart. Additionally, some professionals exhibited knowledge of other techniques such as job listing, network diagram, program evaluation and review technique (PERT), line of balance (LOB), critical path method (CPM), and RACI chart. However, when examining the efficiency of these PM techniques, it was found that none achieved a level of efficiency higher than 40%. This suggests that there is a likelihood of projects being delivered in a less timely, effective, and balanced manner. Regarding the speed of delivery in relation to the use of PM techniques, the results showed that 43.6% of respondents agreed that job listing increased speed of delivery, followed by 36.4% for the Gantt chart, 32.7% for the network diagram, 34.5% for PERT, and 38.2% for LOB.

In a quantitative analysis study, Unegbu *et al*. (2022) measured the relationship among the multivariate that influence project performance and PM. Project performance is defined as criteria or principles that are essential to act as guiding or regulating standards for project success (Atkinson, 1999). To determine this, Unegbu *et al*. (2022) quantified the correlation between the application of fifty-three PM practices and nineteen PM performance measures using a five-point Likert scale. The study was conducted based on the responses of two hundred and twenty-one contractors, clients, and consultants from ten construction companies in Nigeria. The study's findings confirmed the significance of employing effective PM methodologies for achieving project success. It highlighted that proficient scope management has a beneficial impact on both project performance and customer satisfaction. This suggests that enhancing scope management through strategies such as utilizing the Work Breakdown Structure (WBS) and decomposition technique can enhance project performance and customer satisfaction. Furthermore, the study revealed a positive correlation between time management and project success, indicating that implementing superior time management methods such as the 'benchmark job technique' can enhance both project performance and success. Additionally, the study indicated that employing cost management techniques like cost-benefit analysis and cost budgeting directly affects project performance. Thus, managing project costs and economizing should not compromise project performance. Consequently, PM practitioners need to strike a balance between efficient cost management and project performance. Moreover, the study found that quality management has a positive influence on both project performance and customer satisfaction. In summary, delivering a high-quality product can significantly enhance both project performance and customer satisfaction.

According to Unegbu *et al*. (2022), it was established that risk management techniques positively affect project performance. This highlights the importance of prioritizing risk management practices within construction companies. In PM circles, there is a widespread belief that effective risk management contributes significantly to project success and performance. The study also confirmed that communication management directly impacts project success, emphasizing the crucial role of clear and effective communication throughout the project lifecycle. Additionally, stakeholder management was found to have a substantial influence on both project success and customer satisfaction, as evidenced by the significant path coefficients. This aligns with expectations in PM, considering that stakeholder management involves managing individuals with vested interests in the project's outcomes. Moreover, risk management was observed to directly impact customer satisfaction, while quality management was found to directly influence project success. This suggests that customers anticipate improved risk management from project organizations and that enhanced quality management leads to greater project success.

In a study, Ebiloma and Rimtip (2019) provided evidence that professionals in the Nigerian construction industry apply PM techniques. In the assessment, respondents confirmed that the application of these techniques and methodologies has been effective in achieving project success by encouraging collaborative relationships, engaging competent professionals, and enhancing safety during the course of the project. Abdullahi and Tembo (2023) also examined the applicability of lean principles in enhancing the efficiency and effectiveness of construction project planning and scheduling. The study’s findings indicated that lean principles effectively improved the efficiency of these processes by minimizing waste and streamlining operations, particularly by identifying areas of waste in the planning and scheduling phases. Additionally, the research suggested that lean principles fostered better communication and collaboration among project stakeholders, thereby enhancing the overall efficiency of project planning and scheduling. Regarding project delivery time, lean principles contributed to shortened lead times, increased productivity, and reduced delays. Concerning project costs, lean principles led to cost reduction through waste minimization, productivity improvement, and rework reduction. Ultimately, the study concluded that lean principles enhanced the quality of construction projects by reducing errors and defects, improving communication, and fostering collaboration among project stakeholders.

The literature provides solid evidence that using multiple PM strategies across various aspects of construction projects greatly improves delivery schedules, project performance,

overall success, and customer satisfaction once the project is completed. These findings highlight the importance of PM approaches in improving project outcomes, minimizing risks, and assuring stakeholder satisfaction. Construction projects can achieve better efficiency, fulfil stringent quality standards, and closely correspond with client expectations by employing a variety of proven methodologies, building an industry-wide culture of excellence and long-term success.

Relating this to the issue of building collapse in Nigeria, studies such as Okoye *et al*. (2023) pointed out that building collapse in Nigeria is mostly due to human errors. Nicholas *et al.* (2022) identified that the use of substandard materials accounted for 25%, structural failure due to years of existence accounted for 23.9%, poor supervision, poor workmanship, and the use of unqualified personnel accounted for 14.8%, while non-adherence to statutory regulations/warnings and compliance with approved building plans accounted for 6.8%. Furthermore, Hamma-Adama *et al*. (2020) also identified the causes of building collapse in Nigeria to be associated with substandard building materials, poor workmanship/faults on the construction site, faulty design, quackery, illegal conversion/alteration/excessive loading, inadequate or lack of supervision, geotechnical issues, and non-consultation of professionals. Qurix and Doshu (2020) also stated that human factors such as corruption among contractors, inappropriate foundation, cost-cutting by clients due to expensive building materials, lack of monitoring, and compromise from government regulatory agencies, faulty architectural and engineering designs, use of substandard materials, and poor supervision or the absence of supervision by qualified professionals contribute to building collapses. Nwoyiri *et al*. (2023) highlighted deficiencies in structural drawings, lack of proper supervision, alteration of approved drawings, approval of technically deficient drawings, illegal alterations to existing buildings, clients' over-reliance on contractors for decision-making on sites, use of unqualified personnel, and absence of town planning inspection and supervision on sites as factors. Odeyemi *et al*. (2019) also identified an array of factors such as hasty construction, overloading, old age, poor construction, poor quality materials, and structural defects as being responsible for building collapse in Nigeria. Finally, Imafidon and Ogbu (2020), in their analysis of the causes of building collapse, grouped the factors into clusters and identified that the causative factors fall under clusters relating to design and construction, policy-related causes, or quality management-related causes.

The consistent issue addressed in these various studies is that human error is a major contributor to building collapses in Nigeria. These errors often stem from inadequate

supervision and a lack of effective PM techniques. However, by integrating various PM strategies into all aspects of building development, such hazards can be mitigated, thus preventing building collapses. PM strategies offer systematic approaches to tackling the challenges of construction projects, promoting accountability and diligence at every stage. Several preventive measures can be implemented by incorporating these strategies into human efforts and aspects of building construction. Utilizing PM tools such as WBS, daily progress reports, and regular site inspections enhances supervision effectiveness. Clear lines of authority, defined roles, and frequent performance assessments all contribute to improved monitoring, reducing the likelihood of errors and oversights. Quality management procedures like quality control checklists, material testing processes, and adherence to industry standards help ensure that construction activities meet established quality criteria. Rigorous quality assurance techniques instill confidence in the structural integrity of buildings, decreasing the chances of construction flaws and subsequent collapses.

Incorporating risk management methods such as risk identification workshops, risk registers, and contingency planning aids in anticipating potential hazards and developing proactive mitigation strategies. By carefully analyzing and addressing hazards, project teams can prevent building collapses. Effective stakeholder engagement, including stakeholder analysis, frequent communication channels, and participatory decision-making processes, fosters collaboration and transparency. Involving architects, engineers, contractors, regulators, and local populations ensures that multiple perspectives are considered, leading to more informed decision-making and risk mitigation strategies. Utilizing project monitoring tools like Gantt charts, critical path analysis, and milestone tracking allows for real-time performance monitoring. Early detection of deviations from project plans enables prompt corrective actions, preventing issues from escalating and potentially resulting in building collapses. Investing in training and development programs enhances construction personnel's understanding of PM principles and best practices. Equipping teams with the necessary knowledge and skills enables them to identify hazards, adhere to safety protocols, and execute activities accurately, reducing errors and enhancing project outcomes. Integrating lessons learned from past building collapses into PM methods encourages continuous improvement. Conducting post-mortem analyses, sharing best practices, and implementing corrective measures based on past failures foster a culture of learning and accountability, decreasing the likelihood of similar occurrences in the future.

2.8 Risk Management in Construction Projects

Risk management encompasses the series of activities involved in planning, identifying, analysing, responding to, and monitoring and controlling risks within a project, with the aim of enhancing the likelihood and impact of favourable outcomes while reducing the likelihood and impact of unfavourable events throughout the project lifecycle (PMI, 2004).

Risk management stands out as one of the important PM procedures essential for achieving project success. It's widely acknowledged through experience that prioritizing risk management is imperative for project managers, given that unaddressed or unmitigated risks often contribute significantly to project failures. Consequently, the efficacy of risk management directly impacts the tangible accomplishment of a project (Akintunde and Morel, 2023). According to Nnadi, Enebe, and Ugwu (2018), risk management plays a pivotal role in decision-making processes. It holds the potential to influence various aspects of construction projects including productivity, performance, quality, and budget. The objective of risk management is to ensure that all involved stakeholders grasp the distinct risks associated with a construction project and develop strategies for effectively addressing these risks to facilitate successful project completion. Risk management is indispensable for attaining project objectives, not solely for averting negative consequences arising from unforeseen events or uncertainties. Instead, it serves as an essential compass for maximizing favourable outcomes.

2.8.1 Risk management process

The risk management process lays the groundwork for identifying and handling potential hazards within project operations. To effectively address risks, it's imperative to integrate all stages of the risk management process into the project. This process comprises various parts, outlined as follows:

- **Risk identification:** Risk identification marks the inaugural phase in the risk management process, involving the identification of potential risks that may arise throughout the project endeavor (Nnadi, Enebe, and Ugwu, 2018). This initial stage sets the foundation for subsequent risk assessment and control measures, enabling organizations to pinpoint inherent risk areas. Thorough risk identification ensures effective risk management by uncovering hidden sources of losses that could evolve into incidents with uncontrollable unintended outcomes (Ghasemi *et al*., 2018). Failing to identify positive risks carries consequences similar to those of overlooking adverse ones (Fadun and Saka, 2018).

- **Risk assessment/analysis:** Kumar *et al*. (2018) explain that after identification, the subsequent step in risk management involves assessing the identified risks. Risk assessment, within the realm of risk management, entails utilizing valuable information to ascertain the likelihood of occurrence and severity of consequences (Olamiwale, 2014). Risk analysis can be conducted either qualitatively or quantitatively. Qualitative risk analysis entails determining the probability and impact of a risk. Various methods, such as risk matrices, are employed for qualitative risk analysis (Mahamid, 2011; Kassem *et al*., 2020). On the other hand, quantitative risk analysis utilizes numerical data and mathematical models to assess and evaluate risks. It involves assigning specific values or probabilities to different risk factors and then performing calculations to quantify the potential impact and likelihood of identified risks. This process aids in making data-driven decisions and prioritizing risk management actions based on a more objective and quantitative understanding of the risks involved. Several methods are utilized for quantitative risk analysis, including the Analytical Hierarchy Process (Al-Mhdawi *et al*., 2022), Bayesian networks (Qazi *et al*., 2023a; Qazi *et al*., 2023b), and fuzzy sets theory (Al-Mhdawi *et al*., 2023).
- **Risk response:** Risk response is a critical aspect of the risk management process, entailing the decision on whether to implement measures in response to the risks identified during the stages of identification, qualification, and quantification (Ghasemi *et al*., 2018). Risk responses involve considering various options for eliminating or mitigating an anticipated risk and determining the most suitable alternative (Nnadi, Enebe, and Ugwu, 2018). Olamiwale (2014) contends that risk response involves identifying or developing alternative strategies to address risks and outlining actions to manage them, with a focus on leveraging opportunities and alleviating pressures to achieve project objectives. Therefore, it entails selecting an effective approach to mitigate the adverse effects of a risk.
- **Risk Control:** After identifying risks, conducting risk assessments, and formulating appropriate responses, it is imperative to execute the risk plan as part of risk oversight and control, integral components of the project. One of the significant challenges in the monitoring and control process involves implementing risk strategies effectively while ensuring their efficacy. Another key challenge is the development of comprehensive documentation to support the process (Ugwu, Osunsanmi, and Aigbavboa, 2019). Managing project risks is aimed at facilitating effective PM by

proactively addressing risks rather than reacting to them, ensuring the adoption of suitable measures while continuously adjusting them. Given the potential for misidentification of risks or errors in analysis, caution must be exercised in the risk management process to avoid executing actions based on inaccurately identified or analysed risks.

Akintunde and Morel (2023) have identified PM techniques that prove useful at every stage of the risk management process. During the identification stage, various PM practices such as benchmarking, brainstorming, Delphi technique, checklists, risk breakdown structure, expert consultation, stakeholder analysis, past experience, workshops, historical data, and research assumptions are employed for identifying risks in projects. Moving to the assessment/analysis stage, quantitative analysis techniques such as Monte Carlo Simulation, sensitivity analysis, fault tree analysis, and event tree analysis are utilized, while qualitative analysis techniques such as risk probability and impact assessment, probability/impact risk rating matrix, risk categorization, and risk urgency assessment become valuable. Finally, the response stage involves practices such as avoidance (prevention), reduction (mitigation), transfer, and retention.

In examining the impact of risk management techniques, Sobieraj and Metelski (2022) investigated the effectiveness of Monte Carlo Simulation combined with the Time-at-Risk (TaR) approach in quantifying the risk associated with time variation that occurs during building construction and the documented timeframe. The analysis results indicated that this approach enabled the quantification of risk associated with executing a building construction project by integrating various PM techniques such as PERT, triangular distribution, and Weibull distribution. By utilizing this approach, the risk of time variation could be quantified by explicitly assessing the uncertainty in the duration of the entire project and individual stages relative to the specified time frame.

The findings from the studies pointed out the invaluable role of PM techniques in risk management. Using these approaches, risks can be effectively recognized, evaluated, and controlled, reducing potential flaws in project delivery. This complete strategy not only improves project outcomes but also considerably increases client happiness. Project managers may traverse possible hurdles by conducting systematic risk assessments and implementing proactive mitigation methods, resulting in better project execution and higher client

satisfaction. Thus, integrating PM methodologies with risk management emerges as a critical aspect in improving project performance and stakeholder satisfaction.

2.9 Applicability and Challenges of PM System and Techniques in Nigeria

The application of PM systems and the utilization of PM techniques are not foreign concepts in the Nigerian construction industry. Studies such as Ayodele *et al*. (2014) have indicated that professionals in the industry exhibit varying levels of awareness regarding the use of PM techniques, including WBS, decomposition, expert judgment, Gantt charts, benchmark job techniques, among others. However, the study also highlights that the PM system in Nigeria is still predominantly reliant on crude or basic planning tools and techniques. Commonly used PM techniques such as WBS and benefit/cost analysis, along with spreadsheets, remain prevalent, while more advanced tools such as simulation and statistical tools, Line of Balance, parametric techniques, Gantt charts, and linked bar charts are less frequently employed. Ebiloma and Rimtip (2019), also agreed that PM system and techniques is not a new concept in the Nigerian construction industry as many professionals assessed in the study agreed that PM techniques and methodologies have been effective in achieving project success. Research suggests that while the adoption and utilization of cutting-edge technology have progressed among project managers in developed countries, construction project managers in the Nigerian construction industry lag years behind in adopting new technology within the PM system (Olaniyan *et al*., 2019). In 2019, Oyedele conducted research to assess the adoption of PM practices among major construction companies in Nigeria. The results indicated that out of the 20 companies surveyed, only 5 employed PM methodologies in their project execution. However, all 20 companies acknowledged employing PM techniques at various stages of their projects.

Studies have carried out analysis on the factors that might be associated with the low adoption of PM techniques in Nigeria. Ebiloma and Rimtip (2019) highlighted that factors such as the type of contracts prevalent in the Nigeria, lack of understanding of PM Methodologies (PMM), insufficient focus on management practices, resistance to change among stakeholders, and challenges in policy enforcement are accountable for hindering the adoption of PMMs. These factors also contribute significantly to the low utilization and success rate of these methodologies. Ogunde *et al*. (2017) explained these challenges in their study on the analysis of the hurdles encountered in the utilization of construction PM systems in the country. They categorized these challenges into factors related to the project manager,

client, suppliers, construction team, and consultants. Regarding the 'Project Manager factor,' Ogunde *et al*. (2017) noted that while projects in the country are overseen by project managers, some exhibit a passive approach, and others lack a thorough understanding of PM systems, leading to inadequate PM. The client factor highlights the lack of financial support from clients and their limited involvement, hindering project managers from fully implementing PM techniques and tools. Concerning the suppliers' factor, the supply of substandard materials poses a significant challenge to PM. The construction team factor encompasses design errors, misinterpretation of data, subpar workmanship, and insufficient professional standards, all contributing to challenges in the PM system in Nigeria. Lastly, consultant factors such as ineffective communication, inadequate project supervision, passive engagement, and failure to clarify clients on crucial project aspects and associated risks also add to these challenges.

Corruption and political manipulation for personal benefit have been recognized as major factors contributing to the deficiency in PM within the industry. These factors negatively impact project expenses and resource distribution, causing project managers to prioritize personal advantages over contractual integrity, proper PM procedures, and project requirements (Ismaila *et al*., 2022; Obebe *et al*., 2020). Moreover, religious and tribal biases contribute to the limited utilization of project managers within Nigeria's construction sector. According to Ndife (2021), the prevalence of such biases undermines team unity and communication, ultimately resulting in competency issues within organizations and project setbacks (Iroha *et al*., 2024). Furthermore, inadequate acknowledgment, absence of incentives, and insufficient training exacerbate the challenge. Nweze (2016) placed emphasis on how unfavorable working conditions, including meager salaries and restricted career advancement prospects, diminish project managers' dedication to projects. These institutional and systemic challenges not only impede effective PM but also exacerbate project setbacks and less-than-optimal outcomes in Nigeria's construction domain.In improving the use of PM techniques and methodologies, Ebiloma and Rimtip (2019) emphasized the importance of prioritizing efficient management of construction projects, highlighting the need to focus on management practices. The study suggested that fostering competency by involving skilled professionals, implementing robust supervision plans from both governmental and industry perspectives, and establishing policies to promote sound management practices. These measures can serve as catalysts for promoting the adoption of PM methodologies and techniques within the Nigerian construction sector. Ogunde *et al*. (2017) also emphasized the

importance of establishing and enforcing regulatory standards by the government as essential for enhancing the adoption of PM techniques. The study also suggested other methods for improvement, including integrating PM techniques from other fields into the construction industry, documenting all procedures used in construction projects for future reference, and offering comprehensive training on PM techniques to professionals early in their careers to foster familiarity with these methodologies and techniques. Iroha *et al*. (2024) also emphasised that tackling the challenges hindering the effective utilization of project managers and PM methodologies and techniques necessitates extensive policy and organizational reforms. These reforms should aim to foster transparency, competence, inclusiveness, merit-based acknowledgment, and fair opportunities for project managers.

2.10 Case Studies of Building Collapse in Nigeria

There have been several building collapses that have occurred in Nigeria, but according to record, most of the building collapse happened in Lagos state with around 152 recorded building collapse in 19 years. Some of these collapses been major collapse have been investigated over time to determine the cause of building collapse and what might have gone wrong. Some of these collapses include:

- ***The 21-storey building in Ikoyi, Lagos***

  ***Background*:** The not yet completed building project collapsed on 1st of November, 2021. The project site was located at 20, Gerrard Road, Ikoyi, Lagos. The project was initiated by Fourscore Homes which is a member of the National Home Builders Registration Council in South Africa and Zurich Building Guarantee in Europe. The project aims to provide upscale high-rise penthouses, duplexes, flats, and four-bedroom maisonettes, offering a luxurious living experience in the heart of Ikoyi. The anticipated completion date for the project was in 2022. By the time of the collapse on November 1st, 2021, the building had reached 80% completion, and 65% of the available spaces had already been sold, with prices ranging from US$1.2 million to US$5 million (Promptnews, 2021; Ebekozien *et al*., 2023).

  ***Issues*:** The issue arose in 2020 when regulatory authorities found that Fourscore Homes had violated town planning regulations by surpassing the approved height for a 15-story building. The Lagos State Building Control Agency took action by making an arrest, although the developer resumed work shortly after without lasting repercussions. Additionally, during this period, Prowess Engineering Limited, the structural engineering

firm hired by Fourscore Homes, withdrew its services from the construction site due to concerns about the poor quality of the concrete mix being utilized and there was no mention of the engagement of another qualified structural engineering firm to take over from the previous engineering firm (Oghifo and Elumoye, 2021; Ebekozien *et al*., 2023).

- ***The Two-storey building in Lekki Lagos***

Background: The building project partially collapsed on the morning of November 2nd, 2021, following heavy rainfall the previous night. Situated in Lekki, Lagos, the project is a self-construction intended for residential purposes. At the moment of collapse, rendering work had not yet commenced (Adewole, 2021).

Issues: There was no indication of a design team overseeing post-contract administration based on site inspections and observations. This absence might have contributed to the utilization of inferior materials and inadequate supervision. Moreover, there are concerns regarding the insufficient reinforcement of the roof beam (Ebekozien *et al*., 2023).

How PM can be used to address the issue in this case:

The first issue to identify from the case studies is the issue of lack of effective planning and design which could have been managed by employing proper PM which involves thorough planning and design of all phases including structural integrity and material quality, are carefully considered. Compliance from the stakeholders involved in the building was also noticed to be an issue in one of the case studies. This can be solved by employing the compliance management practice such as regular audits of stakeholders as these would have helped in avoiding breaches by any stakeholder and ensure building was completed within the approved parameters. Also, a proper risk management system which involves the identification, assessment and proactive measure to deal with identified risk associated with the use of poor-quality concrete mix, insufficient reinforcement of the roof support beams and withdrawal of structural engineering firm. And finally, PM methods and practices emphasize the importance of quality management throughout the project life cycle. By initiating extensive project quality management processes, including assurance and quality control measures, developers can ensure that construction materials meet standards and that structural integrity is maintained.

2.11 Integration of PM in Construction Education

According to Nweze (2016), many projects in Nigeria have failed due to poor PM and a lack of qualified project managers. It was found, in an interview, that a significant number of project managers acquire their skills through hands-on experience while working or from non-accredited PM institutions. This situation has led to related construction professionals assuming the role of project manager without the necessary knowledge and skills (Nwachukwu *et al*., 2011).

2.12 Conclusion

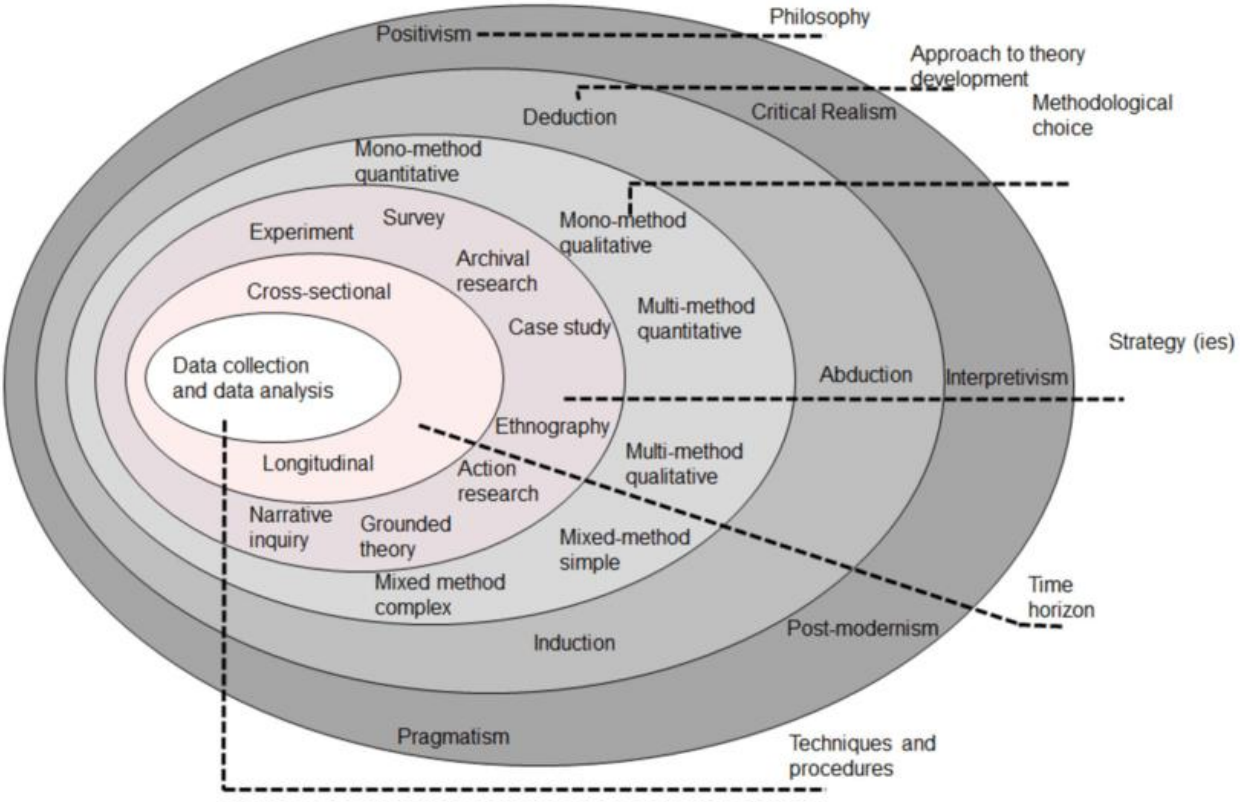
The Literature review provides a comprehensive collection of building collapse incidences, PM techniques, regulatory frameworks, and risk management assessments. It provides a detailed conceptual and empirical assessment of available literature on building collapse. It identified that there are knowledge gap in the maintenance system or compliance to quality assurance or comprehensive quality management system within the body of works reviewed. Hence, the need to fill this knowledge gap by appraising the objectives from the secondary review to understand best practices in other countries alongside the perspectives of local personnel within the building engineering services industry in Nigeria.

CHAPTER THREE

METHODOLOGY

3.0 Scope and Research Design

The study's research question is analytical in nature since it seeks to interrogate the PM solutions to building collapse. The critical realism is the underlying research philosophy owing to its overarching research goal of espousing causal factors responsible prevalent occurrence of building collapse and PM techniques mitigating the growing menace of building collapse. Fellows and Liu (2021) articulate physical or natural and physical scientists' causality as critical since positivism relies on the idea of falsification for the building of its generalisation of facts about life's reality. The phenomenon of building collapse has become a growing menace and reality within the Nigerian construction industry (Aduloju, 2024). This study is guided by the need to understand beyond what causes are responsible for the observable rise in the building collapse incident and utility of PM techniques as a panacea to the alarming rates of building collapse.



Source: The scope of the research in the context of the Research Onion (Saunders et al., 2019, p. 108 ; Saunders et al., 2023).

The research onion has provided a very comprehensive tool for disserting the methodology for any research project. The research utilised a multi-method qualitative approach with the combination of in-depth interviews (IDIs) assessing the variables and a critical review of secondary data appraising the global practices using PM solutions to building collapse.

Using a sample of six selected based on the expert criterion of being engineers with building work experience, the IDIs are conducted with Engineers to elicit the PM techniques that they utilised in mitigating building collapse within their worksites. The interviews used a semi-structured interview guide was administered digitally to the participants during different meetings rooms such as Google Meet and WhatsApp. The interview transcripts were transcribed and analysed using the descriptive-analytic approach.

The processed data collected and presented in line with ethical considerations such as non-maleficence, anonymity, confidentiality and related ethical issues will be strictly adhered while engaging the interviewed participants gave informed consent for participating in the interviews and for it to be recorded.

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION OF RESEARCH FINDINGS.

In this chapter, we embark on a detailed presentation of evidences from across the globe alongside the analysis of the data collected from qualitative research (one one-on-one interview), focusing on the factors contributing to building collapse in Nigeria. The components of our approach to investigation detection include in-depth analysis aimed at revealing building collapse patterns, themes, and insights essential for the understanding of the causes of the tragedies. Aiming to critique both the strengths and weaknesses of the current techniques of PM, the data presentation method on espousing causes as well as working shreds of evidence from across the selected countries across Africa, Asia, Europe and the Americas. These country reviews present shreds of evidence that address the objectives in identifying causes and analysing solutions to explain their effectiveness from the viewpoint of a disaster scenario. At last, this analysis gives me insights from which I can sully effective remedies that cover the entire spectrum of the site management discipline, in-depth to the peculiarities of the construction industry in Nigeria.

4.1 Sociodemographic Characteristics of Respondents

Analysing the sociodemographic information of the respondents from the primary data, showed the sample group is diverse according to age, gender, marital status, religion and qualification levels respectively. This diversity implies that the research would capture the diversified views the interviewed construction professionals on the causation of collapse and solutions using PM techniques.

Fig 4.1 Socio-demographic information of participants within Nigeria's construction industry.

ID	*AGE*	*GENDER*	*MARITAL STATUS*	*RELIGION*	*EDUCATIONAL QUALIFICATION*
Participant 1	30	Female	Single	Christian	Tertiary Level of education
Participant 2	28	Male	Single	Christian	Tertiary Level of education
Participant 3	35	Male	Married	Islam	HND, Tertiary Level of education
Participant 4	42	Male	Married	Christian	Tertiary Level of education
Participant 5	38	Male	Married	Islam	Tertiary Level of education
Participant 6	32	Male	Single	Christian	Tertiary Level of education

Source: Author's IDI Transcripts.

4.2 Identify the primary factors contributing to building collapse in Nigeria, taking into consideration structural, regulatory, and procedural aspects.

The primary data illuminates on the main reasons of building collapse in Nigeria, considering structural, regulatory and procedural issues Through analysis of participant statements using qualitative methods, they made a breakthrough, therefore revealing the root cause of buildings collapse in the country. Sub-structuring were focused on, including use of poor quality materials, violating building codes, derailed plans, not thorough soil survey and eroded foundation design. The outcomes of research cohere with the purpose of study that will reveal how weak the structural elements are which eventually lead to collapses. Finally, among the regulatory challenges were corruption, lax enforcement, enforcement loopholes, and bureaucratic inefficiencies identified to be widespread. Participants highlighted the necessity of having regulatory frameworks upholding construction standards, and pointed out existing complexities in the current framework which ultimately weakens their effectiveness. These discoveries highlight the significance of the law's reform which would help to partly address the corruption and improve the supervision system.

The new regulations to the building standards and codes will to be respected and adhered strictly. The excerpts on causes of building collapse are shown below.

Structural factors in Nigeria often stem from poor quality materials, insufficient adherence to building codes, and compromised structural designs. Additionally, inadequate soil analysis and foundation design contribute significantly to collapses: ***Participant 1***

Structural failures often result from poor design practices, inadequate supervision, and the use of substandard materials. Furthermore, insufficient maintenance exacerbates structural vulnerabilities over time: ***Participant 3***

Structural failures often result from poor construction practices, inadequate supervision, and non-compliance with building codes and regulations. Additionally, factors like improper maintenance and overloading contribute to collapse risks: ***Participant 6***

These excerpts provided reasons for structural failures along with other contributors such as construction defects and poor design practices, weak supervision, low-quality materials used, insufficient maintenance, and overloading. Likewise, it highlighted criticalness of implementing new construction technologies and inspecting the process in the whole construction sector. The interviews involved a recommendations to the policymakers, construction professionals and the regulatory bodies in Nigeria some cues towards various crucial policies as well as their implementation. The recommendations are based on the post-accident study. The recommendations comprise of suggestions to the laws, mechanisms to supervise enforcement of the laws, construction supervision, and commitment to adhere to the safety rules. With the aim of zoning, regulating and re-engineering problems noted in the investigation, stakeholders can formulate strategies aimed at reducing risks of buildings collapse and enhancing building safety standards in Nigeria.

Participant 3: *Regulatory frameworks play a pivotal role in ensuring compliance with safety standards, but their effectiveness is undermined by corruption, weak enforcement, and regulatory loopholes.*

Participant 1: *Regulatory frameworks are crucial in upholding construction standards, but in Nigeria, they face challenges such as corruption and inconsistent enforcement. This allows subpar construction practices to persist, exacerbating the risk of collapses.*

Participant 6: *Regulatory frameworks are critical for upholding safety standards, but their effectiveness is undermined by corruption, insufficient enforcement resources, and bureaucratic inefficiencies. This allows non-compliant practices to persist.*

4.3 Assess Nigeria's construction industry for existing PM techniques focusing on the strengths, weaknesses, and gaps in addressing factors associated with building collapse.

Likewise, the participants expounded on the strengths, and weaknesses as consideration factors when deploying PM techniques. They emphasised practices regarding disaster amelioration and the factors that lead to building collapse. PM techniques included Gantt charts and Building Information Modeling (BIM). The below excerpts, identified challenges with regards to coordinating, prompt and all resources available for building projects, we can be able to have more commitment to health and safety regulations. Participant 2 underscores that an efficient PM approach may be the basis of collapse prevention which involves the usage of coevolution and resources economy.

> ***Participant 2:*** *Challenges include poor project planning, insufficient risk assessment, and inadequate communication among project stakeholders. Additionally, budget constraints sometimes lead to compromising safety measures.*

> ***Participant 5:*** *Regulatory frameworks play a vital role in ensuring compliance with safety standards, but their effectiveness is hampered by corruption, weak enforcement mechanisms, and insufficient oversight. This allows unsafe practices to persist.*

> ***Participant 2:*** *Common techniques include traditional methodologies like Gantt charts and newer approaches such as Building Information Modeling (BIM). However, their adoption varies across projects and firms.*

Nevertheless, the vacuum created in the approach also becomes visible. Barriers arise through disorganized planning, lack of risk assessment, invalid communication among peers, etc. Moreover, budget limits may mean eliminating some safety steps and shown the absence of safety production in practices of supervisors. Participant 5 as the second point highlights the limitation of the regulatory frameworks because of corruption, dysfunctional enforcement mechanisms, and limited authority over the oversight process hence it becomes possible for some unsafe practices to continue operating despite the existing regulations.

> ***Participant 5:*** *PM techniques range from traditional methodologies like Gantt charts and CPM to modern approaches such as Lean Construction and Building Information Modeling (BIM). However, their effective implementation varies.*

> ***Participant 2:*** *Effective PM enhances coordination, facilitates timely decision-making, and improves resource utilization. This fosters greater adherence to safety standards and reduces the risk of collapses.*

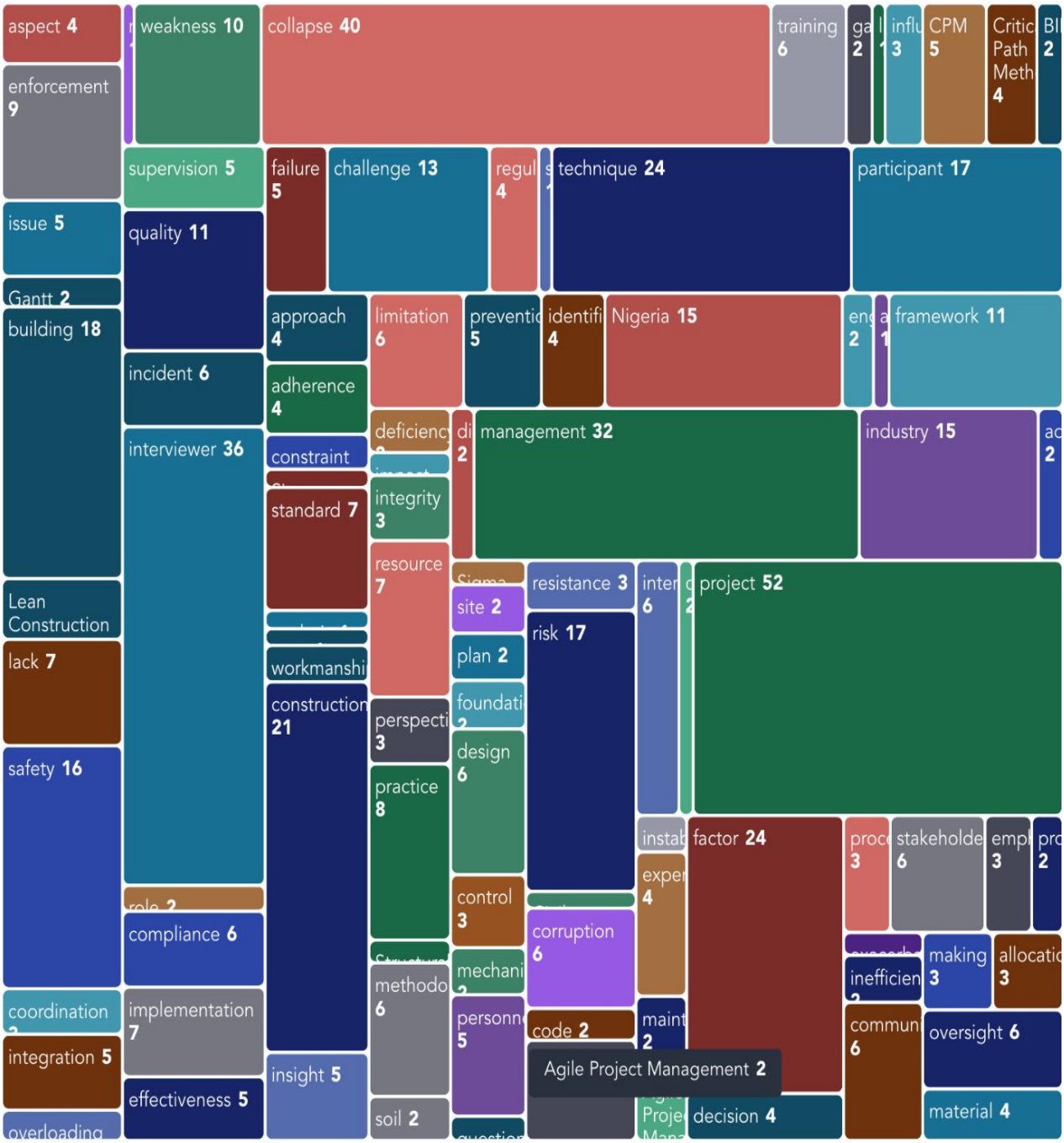
Apparently, the participant statements augment the assessment of management approaches in Nigeria construction sector. The natural disasters may present unnoticeable weak points that are observed when devastating consequences happen. The immediate aftermath of the

disaster provides clues into gaps that should be closed and factors which contribute to the collapse of buildings. In this regard, the outcome is vital for developing appropriate recommendations to be directed to improvements in the area of PM practices leading to an increase in safety standards.

4.4 Word cloud and Word frequency on building collapse in Nigeria's construction industry.

The analysis of key concepts extracted from the transcripts is presented in word frequencies and Word Web below. The word web simply acts as a mind map on pivotal terms related to the subject-matter while the word frequency shows the rate of re-occurrence of these terms to help our analysis and discussion. These highlighted keywords related to the causation and PM techniques for mitigating building collapse. The words reflect across the discussion of findings from across different continents in later sections.

Fig 4.2 Word frequencies on building collapse in Nigeria's construction industry.



Source: Author's IDI Transcripts.

Fig 4.3 Word web from the transcripts

Source: Author's IDI Transcripts.

4.5 Use PM techniques as a method for proffering solutions to the contributing factors associated with building collapse in Nigeria.

Participant 1 narrates the significance of PM as one of the solutions used to frame and handle the contributing factors to the fifty-year phenomenon of building collapse in Nigeria. As stated in their declaration, these methods contribute to coordination, effective implementation, and creation of risk management space. Increased effective performance and compliance in these factors through the PM techniques is an effective way of preventing structural failures. Therefore it's the best approach to tackle problems within the industry of construction. Participant 4 states that present management abilities are inadequate thus resulting in lower project quality and safety. The poor competency of project staff, non-conformance to change among the involved parties and the absence of integration between management and engineering disciplines are the loopholes identified for this project. Inaccurate's bearings about all the sites is the core of this problem. To fix it, managers need to apply PM tools, which will eventually make the results of the whole project and lower risks of collapses.

And, Participant 5, furthermore, points out effect PM plays in addressing underlying factors involving building collapse. It highlights that strategic PM helps to bring out better coordination indeed, identify probable risks in good time, and allocate available resources perfectly. With this role , PM serves as an impetus to improve project surveillance and mitigate failures while their goals remain intact: - completing a project within budget and scope.

> ***Participant 1:*** *These techniques facilitate better coordination among stakeholders, optimize resource allocation, and enable proactive risk management, thereby reducing the likelihood of structural failures.*

> ***Participant 4:*** *Weaknesses include inadequate training of project personnel, resistance to change within the industry, and a lack of integration between PM and engineering disciplines. These factors undermine project quality and safety.*

> ***Participant 5:*** *Effective PM promotes better coordination, facilitates timely risk identification, and improves resource allocation. These aspects contribute to enhanced project oversight and reduced collapse risks.*

4.6 Evaluate the feasibility and practicality of implementing the proposed PM techniques focusing on factors such as cost-effectiveness, acceptability to the industry, and adaptability to the local context in Nigeria.

Participant statements give understanding of success and failure of the implemented PM techniques in the construction industry sector of Nigeria where this study goal is going to at the same time. These include the factors that are related to feasibility, cost-effectiveness, acceptance, and facilitation of the implementation of the model to the local context. Participant 1 points out some challenges with the existing educational system. They include insufficient training of staff, inadequate use of modern technology and systemic issues like delays in decision-making processes. Such obstacles are a hindrance for using the full potential of methodologies for implementing the projects encouraging the more reasonable doubts about their feasibility and practicability. Inadequate professional training and technology may become the reasons for the lack of a clear understanding of the new technological methods.

Participant 5 and 6 underline the organizational inefficiency of the industry that include, but i not limited to, the insufficient integration of safety requirements into the project managing

approaches, the difficulties adopting changes, and the lack of focus on constant advancement. These vulnerabilities imply misrepresentation, improper supervision as well as safety issues within the project, making the project effort highly difficult and ineffective. The reluctance to change the system and the awareness of safety protocols are still some areas that hinder if the company will be embraced by the industry and more importantly, how it will adapt to the local contexts.

> ***Participant 1:*** *Challenges include inadequate training, limited adoption of modern technology, and systemic issues like delays in decision-making processes. These can impede effective implementation of PM methodologies.*

> ***Participant 5:*** *Weaknesses include inadequate integration of safety protocols into PM processes, resistance to change within the industry, and a lack of emphasis on continuous improvement. These factors undermine project safety and quality.*

> ***Participant 6:*** *Weaknesses include inadequate training of project personnel, insufficient integration of safety protocols into PM processes, and limited enforcement of project quality standards. These factors undermine project safety and integrity.*

Overall, the participant statements underscore the importance of addressing key weaknesses and challenges to enhance the feasibility and practicality of implementing proposed PM techniques in Nigeria. Among unfamiliar approaches like better training of operators, spreading awareness about technological gains, including risk control in strategic management and creating a healthable environment for continuous improvement locally may be required to govern the processes and promote successful project implementation. This research is very significant for drawing the follow-up recommendations on how best to amend the ongoing practices in order to increase overall safety and project quality for the construction industry in Nigeria.

4.7 Discussion of findings

4.7.1 Identifying Factors Contributing to Building Collapse

The analysis of the information obtained from the professionals proves that building collapse in Nigeria result typically from structural, regulatory, and procedural factors. Structural factors, the bad level of materials, non-compliance with construction codes, and unrefined designs were identified as the main precursors of the faults and eventual collapse of buildings. The finding affirmed that regulatory challenges such as corruption, poor enforcement, and loopholes, play a critical role in the lack of oversight on the early signs of building collapse

resulting in the undetection and ignoring of technological flaws, including improper engineering systems and inefficient site supervision, were other principal factors. The finding resonates with the work of Egwunatum, Anumudu, Eze and Awodele (2022) which identified non-compliance with established standards and regulations, the shortage of the necessary machineries, equipment, tools and facilities, poor information exchange between the management and supervisory teams on site and poor maintenance culture for equipment, tools and machines are responsible for building collapse.

Further, it corresponds to the existing research that witnesses how structural faults, regulatory inadequacy, or procedural failures may cause building collapse (Awe *et al*., 2024; Adebisi et.al., 2020). These works advocate for the early integration of quality engineering practices in the infancy of managing a project, particularly the adoption of International Standards Organizations protocols like ISO 9001 (Quality Management), ISO 14001 (Environment Management) and ISO 45001 (Occupational Health) which emphasise capacity-building/training and technical expertise for every work position and compliance with industry regulations. Noteworthy, ISO standards made inroads into other sectors such as manufacturing, banking and Oil & Gas sector as these companies . ISO 9001 emphasizes continuous improvement in design and process control, which, when applied correctly, can prevent the use of substandard materials and ensure that buildings meet required specifications. By embedding quality engineering techniques into the construction lifecycle, Nigerian construction projects can move toward a more sustainable model, minimizing the risks of future collapses. Noteworthy, limited regulatory enforcement and insufficient training among construction professionals (Cite Sources)

4.7.2 Assessing Existing PM Techniques

Participants facilitated a dialogue on the strong points, weak points and key voids in still-existing techniques of PM within construction in Nigeria. Points of strengths included a combination of traditional methodologies like Gantt charts and modern approaches, such as Building Information Modeling (BIM), among others. Building Information Modeling (BIM) system entails the creation of digital models of buildings, allowing construction professionaals for real-time updates on material use, structural design, and progress reports. The discourse around BIM has been critical in identifying discrepancies between the design and the actual construction at an early stage, thus reducing the chances of structural failures. Works such as Salzano, Cascone, Zitiello, and Nicolella (2024) attest that BIM as mentioned

by participants, has aided construction practitioners in identifying discrepancies and weaknesses between the model and eventual structure such as inappropriate project planning, insufficient risk assessment, and lack of integrating safety standards were in evidence, an observation was made by an individual. Those findings are congruent with which underlines the relevance of communication, efficient cost control and effective PM for construction site quality and safety (Aibinu & Jagboro, 2002;Yahya. *et al*, 2024; Liu et al., 2020; Aibinu, A. and Venkatesh, 2014).

Reflecting on the wquality assurance, Unegbu, Yawas and Dan-Asabe (2022) reflect on the Quality assurance (QA) is often expressed as a project management approach known as Total Quality Management (TQM). This aspect of building PM has gained traction in terms of construction performance measures and PM practices TQM encompasses a wide range of activities, including inspection, testing, and certification, which collectively ensure that a building meets all safety and performance requirements. Another quality project management approach is the Lean Six Sigma, which streamline operations and ensure excellence in project delivery. Six Sigma focuses on reducing defects and variability in processes, while the Lean/Agile approach aims to optimize resources and minimize waste hence ensuring (Malla, 2024).

4.7.3 Using PM Techniques for Solutions

PM techniques revealed by the study as a working approach for overcoming the issues behind the collapsing of buildings in Nigeria. Seen as the designated driver, competence in PM contributed to improved coordination, faster decision making and efficient utilization of resources. These attributes play a key role in the implementation of safety norms (Participant 2). Using PM techniques can work to minimize the complications coming from structural defects, submission of documents for regulatory license, and defects in previous processes (Ofori, 2000; Ogunlana et al., 2019), which are among the objectives of construction safety and quality.

4.7.4 Evaluating Feasibility and Practicality of Implementation

In light of the respondents' identification of BIM and Quality Engineering systems for the assessment of the structural integrity and potential failures. Structural Integrity and failure of any building have been associated with the quality of the Engineering systems which entails the design, testing, and implementation of the building to perform under various stress conditions like weight, wind, and seismic activity (Haddad, Bahrami, and Eshiet, 2024).

Finite element analysis (FEA) is the technique used to achieve this simulation assessment for buildings to understand how they will perform under various stress conditions like weight, wind, and seismic activity. Kacker, Singh, and Kasar (2024) articulate that the identification of these potential failure points using the FEA, require the implementation of rigorous testing protocols for materials, such as concrete and steel, ensuring that they meet the necessary load-bearing standards.

The value and ability of the extant technique of PM were critiqued with consideration to factors like affordability, acceptance, and fit for Nigeria. Objects of these difficulties, which includes inadequate training, limited technology adaptation as well as resistance, were chosen as the issues (Participan. The goal of such reforms would be to upgrade the training programs, develop the oversight frameworks, and promote a better safety and quality culture in the zone. This situation calls for a broadened approach that employs many PM techniques to deal with the classes of problems leading to building collapse in Nigeria. For instance, structural defects surmounting regulatory issues and flaws through proper management project Nigeria can build a secure, quality, and resilient construction industry. Nonetheless, accomplishing this target requires walking over numerous challenges and obstructions concerning implementation that is why the necessity of such comprehensive changes within the architectural construction industry become quite obvious. In light

4.8 Discussion of Findings from Secondary Review: PM Techniques & Success Stories

This section appraises evidence from different countries across the globe on how they have resolved building collapse challenges and lessons for Nigeria

4.8.1 South Africa: Regulatory Compliance and Infrastructure Safety

Stone (2022) identified that the Earned Value Management (EVM) and Critical Path Method (CPM), have been pivotal PM approaches utilised in South Africa for achieving significant strides in ensuring the structural integrity of its buildings through robust regulatory frameworks and a commitment to PM techniques. The South African Bureau of Standards (SABS) sets stringent building regulations that construction projects must adhere to, ensuring that all materials and designs meet international safety standards (Duku, 2020). In Cape Town, for example, the enforcement of these regulations has drastically reduced the incidence of

building collapse (Mpeta-Phiri Namalima, 2022). South African project managers can monitor the progress and safety of their construction projects in real-time, thus mitigating risks before they materialize.

The Gautrain Rapid Rail Link project, provides a remarkable success story for deployment of project management techniques on a large-scale urban construction (Doyle, 2020). Integrated risk management protocols ensure safety with the implementation of quality assurance programs and leveraging advanced PM software, the project was able to avoid the common pitfalls associated with large infrastructure development, such as delays, cost overruns, and structural weaknesses. It demonstrated the effectiveness of the combination of regulatory oversight and advanced PM techniques in preventing structural failures, when it is integrated across every stage of the construction process (Doyle, 2020).

In comparison to Nigeria, South Africa's approach highlights the critical importance of regulatory enforcement in conjunction with PM methodologies. While Nigeria struggles with weak oversight and enforcement, South Africa has demonstrated how strong regulatory bodies, combined with PM expertise, can significantly improve construction outcomes. Nigeria can learn from South Africa's approach by tightening its regulatory frameworks and training its project managers to use advanced PM tools that emphasize safety, quality, and resource efficiency.

4.8.2 PM Techniques in Europe: Quality Assurance Practices and Case Studies

4.8.2.1 United Kingdom: Building Safety Regulations and PM Integration

The United Kingdom has developed one of the most comprehensive frameworks for construction safety, built on a foundation of rigorous quality assurance processes and PM techniques with the introduction of the Building Safety Bill in 2021 further strengthened regulatory requirements, particularly in response to the Grenfell Tower tragedy, which exposed major failings in fire safety standards (Alencastro, Fuertes, and De Wilde, 2024). Today, construction projects in the UK must undergo thorough risk assessments, with project managers responsible for ensuring compliance with safety codes at every phase of development. Techniques such as PMBOK (PM Body of Knowledge) and PRINCE2 are widely used, ensuring that projects meet deadlines, stay within budget, and adhere to quality and safety standards.

A notable example is the construction of The Shard in London, the tallest building in the UK,the project employed extensive PM techniques, including BIM, risk management and quality control measures, to ensure the safety of the structure (Fu and Richardson, 2024). By using BIM, allowed for real-time collaboration among architects, engineers, and contractors. project team could anticipate and address potential issues before they escalated, ensuring that the final structure met all regulatory and safety requirements. This combination of advanced PM tools and regulatory compliance ensured that The Shard was completed without incident (Fu and Richardson, 2024).

In Nigeria, where building regulations are less stringent, the UK's approach provides a valuable lesson in the role of comprehensive safety laws and robust PM. By integrating similar PM methodologies, Nigerian construction projects could benefit from heightened oversight and better risk mitigation. Furthermore, the widespread adoption of tools like BIM and PRINCE2 would improve communication and collaboration among stakeholders, reducing the risk of structural failures.

PM techniques, particularly those emphasizing quality engineering, quality assurance, and resource utilization, offer a valuable framework for addressing the endemic problem of building collapse in Nigeria. Lessons learned from successful cases in Africa, Europe, Asia, and the Americas demonstrate the importance of regulatory enforcement, advanced PM tools, and international standards in ensuring the structural integrity of buildings. Nigeria, by adopting these best practices, can greatly improve its construction industry and reduce the frequency of building collapse, thereby protecting both lives and property.

4.8.2.2 Germany: Project Lifecycle Management and Structural Safety

Germany’s construction industry is known for its emphasis on precision and structural safety, largely due to its robust Project Lifecycle Management (PLM) approach. The PLM model in German construction projects is characterized by a high level of integration between planning, design, construction, and post-construction phases. PM techniques are deeply embedded in these processes to ensure that each stage meets stringent safety and quality standards. Techniques such as the Critical Path Method (CPM) and Total Quality Management (TQM) are widely used to optimize project schedules and guarantee structural integrity .

One of the key strengths of Germany’s PM approach is its focus on detailed planning and engineering design, which is bolstered by comprehensive risk assessments. This allows

project managers to foresee potential issues and mitigate risks before construction begins. Quality assurance is ensured through adherence to standards such as the DIN (Deutsches Institut für Normung) and Eurocodes, which outline detailed specifications for materials, structural safety, and construction processes. These standards ensure that construction projects meet the highest levels of safety and are capable of withstanding external pressures such as weather conditions and seismic activities .

In addition, Germany is at the forefront of incorporating digital technologies into construction projects. The adoption of BIM has enhanced project oversight by allowing real-time data sharing among stakeholders, ensuring that deviations from safety standards are identified and corrected early in the project lifecycle. These technological tools, combined with a strong regulatory framework, have made Germany a leader in preventing building collapses through effective PM strategies.

4.8.2.3 France: Public-Private Partnership Projects in Construction Safety

In France, Public-Private Partnership (PPP) projects have emerged as a key strategy in ensuring construction safety. The country's PPP model encourages collaboration between public sector agencies and private construction firms, where both parties work together under a framework that prioritizes quality assurance and structural safety. PM methodologies, especially those emphasizing stakeholder management and risk-sharing mechanisms, play a central role in these partnerships. Projects such as the Grand Paris Express, Europe's largest infrastructure project, showcase the importance of PM tools in maintaining safety and quality standards .

A key element in France's success with PPP construction projects is the structured PM frameworks that ensure alignment between public interests and private-sector expertise. For instance, the use of Gantt charts, CPM, and Earned Value Management (EVM) allows project managers to track progress and ensure that safety standards are not compromised during construction. The French government's role in overseeing these projects ensures that regulatory compliance is maintained, while private contractors bring in innovation and efficiency through modern construction techniques and technology.

Moreover, France's legal framework, which includes the French Construction Code, mandates rigorous safety standards that must be met by all parties involved in construction projects. PM systems are used to monitor adherence to these standards, especially in large-scale infrastructure projects where the risk of failure can have far-reaching consequences.

Through these systems, PPP projects in France have been able to achieve high safety outcomes, minimizing the risk of building collapse.

4.8.2.4 Norway: Sustainable Resource Utilization and BIM Implementation

Norway has become a global leader in sustainable construction practices, and PM (PM) plays a crucial role in ensuring that projects not only meet safety standards but also optimize resource utilization. The country's adoption of BIM in both private and public sector construction projects has greatly improved project efficiency and safety. BIM enables stakeholders to visualize potential issues during the design phase, thereby preventing structural failures that could lead to building collapse. Through BIM, project managers in Norway can streamline resource allocation, ensuring that materials are used efficiently without compromising quality .

Sustainability is a core principle in Norwegian construction projects, where PM techniques such as Lean Construction are employed to minimize waste and maximize value. These PM tools help ensure that construction materials are sourced sustainably, and building designs are energy-efficient. Furthermore, the Norwegian government's Building Regulations set strict standards for construction safety, which are enforced through a combination of digital oversight tools and PM practices such as continuous quality checks and performance tracking.

Norwegian construction projects are also characterized by a high level of stakeholder involvement, where PM techniques such as stakeholder analysis and communication management are key to achieving project goals. The focus on collaboration between government agencies, contractors, and the public has ensured that safety remains a top priority in construction projects. This approach has significantly reduced the occurrence of building collapses in Norway, making it one of the safest countries in Europe for construction.

4.8.2.5 Sweden: Quality Control Mechanisms in High-Rise Construction

Sweden's booming urban centers have led to a rise in high-rise construction, and PM (PM) techniques are vital in ensuring the structural safety of these projects. In Sweden, quality control mechanisms are embedded within the PM framework, where every stage of construction is subject to rigorous checks and balances. PM methodologies such as Agile and Scrum are frequently used to break down construction processes into smaller, manageable tasks, allowing for continuous assessment of quality .

One of the standout features of Sweden's approach to PM in high-rise construction is the emphasis on innovation. The Swedish construction industry is quick to adopt cutting-edge technologies, such as automated inspection tools and real-time data analytics, to monitor building integrity. These technologies enable project managers to track deviations from design specifications and rectify them immediately. In addition, the use of prefabrication techniques, managed through PM systems, has improved the precision of building components, reducing the risk of structural failures.

Sweden's regulatory environment also plays a significant role in upholding construction quality. The Swedish National Board of Housing, Building, and Planning sets stringent regulations that are enforced through PM practices like compliance monitoring and project audits. These regulations ensure that all high-rise buildings meet the necessary safety standards. The combination of innovative PM techniques and strong regulatory oversight has made Sweden a model for successful high-rise construction without the risk of collapse.

4.8.2.6 Netherlands: Regulatory Oversight and PM Role in Flood-Resistant Structures

The Netherlands, a country known for its geographic vulnerability to flooding, has developed advanced PM (PM) techniques to ensure that its buildings and infrastructure are flood-resistant. The Dutch government's strict regulatory framework mandates that all construction projects incorporate flood mitigation measures, and PM tools are used to oversee the implementation of these measures. Techniques such as risk management, stakeholder engagement, and real-time project monitoring are essential in ensuring that flood defenses are integrated into construction projects without compromising structural integrity .

One of the key PM strategies employed in Dutch construction is the use of scenario planning, where potential environmental risks, such as rising sea levels, are factored into building designs. PM systems enable project managers to assess these risks continuously and adjust project plans accordingly. Additionally, the Dutch construction industry is highly collaborative, with PM methodologies emphasizing stakeholder management to ensure that architects, engineers, and regulatory bodies work together to meet safety standards .

In terms of resource utilization, the Netherlands excels in using PM frameworks to optimize the use of sustainable materials in flood-resistant construction. The country's focus on circular construction practices, where materials are reused and recycled, is managed through PM tools that track resource consumption and waste reduction. This sustainable approach not

only ensures the long-term viability of buildings but also contributes to flood resilience, as materials used are designed to withstand environmental pressures.

4.8.2.7 Italy: Use of Project Risk Management in Historical Building Renovations

Italy's construction industry places great emphasis on the preservation of its vast architectural heritage, necessitating rigorous PM (PM) techniques. One critical PM technique used in Italy, particularly for historical buildings, is Project Risk Management (PRM), which involves identifying, analyzing, and responding to risks throughout a project's lifecycle. In historical renovations, risks such as structural instability, deterioration, and compliance with cultural heritage regulations are prevalent. PM techniques such as risk matrices, scenario analysis, and real-time project monitoring allow for effective mitigation of these risks.

Italian project managers have successfully applied PRM in restoring historical sites like the Colosseum and the Leaning Tower of Pisa. These projects employed techniques such as Building Information Modelling (BIM) for detailed assessments of structures, allowing project teams to simulate and evaluate the impact of different interventions. Furthermore, the integration of Lean Construction principles ensured optimal resource allocation, reducing both waste and time delays.

Italy's use of PRM in the renovation of historical structures offers valuable insights for Nigerian projects involving older buildings or heritage sites. Nigerian project managers could adopt these practices to prevent building collapses, particularly in urban areas where structural degradation is a concern. By applying risk mitigation techniques, Nigeria can better preserve its architectural legacy while ensuring modern safety standards are met.

4.8.2.8 Spain: Excellence in Green Construction Practices Through PM

Spain has been a leading advocate for green construction, incorporating sustainable practices into its PM frameworks. Green construction in Spain focuses on reducing environmental impact through energy efficiency, the use of sustainable materials, and minimizing waste. Project managers in Spain have adopted methods such as the Lean and Agile PM methodologies to achieve these goals, emphasizing continuous improvement and stakeholder engagement.

Spain's efforts are exemplified in large-scale projects like the La Vela building in Madrid, which used energy-efficient materials and renewable energy sources. Project managers in these projects ensure compliance with environmental regulations by integrating Life Cycle Assessment (LCA) tools to evaluate the long-term sustainability of construction materials and processes. Quality Assurance (QA) methods are also strictly enforced to meet ISO 14001 standards, ensuring that environmental risks are mitigated at every phase of the project.

For Nigeria, the Spanish approach to green construction can serve as a model for integrating sustainability into its building sector. As Nigeria faces increasing challenges from climate change and resource depletion, adopting Spain's PM techniques could reduce the risk of building collapses through the use of more durable and eco-friendly materials, along with better planning and resource management.

4.8.2.9 Denmark: Collaborative PM in Public Infrastructure Projects

Denmark is known for its strong tradition of collaboration in PM, especially in public infrastructure projects. Danish construction projects often involve multiple stakeholders, including public agencies, private contractors, and civil society groups, making collaboration crucial. Project managers in Denmark employ collaborative PM techniques such as Integrated Project Delivery (IPD) and Cross-Functional Teamwork, which ensure that all parties work together effectively to meet project goals.

For example, the construction of the Copenhagen Metro involved close coordination between government entities and private construction firms. Using PM tools like BIM and Earned Value Management (EVM), project managers monitored progress in real-time, ensuring that quality, cost, and time objectives were met. This collaborative approach reduced risks of delays, cost overruns, and construction failures, ensuring the long-term sustainability of the metro system.

In Nigeria, adopting Denmark's collaborative PM models could significantly improve public infrastructure projects. By fostering greater cooperation among stakeholders, Nigerian project managers could ensure that projects are completed on time and within budget, reducing the risk of building collapses due to poor coordination and mismanagement.

4.8.2.10 Finland: Technological Integration for Preventing Structural Failures

Finland has long been at the forefront of integrating advanced technologies into PM to prevent structural failures. Finnish project managers use cutting-edge technologies like 3D scanning, BIM, and drone surveys to enhance precision in construction planning and execution. These technologies allow for real-time monitoring and analysis of building structures, which helps detect early signs of structural weaknesses that could lead to collapses.

The Olkiluoto Nuclear Power Plant is a prime example of how Finland leverages technology in PM. Throughout its construction, project managers utilized BIM to ensure meticulous structural design and risk management. Moreover, drone surveillance was employed to conduct safety inspections that would have otherwise been time-consuming and prone to human error. These advanced technological solutions allowed for rapid identification of issues and ensured that corrective actions were taken promptly.

For Nigeria, Finland's technological approach offers significant potential. Implementing similar PM techniques using technology can help Nigerian construction companies avoid the pitfalls of manual supervision and outdated construction practices, thus reducing the likelihood of building collapse.

4.8.2.11 Portugal: Project Monitoring Systems for Preventive Maintenance

Portugal has developed a robust system for project monitoring, particularly in preventive maintenance for construction projects. The country's PM techniques focus on continuous assessment and real-time adjustments to ensure long-term building sustainability. Portuguese project managers often use advanced monitoring systems such as IoT-based sensors and predictive maintenance software, which allow them to track structural health over time and anticipate potential issues before they escalate.

A notable example is the Vasco da Gama Bridge in Lisbon, where project managers employed IoT sensors to monitor structural integrity and environmental conditions such as wind and temperature variations. These systems provided valuable data for real-time decision-making, allowing for immediate interventions when anomalies were detected. The integration of these monitoring systems ensured that the bridge has remained in excellent condition since its completion, with no major structural failures reported.

For Nigeria, Portugal's emphasis on preventive maintenance through project monitoring offers a valuable lesson. By implementing similar PM techniques, Nigerian infrastructure projects could benefit from continuous oversight, allowing for timely maintenance and reducing the likelihood of catastrophic failures.

4.8.2.12 Greece: Heritage Preservation and Modern Construction Safety

Greece's rich historical heritage requires a delicate balance between preservation and modern construction safety. Greek project managers apply PM techniques that prioritize structural integrity while preserving historical elements. This involves a combination of traditional craftsmanship and modern construction technologies. The use of seismic retrofitting, for instance, is common in Greece, given the country's vulnerability to earthquakes. Project managers often employ risk management tools and engineering solutions tailored to seismic activities to strengthen historical structures.

One prominent example is the Acropolis restoration project, where Greek project managers employed a detailed PM framework that included risk assessment and phased project execution to ensure both preservation and safety. Techniques such as 3D laser scanning and structural health monitoring systems were used to assess the stability of the structures and guide the restoration process. Additionally, quality assurance processes were integral to maintaining compliance with both heritage and safety standards.

Nigeria, too, has a wealth of historical architecture, and Greece's PM techniques in heritage preservation could be adapted for use in Nigerian projects, particularly in cities like Lagos and Ibadan, where colonial-era buildings are still in use. Applying seismic retrofitting and similar techniques can also help in improving the resilience of structures against environmental hazards.

4.8.2.13 Austria: Implementation of PM Software for Quality Compliance

Austria has been highly successful in implementing PM software solutions to ensure quality compliance in construction projects. Austrian project managers regularly use software such as Primavera P6 and Microsoft Project to manage timelines, resources, and quality assurance (QA) protocols. These PM tools enable precise scheduling, resource allocation, and documentation, ensuring that all project activities meet pre-defined quality benchmarks.

One notable case is the construction of the ÖBB (Austrian Federal Railways) headquarters in Vienna, where project managers utilized Primavera P6 to streamline project scheduling and manage multiple contractors. This ensured that all aspects of the project, from material procurement to on-site construction, adhered to strict QA processes. The use of these software tools also facilitated collaboration between stakeholders, helping avoid miscommunication and delays that could compromise structural integrity.

For Nigeria, adopting Austria's PM software-driven approach could lead to significant improvements in project quality and efficiency. Implementing similar software tools in Nigerian construction projects could help project managers track progress, enforce QA standards, and ultimately reduce the risk of building collapse.

4.8.2.14 Switzerland: Project Evaluation and Excellence in Resource Utilization

Switzerland is known for its meticulous approach to project evaluation and resource utilization, particularly in its high-precision construction sector. Swiss project managers employ detailed project evaluation techniques that involve continuous feedback loops, allowing for real-time adjustments to resource allocation. Tools like Earned Value Management (EVM) are frequently used to monitor the progress of construction projects and ensure that they remain within scope, time, and cost constraints.

The construction of the Gotthard Base Tunnel, one of the largest infrastructure projects in Switzerland, exemplifies this approach. Project managers employed EVM to track the tunnel's construction and ensure that resources were optimally utilized. Moreover, Switzerland's commitment to quality is reflected in its stringent regulatory standards, which require that all projects adhere to ISO 9001 and other relevant quality management systems.

In Nigeria, Swiss PM techniques in resource utilization can offer a framework for improving construction practices. By adopting resource optimization tools and rigorous project evaluation methods, Nigerian project managers could enhance both efficiency and quality, thus minimizing the risk of building collapse.

4.8.2.15 Belgium: Risk Management and Urban Planning in Construction

Belgium has demonstrated excellence in integrating risk management into urban planning, especially in the context of large-scale construction projects. Belgian project managers utilize

risk management tools like Failure Mode and Effects Analysis (FMEA) and risk registers to identify and mitigate potential issues before construction begins. This proactive approach is particularly important in urban settings, where the risk of disruption to infrastructure is high.

A prime example is the Brussels North-South railway junction, where Belgian project managers applied comprehensive risk management strategies to address the challenges of building in a densely populated area. Risk assessments were conducted to evaluate the impact of construction on existing infrastructure, and mitigation plans were developed to minimize these risks

4.8.2.16 Ireland: BIM and Lean Management Practices

Ireland has increasingly embraced Building Information Modelling (BIM) and Lean Management practices in its construction sector, significantly improving project delivery, cost efficiency, and safety standards. BIM, a digital representation of the physical and functional characteristics of a facility, enables Irish project managers to visualize construction projects in a virtual environment, ensuring that potential flaws are identified and corrected before physical implementation. This preemptive approach reduces the likelihood of structural failures that could lead to building collapses. Furthermore, Irish construction firms integrate BIM with PM software to improve real-time monitoring of projects, allowing for enhanced resource planning and decision-making .

Lean Management, which focuses on maximizing value by minimizing waste, is another key PM technique employed in Ireland. By streamlining construction processes and eliminating inefficiencies, Lean Management ensures that projects are completed on time and within budget, while maintaining high standards of quality and safety. The Lean Construction Institute (LCI) of Ireland promotes these practices, offering training and resources to construction firms on how to implement Lean principles effectively . This adoption of Lean Management has led to more sustainable practices, such as reducing material waste and energy consumption, which further enhances the quality of building projects and reduces the risk of collapse .

Ireland’s regulatory framework also supports the integration of BIM and Lean Management. The Irish government has introduced policies requiring BIM adoption in all public sector construction projects, which has further incentivized the private sector to follow suit . The

combination of government regulations and the private sector's willingness to adopt advanced PM techniques has made Ireland a leader in construction safety and quality assurance, preventing building collapses through proactive PM.

4.8.2.17 Poland: Building Safety and Regulatory Frameworks

In Poland, public sector PM has played a crucial role in enhancing construction safety, particularly through the development of robust regulatory frameworks. The Polish government, in collaboration with the European Union, has implemented stringent building codes and safety regulations to ensure that construction projects meet international standards. These regulations mandate that all public and private construction projects undergo rigorous inspection and adhere to quality assurance protocols throughout their lifecycle . This focus on regulatory compliance, supported by public sector project managers, ensures that construction practices in Poland mitigate risks related to structural failures and building collapses.

Poland's public sector project managers are also responsible for overseeing large infrastructure projects, such as bridges, roads, and public buildings, ensuring that quality control measures are implemented from the design phase to the final construction. The integration of risk management practices into these projects is another key PM technique used in the country. Risk assessments are conducted at each stage of construction to identify potential hazards, and contingency plans are developed to address them . This proactive approach has significantly reduced the likelihood of building collapses in major public sector projects, setting a benchmark for the private sector to follow.

Moreover, Poland's use of PM tools like Earned Value Management (EVM) and the Critical Path Method (CPM) has enhanced the efficiency of construction projects by ensuring that resources are utilized optimally . These tools allow project managers to track project progress, control costs, and predict potential delays, thereby ensuring that construction projects are completed within the allocated time and budget while maintaining high safety standards. As a result, Poland has established itself as a leader in construction safety, with public sector PM practices playing a pivotal role in preventing building collapses.

4.8.2.18 Czech Republic: Quality Engineering in Post-Socialist Urban Development

The Czech Republic has undergone significant urban development since the post-socialist era, with quality engineering practices playing a central role in ensuring the structural integrity of buildings. One of the key PM techniques employed in the Czech construction industry is the integration of Total Quality Management (TQM) into project workflows. TQM focuses on continuous improvement in all aspects of construction, from design to completion, ensuring that every phase meets strict quality standards . This has been particularly important in the context of urban redevelopment projects, where aging infrastructure from the socialist era often poses significant risks of collapse.

Project managers in the Czech Republic emphasize the importance of quality assurance protocols, such as regular site inspections and the use of advanced construction materials. The introduction of these measures has been crucial in retrofitting old buildings to meet modern safety standards. For instance, the use of seismic reinforcement techniques in regions prone to earthquakes has been a major factor in preventing building collapse . Additionally, Czech project managers leverage digital tools such as BIM to enhance the precision of construction designs and ensure that potential structural weaknesses are identified and addressed before construction begins.

Furthermore, the Czech Republic has made significant strides in adopting European Union construction standards, which has elevated the quality of construction projects across the country. Project managers are required to ensure that all building projects comply with these standards, which include specific guidelines on structural integrity, fire safety, and earthquake resistance . By integrating quality engineering practices with stringent regulatory oversight, the Czech Republic has successfully modernized its urban infrastructure, reducing the risk of building collapses in both new constructions and retrofitted structures.

4.8.2.19 Hungary: Resource Optimization in Modernizing Infrastructure

Hungary’s construction industry has seen significant modernization efforts, particularly in optimizing resources to enhance project efficiency and safety. One of the key PM techniques employed in Hungary is the use of Lean Construction principles, which focus on reducing waste and maximizing value in construction projects. Hungarian project managers utilize Lean techniques to ensure that resources such as labor, materials, and time are utilized efficiently, reducing the likelihood of delays or cost overruns, which can compromise building safety . This approach has been particularly effective in large-scale infrastructure

projects, where resource optimization is crucial for maintaining the structural integrity of buildings.

In addition to Lean principles, Hungary has also adopted advanced PM software to track resource allocation and project timelines. Tools such as Primavera and Microsoft Project allow project managers to monitor the progress of construction projects in real-time, ensuring that resources are allocated effectively and potential bottlenecks are addressed promptly . This proactive approach to resource management has helped Hungarian construction firms avoid common pitfalls suc h as material shortages or labor inefficiencies, which can lead to substandard construction and increase the risk of building collapse.

Moreover, Hungary's focus on resource optimization extends to the selection of construction materials. Project managers work closely with engineers to ensure that high-quality, durable materials are used in construction projects, particularly in high-risk areas such as flood zones or earthquake-prone regions . By combining advanced PM techniques with a focus on quality materials and resource efficiency, Hungary has successfully modernized its infrastructure, reducing the incidence of building collapses and improving overall construction safety.

4.8.2.20 Croatia: Local PM Practices in Public and Private Construction

Croatia has developed a strong PM culture in both public and private sector construction projects, focusing on collaboration between stakeholders to ensure building safety. One of the key PM techniques used in Croatia is the implementation of collaborative PM approaches, where public authorities, private contractors, and regulatory bodies work together to oversee construction projects from inception to completion . This collaboration ensures that quality control measures are consistently applied throughout the project lifecycle, reducing the likelihood of building collapse due to poor workmanship or inadequate materials.

In the private sector, Croatian construction firms have increasingly adopted international PM standards, such as ISO 9001, to improve their quality management systems. These standards provide a framework for ensuring that construction projects meet high safety and quality requirements, with a particular focus on risk management and continuous improvement . Croatian project managers also use advanced PM tools like Gantt charts and CPM to track project progress and ensure that timelines are adhered to, which helps prevent delays that could compromise building safety .

In the public sector, Croatia has implemented stringent building regulations that require all construction projects to undergo thorough inspection and certification processes before approval. These regulations, coupled with the use of PM techniques such as Earned Value Management (EVM) and resource planning, ensure that public infrastructure projects are completed on time and within budget while maintaining high safety standards. The successful integration of these PM practices in both the public and private sectors has made Croatia a model for construction safety in the region, significantly reducing the incidence of building collapses.

4.8.3 PM Techniques in Asia: Quality Assurance Practices and Case Studies

4.8.3.1 Japan: PM in Earthquake-Resistant Building Practices

Japan is a leader in earthquake-resistant construction, largely due to its advanced PM (PM) practices that prioritize risk mitigation. The country has developed comprehensive building codes like the Building Standard Law of Japan (BSLJ), which mandates earthquake-resistant designs for all structures. Project managers in Japan implement seismic isolation technologies such as base isolation and damping systems to reduce the impact of earthquakes on buildings. PM tools like Building Information Modelling (BIM) are extensively used to simulate structural responses to earthquakes, ensuring that construction projects adhere to high safety standards. These practices, combined with rigorous quality control, have minimized building collapse in earthquake-prone regions.

Incorporating PM practices has also allowed Japan to optimize resources effectively. For example, during the reconstruction efforts after the 2011 Great East Japan Earthquake, project managers implemented Lean Construction techniques to reduce material waste and improve workflow efficiency. Resource management is also enhanced through advanced scheduling tools like Critical Path Method (CPM), ensuring that projects are completed on time while maintaining high-quality standards. By prioritizing both safety and resource efficiency, Japan sets a global benchmark in construction PM for disaster resilience.

Another key aspect of Japan's success is the collaboration between government agencies, private construction firms, and academic institutions. This multi-stakeholder approach fosters continuous innovation in construction practices. For instance, researchers regularly collaborate with PM professionals to test and develop new seismic technologies. Government

regulations further mandate rigorous PM oversight throughout the construction lifecycle, from planning to post-construction quality assurance checks. These coordinated efforts have created a robust system that mitigates building collapse risks in one of the most seismically active regions of the world.

4.8.3.2 China: Large-Scale Infrastructure Projects and Quality Assurance

China's rapid urbanization has driven the need for robust PM in construction, particularly in large-scale infrastructure projects. The country has leveraged PM methodologies like Agile Construction and BIM to enhance quality assurance and minimize building collapse risks. One of China's key PM innovations is its use of prefabricated construction techniques, which significantly improve both quality and speed in the construction process. Through quality assurance protocols integrated into every stage of construction, China has reduced the occurrence of structural failures, even in its most ambitious projects like the Three Gorges Dam and urban megaprojects.

In terms of resource optimization, China has embraced the use of automated systems in construction projects, particularly in material management and labor allocation. These systems allow project managers to track resource utilization in real-time, ensuring that materials are used efficiently and labor is deployed where most needed. China's project managers frequently utilize Earned Value Management (EVM) to control project costs and ensure that projects are completed within budgetary constraints. These resource management techniques are critical in a country where construction operates on a massive scale, and delays or resource waste could lead to significant economic losses.

Moreover, the Chinese government plays a vital role in the enforcement of quality assurance in construction projects. Strict regulations and regular inspections ensure that project managers adhere to high safety and quality standards. The Ministry of Housing and Urban-Rural Development (MOHURD) mandates the use of advanced PM practices in all major public and private construction projects, particularly in the fast-growing urban regions. These regulations, combined with China's adoption of global construction standards like ISO 9001, have contributed to a decline in building collapses and structural failures across the country.

4.8.3.3 India: Improving Construction Safety through PM Software and Standards

India’s construction industry has faced challenges related to building safety, largely due to inadequate quality control and resource mismanagement. However, in recent years, there has been significant progress with the adoption of PM (PM) software and international standards such as ISO 9001 and ISO 45001. PM software tools like Primavera and MS Project are increasingly used to streamline construction timelines, manage resources, and ensure compliance with safety protocols. These tools enable project managers to monitor construction phases in real time, reducing the likelihood of structural failures caused by oversight or poor-quality materials.

In addition to software adoption, India has made strides in quality assurance through the enforcement of standards set by the Bureau of Indian Standards (BIS). This regulatory body ensures that construction projects meet safety and quality criteria, particularly in urban areas prone to building collapses. Moreover, project managers are now integrating Lean Construction methodologies to minimize waste and optimize the use of resources. This approach has proven effective in enhancing the efficiency of construction projects while maintaining high standards of safety and quality.

One of India’s major challenges remains the lack of skilled labor, which impacts project quality and safety. To mitigate this, project managers are increasingly focusing on capacity-building initiatives, such as on-site training programs that emphasize safety standards and construction best practices. Additionally, collaborations between government bodies, construction firms, and international organizations have introduced more robust PM practices into the industry. These developments are slowly transforming India’s construction landscape, reducing the incidence of building collapse, particularly in urban centers like Mumbai and Delhi.

4.8.3.4 Singapore: Integration of PM for Sustainable Urban Development

Singapore is recognized globally for its advanced urban development and stringent construction safety standards. The country’s success is largely due to its adoption of PM (PM) tools like BIM and Integrated Project Delivery (IPD), which enhance collaboration among all stakeholders in the construction process. Through these tools, project managers can visualize every stage of a building's lifecycle, from design to post-construction maintenance, ensuring that safety and quality are prioritized. This approach has been instrumental in reducing building collapse incidents in Singapore's high-density urban environment.

A key aspect of Singapore's PM strategy is its emphasis on sustainability. The Building and Construction Authority (BCA) mandates that all construction projects adhere to the Green Mark certification, which promotes energy efficiency, water conservation, and sustainable materials. Project managers play a critical role in ensuring that these sustainability goals are met without compromising on structural integrity or quality. This focus on sustainable development has positioned Singapore as a global leader in both resource optimization and environmental responsibility in construction.

Moreover, Singapore has fostered a culture of continuous improvement in its construction industry. Project managers are required to undergo regular training and certification programs to stay updated on the latest PM tools and techniques. The use of PM software for real-time monitoring and quality control is mandatory for large-scale projects, ensuring that construction timelines are adhered to and that safety standards are consistently met. These practices, combined with stringent government regulations, have made Singapore one of the safest places in the world in terms of building collapse prevention.

4.8.3.5 South Korea: PM and Excellence in Resource Utilization

South Korea has emerged as a major player in the global construction industry, particularly due to its focus on resource optimization and excellence in PM (PM). The country employs advanced PM techniques like Lean Construction and the use of BIM to ensure that resources are utilized efficiently and project timelines are met. South Korea's construction industry is known for its high-rise buildings and complex infrastructure projects, which require meticulous planning and resource management to prevent building collapses and structural failures.

One of the key PM strategies in South Korea is the integration of real-time data analytics to track resource utilization. Project managers use sophisticated software to monitor material usage, labor deployment, and project timelines, allowing for immediate adjustments when inefficiencies or risks are identified. This data-driven approach has significantly reduced the incidence of resource wastage and has ensured that construction projects are completed within budget and on schedule. By optimizing resources through PM tools, South Korea has been able to maintain high standards of safety and quality in its construction industry.

Additionally, South Korea places a strong emphasis on quality assurance through rigorous regulatory oversight. The government enforces strict construction standards, and project managers are required to comply with safety protocols at every stage of the project lifecycle. Regular inspections and audits are conducted to ensure that buildings meet structural integrity requirements, particularly in high-risk areas prone to earthquakes and typhoons. These combined efforts in PM and regulatory compliance have positioned South Korea as a leader in building safety and resource optimization.

4.8.3.6 Malaysia: Quality Control in Large Public Projects

Malaysia's construction industry has experienced significant growth over the past decade, particularly in large public infrastructure projects. To ensure the quality and safety of these projects, Malaysia has adopted PM (PM) techniques that emphasize quality control and adherence to international standards. The implementation of ISO 9001 standards in construction projects has been a key factor in reducing building collapses and structural failures. Project managers in Malaysia are tasked with overseeing quality assurance processes at every stage of construction, from design to completion, ensuring that all materials and methods meet the required safety standards.

In addition to ISO standards, Malaysia has adopted BIM technology to enhance the coordination between different stakeholders in large public projects. BIM allows project managers to visualize the entire construction process and identify potential risks before they become critical issues. This proactive approach to risk management has significantly improved the quality and safety of public infrastructure projects in Malaysia. Moreover, BIM integration has facilitated better communication between project teams, ensuring that construction timelines are adhered to and resources are used efficiently.

One of the challenges Malaysia faces is the shortage of skilled labor, which can impact the quality of construction. To address this issue, the government has introduced training programs to improve the skills of workers in the construction industry. Project managers are also playing a key role in ensuring that quality control is maintained by implementing regular inspections and audits throughout the construction process. These combined efforts in quality control and PM techniques have contributed to a reduction in building collapses and have improved the overall safety of Malaysia's construction projects.

4.8.3.7 Indonesia: Project Risk Management in Disaster-Prone Areas

Indonesia, being located in the Pacific Ring of Fire, is highly prone to natural disasters, including earthquakes, tsunamis, and volcanic eruptions, making construction projects in the country particularly vulnerable. The use of PM (PM) techniques has been instrumental in ensuring that infrastructure projects incorporate disaster risk management. A crucial PM tool in use is risk assessment modeling, which evaluates potential hazards and integrates preventive measures early in the construction process. This approach aligns with the principles of quality engineering, focusing on reinforcing structural resilience through the use of advanced materials and designs that can withstand seismic activities. International collaboration and partnerships, such as with Japan, have enhanced Indonesia's capacity to integrate global best practices for disaster risk mitigation.

Furthermore, the application of Building Information Modeling (BIM) and geographic information systems (GIS) in Indonesia's construction projects has improved decision-making and project monitoring in disaster-prone areas. These tools allow for precise topographical mapping and simulation of potential disaster impacts, enabling project managers to better allocate resources and make informed decisions on site selection and structural engineering. This proactive risk management reduces the likelihood of building collapses and ensures that completed projects meet safety standards under high-risk environmental conditions.

Despite these advances, challenges remain in ensuring that all regions in Indonesia, especially remote areas, adopt such PM techniques. The lack of regulatory enforcement and limited access to cutting-edge construction technology in these regions can lead to substandard building practices. Addressing these challenges requires stronger governmental oversight, more widespread adoption of technology-driven PM practices, and further investment in training local contractors on risk management strategies, ensuring uniform safety standards across the country.

4.8.3.8 Thailand: Regulatory Compliance and Use of PM in the Private Sector

Thailand has made significant strides in improving construction quality through the implementation of strict regulatory frameworks and the use of PM techniques in both public and private sector projects. The Construction Management Act, which was updated in the 2000s, established comprehensive building codes and safety regulations aimed at preventing

building collapses and improving construction standards. Compliance with these regulations is strictly enforced, especially in urban areas like Bangkok, where high-rise buildings dominate the skyline. These regulations, combined with PM techniques such as quality assurance and performance monitoring, have contributed to the steady improvement in construction safety.

Private sector construction companies in Thailand have been key drivers in adopting advanced PM practices. Many of these companies utilize Lean PM methodologies to reduce waste and optimize the use of resources, leading to more efficient construction processes. Lean techniques, which focus on eliminating inefficiencies in the supply chain and construction phases, have been pivotal in delivering high-quality buildings within budget constraints. These techniques are complemented by the use of project scheduling tools like the Critical Path Method (CPM), which ensures timely project delivery while maintaining quality and safety standards.

However, despite the success in urban areas, rural construction projects often lag behind in terms of regulatory compliance and the adoption of PM tools. Many construction companies in Thailand's rural regions struggle to meet national standards due to limited financial resources and technical expertise. To mitigate these disparities, the Thai government has introduced various capacity-building initiatives, including training programs for local contractors and increased government funding for rural construction projects. These initiatives aim to bridge the gap between rural and urban construction standards and ensure that all areas of the country benefit from robust PM practices and regulatory compliance.

4.8.3.9 Vietnam: Implementation of International Standards for Building Safety

Vietnam has experienced rapid urbanization in recent decades, leading to a construction boom, especially in cities like Ho Chi Minh and Hanoi. With this growth has come increased scrutiny of building safety and quality, prompting the adoption of international standards, such as ISO 9001, to guide construction practices. The integration of these standards into the PM framework has been pivotal in improving construction outcomes and reducing instances of building collapse. ISO 9001, in particular, has been instrumental in setting benchmarks for quality management and ensuring that project deliverables meet both safety and functional requirements.

The Vietnamese government has actively promoted the adoption of global standards and PM techniques across both public and private construction projects. This has led to improvements in how projects are planned, executed, and monitored. For instance, Quality Assurance (QA) processes have been standardized, requiring contractors to implement regular site inspections and independent audits. These QA processes, when combined with risk management techniques, have ensured that structural integrity is maintained throughout the project lifecycle. The emphasis on accountability and third-party assessments has reduced opportunities for cutting corners or using substandard materials, which have historically contributed to building collapses.

However, there are still challenges, particularly in smaller cities and rural areas where international standards are not uniformly enforced. In these regions, smaller construction firms may lack the resources or technical expertise to fully implement sophisticated PM and QA systems. Addressing these disparities requires targeted government interventions, such as subsidized training programs and incentives for small and medium-sized enterprises (SMEs) to adopt international standards. Such measures would not only enhance the safety of construction projects nationwide but also ensure that Vietnam’s construction industry remains competitive on a global scale.

4.8.3.10 Philippines: Addressing Quality Challenges in Low-Income Housing through PM

The Philippines faces unique challenges in its construction sector, particularly in the area of low-income housing. The rapid population growth and urbanization, combined with the frequency of natural disasters such as typhoons and earthquakes, have created an urgent need for affordable, yet resilient housing solutions. PM techniques have been essential in addressing these challenges by streamlining the construction process, ensuring quality control, and improving resource allocation. The adoption of PM frameworks like Agile and Lean Construction has allowed for greater flexibility in responding to resource constraints while maintaining quality standards.

One notable PM initiative in the Philippines has been the government's partnership with international organizations to develop housing projects that incorporate both affordability and resilience. The use of pre-fabricated building materials, for example, has become a popular PM-driven solution, as it allows for quicker construction times and reduces costs while ensuring that the structures meet safety standards. Additionally, BIM has been utilized to

model potential disaster impacts, ensuring that housing projects are designed to withstand the frequent typhoons and seismic activity in the region. These PM techniques have proven critical in the Philippines, where resource constraints often limit the ability of builders to adopt traditional construction methods.

Despite these advancements, low-income housing projects in the Philippines still face significant challenges related to quality assurance and sustainability. Corruption and weak regulatory oversight have been cited as barriers to ensuring that PM principles are applied consistently across all projects. For example, contractors sometimes use substandard materials to cut costs, which can compromise the integrity of the structures. To address these issues, there is a need for stronger enforcement of construction regulations, coupled with greater transparency in PM and execution. By strengthening these areas, the Philippines can better ensure that its low-income housing projects meet both the immediate needs of its growing population and the long-term goal of building resilient communities.

4.8.4 PM Techniques in the Americas: Quality Assurance Practices and Case Studies

4.8.4.1 United States: Regulatory and PM Practices in Infrastructure Projects

The United States has long been a global leader in the implementation of advanced PM (PM) techniques, particularly in the construction and infrastructure sectors. One of the primary strengths of the U.S. construction industry is its robust regulatory framework that emphasizes safety, quality, and environmental sustainability. The American Society of Civil Engineers (ASCE) and the Occupational Safety and Health Administration (OSHA) set standards to guide PM activities in large infrastructure projects. These regulations help mitigate risks associated with building collapse by enforcing strict compliance with safety protocols during both the design and execution phases of construction projects. As a result, the use of quality management systems such as ISO 9001 and the integration of Building Information Modeling (BIM) have become standard practice across many U.S. states, helping prevent structural failures.

In addition to regulatory frameworks, the U.S. employs sophisticated PM methodologies, including the Critical Path Method (CPM), Earned Value Management (EVM), and Lean Construction, which focus on optimizing resource utilization and maintaining control over project timelines. CPM allows project managers to prioritize critical tasks, ensuring that

project delays are minimized, while EVM integrates financial management with PM to track project performance against planned costs and timelines. These techniques have been instrumental in ensuring that construction projects meet both time and quality benchmarks, ultimately reducing the likelihood of failures that could lead to collapses. Successful infrastructure projects like the Golden Gate Bridge retrofit and post-9/11 reconstruction of the World Trade Center illustrate the effectiveness of these PM tools.

Case studies from high-risk regions such as California, which is prone to earthquakes, highlight how advanced PM techniques are integrated into large-scale projects. The application of seismic building codes, enforced by the California Department of Building and Safety, demonstrates how risk management and advanced engineering principles are employed to safeguard against potential disasters. By embedding these PM techniques into all stages of construction, the U.S. has created a culture of safety and resilience that significantly reduces the risk of building collapse.

4.8.4.2 Canada: Excellence in Resource Utilization in Urban Construction

Canada’s construction industry is well-known for its emphasis on sustainable practices and efficient resource utilization. The country has prioritized quality control and assurance processes across its urban construction projects, utilizing PM methodologies that emphasize environmental stewardship and long-term durability. Canada's approach to construction is heavily influenced by its stringent building codes, enforced by regional and municipal governments. These codes are regularly updated to reflect advances in technology and materials science, particularly with regard to sustainable construction practices that minimize waste and optimize the use of raw materials, labor, and time.

Canada’s success in applying PM tools like Lean Construction and Just-in-Time (JIT) management has significantly improved its ability to manage resources effectively. Lean Construction, which focuses on reducing waste and improving efficiency throughout the construction process, has become a staple in Canadian urban projects. This technique is particularly useful in ensuring that building materials are delivered and used in a timely manner, reducing the risk of material degradation or resource scarcity that could lead to compromised structural integrity. Case studies from cities like Toronto and Vancouver, where skyscrapers and other high-rise buildings are increasingly common, demonstrate the importance of resource optimization in preventing building collapses. Projects like the CN

Tower and other high-profile constructions have successfully incorporated these PM techniques to ensure long-term durability and safety.

Furthermore, Canada's construction industry places significant emphasis on collaborative PM, where stakeholders—including architects, engineers, contractors, and government bodies—work closely together to ensure that all aspects of the project meet high safety and quality standards. Collaborative PM techniques like Integrated Project Delivery (IPD) allow for early involvement of all stakeholders, which helps identify potential risks early in the project lifecycle. This proactive approach has played a crucial role in preventing building collapse in Canadian urban projects, where complex engineering challenges often require innovative solutions and meticulous planning.

4.8.4.3 Brazil: Managing Large-Scale Public Projects with PM Tools

Brazil presents a unique case in the application of PM techniques to large-scale public infrastructure projects. As the largest economy in South America, Brazil has undertaken numerous construction projects of significant scale, such as stadiums for the FIFA World Cup and Olympic Games, as well as large urban infrastructure developments. However, these projects have often faced challenges related to corruption, poor planning, and cost overruns, which have, at times, contributed to structural failures. To combat these issues, Brazil has increasingly turned to PM techniques, particularly the integration of risk management and advanced PM software, to enhance oversight and transparency in public projects.

One of the most significant tools used in Brazil's construction sector is the Program Evaluation and Review Technique (PERT), which allows project managers to analyze the time required to complete each component of a project and to identify critical tasks that could potentially delay completion. This approach is particularly important in large-scale projects, where delays and cost overruns can have serious implications for the overall integrity of the project. In the case of the Maracanã Stadium renovation, for instance, PERT and other PM methodologies helped project managers navigate complex logistical challenges, ensuring that the project was completed on time and within the necessary safety standards.

Additionally, the Brazilian construction industry has begun to adopt international standards such as ISO 21500 (Guidance on PM) to streamline project execution and ensure quality control. ISO standards provide a framework for managing risks, resources, and stakeholder

engagement, which are crucial in the successful delivery of large public projects. In recent years, there has been a concerted effort to train project managers in these international best practices, as demonstrated by the implementation of PM programs in cities like São Paulo and Rio de Janeiro. These initiatives have had a noticeable impact on the quality of public infrastructure, reducing the likelihood of building collapses in high-profile projects.

4.8.4.4 Argentina: Project Supervision in Public Housing Projects

Argentina's construction sector has faced its share of challenges, particularly in the delivery of public housing projects. Historically, public housing developments in Argentina have been plagued by delays, cost overruns, and poor-quality materials, all of which have contributed to instances of building collapse and structural failures. To address these issues, the Argentine government has adopted more rigorous PM practices, with a focus on improving project supervision and accountability in public sector construction projects.

The introduction of the PM Institute's (PMI) best practices in Argentina has been a game-changer for the construction industry, particularly in public housing projects. PMI's PMBOK (PM Body of Knowledge) guidelines emphasize five key process groups: initiating, planning, executing, monitoring, and closing. By adhering to these guidelines, Argentina has improved its ability to manage project timelines, control costs, and ensure that the quality of construction materials meets the required standards. This is particularly important in public housing projects, where the use of substandard materials has historically led to structural weaknesses and, in some cases, building collapses.

Additionally, Argentina has placed a strong emphasis on improving project supervision through the establishment of independent oversight bodies responsible for conducting regular inspections of construction sites. These oversight bodies ensure that contractors adhere to safety regulations and that the materials used in construction meet the necessary quality standards. Case studies from Buenos Aires highlight the effectiveness of these PM strategies in reducing building collapse incidents. The city's Villa 31 public housing development, for instance, benefited from rigorous project supervision, ensuring that the housing units were delivered on time, within budget, and up to code.

4.8.4.5 Chile: Risk Management and Quality Assurance in Earthquake Zones

Chile's geographical location along the Pacific Ring of Fire makes it one of the most seismically active countries in the world. As a result, the country has developed a robust set of PM techniques specifically geared toward managing the risks associated with earthquakes and other natural disasters. Chile's construction industry is a global leader in implementing seismic risk management, with a strong emphasis on quality assurance and the use of advanced engineering technologies to ensure the structural integrity of buildings in earthquake-prone areas.

One of the key components of Chile's PM strategy is the integration of seismic risk assessment into the early stages of project planning. The use of PM software tools like Primavera P6 and BIM allows project managers to model potential earthquake scenarios and assess the impact on building structures. This proactive approach to risk management ensures that construction projects in Chile are designed and built to withstand seismic activity. For example, the country's national building code requires that all new construction projects meet stringent seismic safety standards, which are enforced through rigorous quality assurance processes at every stage of the project lifecycle.

Chile's success in mitigating the risk of building collapse in earthquake zones can be attributed to its commitment to continuous improvement in PM practices. The country regularly updates its building codes and PM methodologies in response to new scientific research on earthquake resilience. Notably, the rebuilding efforts following the 2010 earthquake, which devastated much of the central region of Chile, serve as a case study in effective risk management and quality assurance. The reconstruction of cities like Concepción and Talcahuano involved the use of advanced PM techniques, ensuring that the new buildings were not only structurally sound but also more resilient to future seismic events.

4.8.4.6 Colombia: Public-Private Partnerships and PM in Infrastructure Development

Colombia has increasingly turned to public-private partnerships (PPPs) as a key strategy for developing its infrastructure, particularly in urban areas. This approach has allowed the government to leverage private sector expertise and capital while sharing the risks associated with large-scale projects. The Colombian government has implemented the National Infrastructure Agency (ANI), which oversees PPPs and ensures compliance with rigorous PM standards. By adopting a structured PM framework, Colombia has improved transparency

and accountability in infrastructure projects, ultimately reducing the potential for failure or collapse (Sánchez et al., 2019).

One notable example is the Autopista al Mar 1 project, which aimed to enhance connectivity between Medellín and the Caribbean coast. The project was managed through a PPP framework, enabling a collaborative approach between the government and private sector. The successful execution of this project can be attributed to effective risk management strategies and the implementation of quality assurance protocols throughout the project lifecycle. As a result, the Autopista al Mar 1 has significantly improved transportation efficiency and economic activity in the region, demonstrating how PM techniques can contribute to sustainable infrastructure development (González et al., 2020).

Despite the successes, challenges remain in Colombia's infrastructure development, particularly regarding regulatory complexities and political instability. Effective PM practices, including stakeholder engagement and continuous risk assessment, are crucial to navigating these challenges. Enhancing collaboration between public and private entities will also be essential for ensuring that infrastructure projects meet quality standards and deliver long-term benefits to communities (Figueroa et al., 2021).

4.8.4.7 Mexico: Project Risk Management in Urban Construction

In Mexico, urban construction projects have historically faced significant risks, including regulatory non-compliance, poor quality materials, and inadequate project oversight. The implementation of structured project risk management frameworks has become essential to address these challenges and mitigate the incidence of building collapse. The Mexican government, alongside industry stakeholders, has developed guidelines that emphasize the importance of risk assessment and management throughout the construction process, aligning with international best practices (Aguirre et al., 2020).

One prominent initiative is the "National Program for the Certification of Construction Companies," which aims to enhance the capabilities of construction firms in managing risks effectively. This program encourages companies to adopt PM methodologies such as the PM Institute’s PMBOK Guide, which outlines standardized practices for risk management, quality assurance, and stakeholder engagement. By fostering a culture of continuous improvement and accountability, Mexican construction companies have begun to see a

reduction in structural failures and improved compliance with safety regulations (Salinas et al., 2019).

However, the effectiveness of risk management practices in Mexico is still hindered by issues such as corruption and a lack of regulatory enforcement. For project risk management to succeed, it is imperative that all stakeholders, including government agencies, construction firms, and civil society, collaborate to promote transparency and integrity in project execution. Strengthening institutional frameworks and enhancing the technical capacity of local contractors will be critical for ensuring the long-term sustainability of Mexico's urban construction projects (González et al., 2021).

4.8.4.8 Peru: Enhancing Resource Utilization through Lean Construction

In Peru, the construction industry has embraced Lean Construction principles as a means of enhancing resource utilization and minimizing waste in project delivery. Lean Construction focuses on maximizing value for clients while minimizing resource consumption, which is particularly relevant in a country facing significant challenges related to building quality and safety. By implementing Lean methodologies, Peruvian construction firms aim to streamline processes and eliminate inefficiencies, thus reducing the likelihood of construction failures (Carvajal et al., 2019).

A notable case is the construction of the Línea 1 Metro de Lima project, which utilized Lean Construction practices to optimize workflows and improve collaboration among project teams. Through the application of Lean tools such as Value Stream Mapping and Just-In-Time delivery, the project was able to achieve significant time and cost savings while maintaining high-quality standards. This approach not only resulted in a successful project outcome but also served as a model for future infrastructure initiatives in Peru, illustrating the benefits of integrating Lean principles into PM practices (Rojas et al., 2020).

Despite the positive outcomes, the adoption of Lean Construction practices in Peru is not without challenges. The construction sector must overcome cultural resistance to change and invest in training to equip professionals with the necessary skills to implement Lean methodologies effectively. Ongoing collaboration among industry stakeholders, government agencies, and educational institutions will be essential to fostering a Lean mindset and

ensuring the long-term sustainability of resource optimization efforts in Peruvian construction (Castillo et al., 2021).

4.8.4.9 Uruguay: Role of PM in Government-Led Construction Projects

Uruguay has demonstrated a strong commitment to effective PM in its government-led construction projects, particularly in the areas of social housing and urban infrastructure development. The government has adopted comprehensive PM frameworks that emphasize transparency, accountability, and stakeholder engagement. By aligning project objectives with community needs, Uruguay has been able to deliver successful construction outcomes while minimizing the risk of failures (Pérez et al., 2019).

An exemplary project is the "Programa de Vivienda Digna," which focuses on providing quality housing for low-income families. The program employs rigorous PM practices, including regular monitoring and evaluation, to ensure that construction meets established quality standards. By engaging local communities in the planning and execution phases, the project has fostered a sense of ownership among beneficiaries and improved the overall effectiveness of the housing initiative (Martínez et al., 2020).

While Uruguay’s approach to PM in construction has yielded positive results, ongoing challenges such as resource constraints and fluctuating political support pose risks to the sustainability of these efforts. Continued investment in PM training and capacity-building initiatives will be essential for enhancing the skills of professionals in the construction sector. Additionally, strengthening public-private collaboration can further enhance the effectiveness of government-led projects, ultimately leading to improved construction quality and reduced instances of building collapse (Aguirre et al., 2021).

4.8.4.10 Ecuador: Sustainable Building Practices through PM Approaches

Ecuador has increasingly recognized the importance of sustainable building practices in mitigating the risks associated with construction failures. The integration of PM approaches that emphasize sustainability is vital for ensuring that construction projects contribute positively to both the environment and the community. Ecuador's government has implemented regulations and guidelines that promote sustainable construction practices,

aligning with global initiatives to address climate change and resource depletion (González et al., 2020).

One significant initiative is the "Plan Nacional de Desarrollo Urbano," which outlines strategies for sustainable urban development, including the promotion of green building techniques and energy-efficient materials. Through effective PM, these strategies have been integrated into public infrastructure projects, resulting in enhanced quality and safety outcomes. The incorporation of sustainability principles into PM practices has not only improved the resilience of structures but has also fostered community engagement and support for construction initiatives (Rivadeneira et al., 2021).

Despite these advancements, challenges remain in the widespread adoption of sustainable building practices in Ecuador. Issues such as inadequate funding, lack of technical expertise, and resistance to change among construction professionals hinder progress. For Ecuador to realize its vision of sustainable construction, a concerted effort is needed to promote education and training in sustainable PM. Collaboration between government agencies, private sector actors, and civil society will be critical for fostering an environment that supports sustainable building practices and reduces the incidence of building collapse (Bermúdez et al., 2021).

4.9 Comparative Analysis: Nigeria's Position and Global Best Practices

4.9.1 Identifying Gaps Between Nigeria and Other Countries in PM Implementation

Nigeria faces significant challenges in the realm of PM (PM), particularly concerning the construction industry and building safety. A critical gap is the lack of standardized PM practices and regulatory oversight compared to countries like South Africa and Kenya, where government initiatives have successfully improved building safety standards. In Nigeria, the construction sector often operates without stringent adherence to international PM frameworks, leading to inconsistent quality control, insufficient risk management practices, and a general culture of impunity. This deficiency is exacerbated by a lack of skilled PM professionals who can effectively implement and monitor projects, contributing to a high incidence of building failures.

Moreover, in contrast to countries like Singapore and Japan, where technological advancements such as Building Information Modelling (BIM) and automated PM tools have

transformed the construction landscape, Nigeria remains largely reliant on traditional methods. The slow adoption of technology hampers project efficiency, quality assurance, and real-time monitoring, which are vital for preventing construction-related disasters. In nations where PM is closely integrated with regulatory frameworks, such as in Germany, the proactive identification of potential risks significantly reduces the likelihood of building collapses. Thus, Nigeria's reliance on outdated methodologies and lack of integration with modern PM tools underscores the urgent need for reform.

Furthermore, the disparity in educational standards and professional training in PM further widens the gap. Bridging these gaps through targeted reforms in education and regulatory frameworks is essential for Nigeria to align with global best practices.While countries in Europe and North America emphasize continuous professional development and certification in PM practices, Nigeria's educational institutions often lag in providing comprehensive training programs tailored to the construction sector's unique challenges.

4.9.2 Best Practices That Can Be Adopted in Nigeria

To address the challenges identified in Nigeria's construction sector, several best practices from around the world can be adopted to enhance PM effectiveness. One of the primary practices is the implementation of internationally recognized standards, such as ISO 9001 for Quality Management Systems. Countries like South Africa and Egypt have successfully integrated these standards into their construction industries, leading to improved project outcomes and increased stakeholder confidence. By adopting similar standards, Nigeria can foster a culture of quality assurance and continuous improvement, ultimately reducing the incidence of building collapse.

Another valuable practice is the incorporation of advanced technologies such as Building Information Modelling (BIM) and Geographic Information Systems (GIS) in project planning and execution. For example, Singapore's construction industry has leveraged BIM to enhance collaboration among stakeholders, streamline project workflows, and ensure accurate assessments of building safety. By investing in technology and training for construction professionals, Nigeria can facilitate better decision-making, risk assessment, and resource allocation, thereby mitigating the risks associated with construction failures.

Establishing public-private partnerships (PPPs) to fund and oversee construction projects can provide Nigeria with a framework for improved accountability and resource management.

Countries like Canada have successfully utilized PPPs to enhance infrastructure development while ensuring adherence to quality standards. By involving private sector expertise and resources in public projects, Nigeria can ensure that construction practices meet international quality and safety standards. This collaborative approach can lead to increased efficiency, reduced costs, and ultimately a decrease in the frequency of building collapses.

Moreover, the collaborative approaches seen in countries like Norway and Finland highlight the significance of stakeholder engagement in PM. These nations foster strong partnerships between government, private sector, and local communities, ensuring that construction projects are aligned with the needs and expectations of all stakeholders. Lastly, the necessity of continuous professional development and capacity building cannot be overstated. Countries like Germany and Canada invest heavily in training programs for project managers, engineers, and construction workers to keep pace with evolving industry standards and technologies. Establishing partnerships with international organizations to facilitate knowledge transfer and capacity-building initiatives can further enhance the skills of Nigerian professionals, ensuring they are equipped to tackle the challenges of modern construction effectively.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

It realised that weak regulations, lack of punitive compliance enforcement and poor quality culture within the Nigerian construction industry culture are the macro-causal factors while individual construction/building engineering firms are advised to glean from success stories and reliant structural integrity experiences from other countries where robust PM frameworks provide invaluable lessons for Nigeria. For instance, the integration of comprehensive risk management strategies in countries like the United Kingdom has proven essential in preventing construction-related failures. Further, it appreciates the strong partnerships between government, private sector, and local communities, which have been pivotal in improving transparency, accountability, and project outcomes as well as construction projects aligned with the needs and expectations of all stakeholders. Nigeria can leverage local knowledge and resources to enhance the safety and quality of its construction projects.

Finally, it concludes that stricter implementation of ISO 9001 and ISO 45001 management systems as a mandatory regulatory requirement especially these project management protocols emphasis on continuous professional development and capacity building cannot be overstated. By prioritizing education and training in PM practices, Nigeria can develop a skilled workforce capable of driving change in the construction sector.

5.2 Recommendations for Nigeria: PM Solutions to Mitigate Building Collapse

5.2.1 Enhancing PM Training in the Nigerian Construction Industry

To effectively combat the menace of building collapse in Nigeria, enhancing PM (PM) training within the construction industry is crucial. Many construction professionals lack formal training in modern PM techniques, which leads to inefficiencies and increased risks in project execution (Oladapo, 2020). Training programs should emphasize critical areas such as risk management, quality assurance, and resource optimization, equipping practitioners with the skills necessary to implement best practices. Engaging local universities and technical

institutions in developing specialized PM curricula can provide a robust framework for training future project managers (Ejeh et al., 2021).

Furthermore, continuous professional development through workshops, seminars, and certification programs should be encouraged for existing professionals. Institutions like the PM Institute (PMI) can collaborate with Nigerian educational bodies to offer internationally recognized certifications. This initiative will not only enhance the competency of project managers but will also foster a culture of quality and accountability within the construction sector, aligning local practices with global standards (Olufemi, 2022). With a well-trained workforce, the construction industry can adopt advanced PM methodologies that significantly reduce the incidence of building failures.

Lastly, it is essential for the Nigerian government to promote and fund PM education as part of broader infrastructure development initiatives. By investing in training programs, the government can ensure that project managers are well-equipped to handle the complexities of modern construction projects, including adherence to safety standards and quality regulations. This investment will contribute to a sustainable construction environment, ultimately leading to enhanced public trust in the sector and reduced economic losses due to building collapses (Bafeng et al., 2022). It concludes that the lack of a structured PM education system inhibits the emergence of qualified professionals capable of driving change and fostering a culture of safety and quality in construction practices.

5.2.2 Recommendations for Regulatory Bodies and Construction Firms

Regulatory bodies play a pivotal role in ensuring adherence to building codes and standards in Nigeria. To enhance their effectiveness, these agencies must implement stricter enforcement mechanisms and regular inspections throughout the construction process (Akintola & Oyewole, 2023). Current regulatory frameworks often suffer from inefficiencies due to corruption and lack of resources, undermining the effectiveness of existing laws. Streamlining processes, increasing transparency, and enhancing communication between regulatory bodies and construction firms can foster a more accountable environment. Implementing a comprehensive database for construction projects that includes information on materials, contractors, and compliance history could also aid regulators in monitoring projects more effectively (Oluwatobi et al., 2023).

Construction firms must prioritize the integration of PM practices to ensure that projects are completed on time, within budget, and to the required quality standards. Embracing methodologies such as Lean Construction and Agile PM can help firms optimize resources and enhance project efficiency (Jiang & Zhao, 2021). Additionally, adopting Building Information Modelling (BIM) can improve project visualization and facilitate better communication among stakeholders, reducing misunderstandings and errors during construction (Akinwumi et al., 2022). By investing in technology and innovative PM practices, construction firms can significantly mitigate risks associated with building collapses.

Moreover, fostering a culture of safety and quality within construction firms is essential. This can be achieved by implementing robust quality assurance programs that focus on continuous improvement and compliance with international standards. Engaging employees in training and awareness programs about quality control and safety measures can lead to a more proactive approach to risk management (Ugochukwu, 2022). Construction firms that prioritize quality and safety will not only enhance their reputation but will also contribute to the overall goal of reducing building collapses in Nigeria.

5.2.3 Short-Term and Long-Term Actions for Sustainable PM-Driven Building Practices

Short-term actions to address building collapse in Nigeria should focus on immediate safety audits of existing structures, particularly in urban areas known for frequent collapses. Regulatory bodies should initiate comprehensive assessments of buildings to identify structural deficiencies and non-compliance with safety standards (Aliyu et al., 2021). This proactive approach will provide a clearer understanding of the risks and facilitate targeted interventions to reinforce or rehabilitate at-risk structures. Additionally, establishing emergency response teams trained in disaster management can mitigate the effects of sudden collapses, ensuring swift action in protecting lives and property (Adeleke et al., 2022).

In the long term, Nigeria should aim to develop a national framework for sustainable construction that integrates PM methodologies with environmental and social considerations. This framework should promote the use of sustainable materials and construction practices, reducing the environmental impact of building projects (Nwogbo, 2022). Incorporating green building certifications and incentivizing developers to adopt sustainable practices can lead to

a more resilient construction sector. Furthermore, fostering partnerships between government, private sector stakeholders, and civil society can enhance the effectiveness of this framework, ensuring that all voices are heard in the planning and execution of construction projects.

Finally, fostering a collaborative environment among stakeholders in the construction industry is vital for sustainable PM practices. Regular forums and workshops that bring together government agencies, construction firms, engineers, and the community can facilitate knowledge sharing and innovation in PM techniques (Ibrahim & Nkwor, 2022). Establishing platforms for dialogue will help identify challenges, share success stories, and collectively develop strategies to address the issue of building collapse. By promoting collaboration, Nigeria can create a more resilient construction sector capable of adapting to future challenges.

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Appendix

QUALITATIVE RESEARCH INTERVIEW GUIDE

Dear Participant,

We appreciate your willingness to participate in this qualitative research study focusing on **"Proferring Solutions to Building Collapse in Nigeria using PM Techniques."** Your insights and experiences in the construction industry are invaluable to our research objectives. Your expertise and experiences in the construction industry are crucial to our research. Your candid responses will help us gain a deeper understanding of the challenges faced and potential solutions to address building collapse incidents in Nigeria. Rest assured, all information provided will be kept strictly confidential. Your identity will remain anonymous in any reports or publications arising from this study.

We will now proceed with a series of questions designed to explore your perspectives and insights. Your honest responses will greatly contribute to the success of this research.

Research Questions:

1. What are the primary structural factors that contribute to building collapse in Nigeria?
2. How do regulatory frameworks influence building collapse incidents in Nigeria?
3. What procedural challenges exist in the construction industry that contribute to building collapses?
4. Can you describe the current PM techniques used in Nigeria's construction industry?
5. What are the strengths of the existing PM techniques in addressing factors associated with building collapse?
6. What are the weaknesses or limitations of the current PM techniques in preventing building collapses?
7. How do stakeholders in the construction industry perceive the gaps in addressing factors related to building collapse?
8. In what ways can PM techniques be utilized to mitigate the factors contributing to building collapse in Nigeria?
9. What are the potential challenges or barriers to implementing PM techniques as solutions to building collapse?
10. How feasible and practical are the proposed PM techniques in the context of Nigeria's construction industry?

We sincerely appreciate your time and contribution to this study.