EXPLORING THE CORRELATION BETWEEN MAINTENANCE OF EQUIPMENTS AND SAFETY RISKS ON CONSTRUCTION SITES IN EDO STATE

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UNIVERSITY OF BENIN

DECEMBER, 2025.

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BEING A PROJECT SUBMITTED TO THE DEPARTMENT OF QUANTITY SURVEYING
FACULTY OF ENVIRONMENTAL SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE

DEGREE OF BACHELOR OF SCIENCE (B.Sc.) IN QUANTITY SURVEYING

DECEMBER, 2025.

DECLARATION

I declare that this project is an original work carried out by me, **Favour Oghenemudiakevwe USINO** with Matriculation Number **ENV2002816** in the Department of Quantity Surveying, Faculty of Environmental Sciences, University of Benin, Benin City.

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Favour Oghenemudiakevwe Usino   Date

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CERTIFICATION

We certify that this project with the title **Exploring The Correlation Between Maintenance Of Equipments And Safety Risks On Construction Sites In Edo State** submitted by **Favour Oghenemudiakevwe USINO** is an original work carried out by me, with Matriculation Number **ENV2002816** has satisfied the regulations governing the award of Bachelor's Degree in Quantity Surveying from the University of Benin, Benin City, Edo State.

Supervisor: Mr. M.O. Imafidon Signature:…………………Date:…………

Ag. Head of Department: Dr. T. S. Fawale Signature:…………...……Date:…………

External Examiner: Prof. O. A Awodele Signature:…………..…..……Date

DEDICATION

I dedicate this project work to the God Almighty, the Alpha and Omega, the beginning and the end and the creator of the universe who inspired me and saw me through my academic journey in this Great Citadel of Learning.

ACKNOWLEDGEMENTS

My sincere acknowledgement goes to God Almighty for his support through this phase, spiritually, emotionally and academically.

I acknowledge with gratitude my project supervisor, Mr. M.O. Imafidon, during the course of this research.

I also appreciate all the lecturers in the Department of Quantity Surveying, Prof. C. P Ogbu (Course Adviser), Prof. V. N. Okorie, Mr. G. A. Sanni, Dr. T. S. Fawale (HOD), Mr. E. M. Osazuwa, Mr. M. O. Imafidon, Dr. Kadiri, Dr. Idowu and Bldr. Fidelis Idenumah and other staff for their continued support towards all students.

I also want to appreciate my fellow course mate for their numerous supports in my journey as a student in this Great Institute. I want to express my sincere gratitude to my friends Destiny, Winning, Shalom, Fortune, Michael, Ted for their continuous support and assistance throughout my academic period in this Great Citadel of Learning.

I want to specially appreciate my incredible parents Mr. and Mrs. Edward Usino, for their immeasurable contribution and guidance throughout my academic year. I'm also grateful to my lovely siblings Christiana, Akpevwe, Ochuko and Vwegba. Many people have been instrumental however, my deepest gratitude goes to my amazing uncle and family Mr.. and Mrs. Samuel Ubroda for their care, love and support throughout my academic year, may God in his infinite mercy continue to bless you.

Last but not least, I wanna thank me for believing in me, I wanna thank me for doing all this hard work, I wanna thank me for having no days off, I wanna thank me for never quitting, I wanna thank me for always being a giver and trying to give more than I receive, I wanna thank me for trying to do more right than wrong, I wanna thank me for just being me at all times.

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ABSTRACT

This study investigates the relationship between construction equipment maintenance and safety risks on construction sites in Edo State. The purpose of the study is to determine how different maintenance practices influence the likelihood of equipment-related accidents and identify the key challenges affecting effective maintenance implementation. Using a quantitative research design, data were collected from 102 construction professionals, including site engineers, equipment operators, and safety officers, through structured questionnaires. Descriptive statistics were applied to identify commonly adopted maintenance strategies, while Spearman Rank Correlation was used to assess the strength of the relationship between equipment maintenance and safety risks. The findings reveal that preventive maintenance practices such as scheduled servicing, tire pressure checks, hydraulic inspections, and safety system testing are the most widely implemented and significantly reduce the occurrence of mechanical failures, hydraulic leaks, electrical faults, and unplanned equipment breakdowns. A strong positive correlation was established between poor maintenance and increased safety risks, indicating that inadequate servicing greatly heightens the likelihood of equipment-related accidents on construction sites. The study further identifies major challenges limiting effective maintenance, including insufficient budgets, shortage of skilled technicians, poor record-keeping systems, and pressure to meet project deadlines. The practical implications suggest that improving maintenance culture, providing adequate funding, enhancing technical capacity, and enforcing safety compliance are essential for reducing accidents and improving safety performance in the construction industry. The originality and value of this research lie in its provision of empirical evidence from Edo State, where equipment-related safety challenges are prevalent, thereby contributing to the limited body of local literature on maintenance-driven safety management and offering actionable insights for construction firms, safety regulators, and policymakers committed to enhancing workplace safety standards.

KEYWORDS: Maintenance Practices, Costruction Equipments, Equipment Failures, Safety Risk.

CHAPTER ONE

INTRODUCTION

1.1 Background To The Study

Construction sites are recognized globally as one of the most hazardous work environments due to the complex and dynamic nature of construction activities. Workers operate heavy machinery, work at heights, and handle potentially dangerous materials on a daily basis. Despite significant improvements in safety regulations and technological advancements, the construction industry continues to report high rates of accidents and fatalities. According to the International Labour Organization ILO, (2023), the construction sector accounts for nearly thirty percent (30%) of all occupational fatalities globally. A considerable portion of these incidents can be attributed to poor equipment maintenance practices, which lead to equipment malfunctions, structural failures, and other preventable hazards (U.S. Chemical Safety Board, 2016). This study seeks to examine the relationship between maintenance of construction equipment and safety risks on construction sites, with the goal of determining whether improved maintenance can contribute to a reduction in workplace accidents. Maintenance in the construction industry involves the regular inspection, servicing, and repair of equipment, tools, and site infrastructure to ensure their safe and efficient operation (HSE, 2021; Rausand & Vatn, 2023).

Given that construction projects rely heavily on machinery such as cranes, excavators, and scaffolding, as well as power tools and temporary electrical systems, proper maintenance is essential to prevent accidents. Research has identified three primary maintenance approaches used in the industry: preventive maintenance (scheduled checks and servicing to avoid breakdowns), corrective maintenance (repairs conducted after failures occur), and predictive maintenance (using advanced technology to detect potential failures) (ISO 13374, 2015; Carnero, 2020; Kumar, 2022; Susto et al., 2015). According to Al-Turki, Ayar, and Yilbas (2016), a well-structured preventive maintenance strategy can reduce equipment failure rates by 25–30%, improve system reliability, and reduce long-term costs. The Khan et al., (2024) emphasizes that predictive maintenance, through technologies like IoT (Internet of Things) sensors, has shown particular promise in preventing electrical hazards. However, as observed by Marquez and Gupta (2018), many construction firms continue to rely on reactive maintenance approaches due to limited budgets and the emphasis on immediate project deadlines over long-term asset performance.

The connection between poor maintenance and increased safety risks has been well documented (Ungureanu et al., 2015; Tabor, J. 2021). For instance, investigations by the Occupational Safety and Health Administration (OSHA, 2021) revealed that a significant number of crane related accidents were caused by neglected maintenance, including worn out cables and faulty braking systems. However, Abas et al., (2020) found that scaffolding collapses due to lack of routine inspections and maintenance is one of the leading causes of falls in construction sites. Electrical accidents is another major hazard on construction sites, and has been linked to poorly maintained wiring and power tools, as highlighted in a report by SafeWork Australia (2023). These findings underscore the importance of proper maintenance in preventing accidents and enhancing overall site safety.

Despite the clear benefits of effective maintenance, many construction companies face challenges in implementing consistent maintenance programs. One of the primary obstacles is cost, as some firms prioritize short term savings over long term safety investments, not realizing that accidents often lead to higher expenses due to medical costs, legal liabilities, and project delays. Additionally, a shortage of skilled workers trained in maintenance procedures can result in overlooked hazards, while tight project schedules may lead to rushed or skipped inspections. These challenges highlight the need for greater awareness and enforcement of maintenance best practices within the industry.

When maintenance is properly executed, it leads to measurable improvements in workplace safety. Studies have shown that construction sites with structured maintenance programs experience fewer equipment malfunctions, reduced structural failures, and lower risks of electrical hazards. Zhou et al. (2021) demonstrated that sites with proactive maintenance strategies reported up to 40% fewer accidents compared to those with reactive or inconsistent maintenance approaches. These findings reveal that investing in maintenance will not only protect workers but also enhances productivity and reduces costs associated with accidents and downtime.

Existing research supports the idea that poor maintenance contributes to equipment failures, structural hazards, and electrical accidents, while improved maintenance can lead to safer work environments. This study aims to further explore the relationship by analyzing how different maintenance strategies influence safety risks on construction sites. The findings could provide valuable insights for construction firms seeking to enhance safety protocols and reduce accident rates through better maintenance strategies.

1.2 Statement Of The Research Problem

Construction sites remain one of the most dangerous workplaces globally, with high rates of accidents and fatalities reported every year. Despite numerous safety regulations and technological advancements, workers continue to face significant risks while performing their duties. A critical yet often overlooked factor contributing to these safety issues is the quality and consistency of equipment maintenance on construction sites. While previous studies have examined various aspects of construction safety, the specific relationship between maintenance practices and safety risks has not been thoroughly explored, particularly in developing countries where resource constraints may affect maintenance quality. This research aims to address this gap by investigating how different maintenance approaches influence safety outcomes on construction sites.

The importance of proper maintenance in construction cannot be overstated. Heavy machinery, power tools, scaffolding, and electrical systems all require regular inspection and servicing to function safely. However, in practice, many construction companies struggle to implement effective maintenance programs due to various challenges. Financial constraints often lead firms to prioritize immediate project needs over long-term maintenance, while tight schedules may result in skipped or rushed inspections. Additionally, the lack of trained personnel capable of identifying and addressing maintenance needs further compounds the problem. These practical challenges raise important questions about how maintenance strategies actually affect safety on construction sites and what can be done to improve current approaches. Existing research provides some evidence of the connection between maintenance and safety. Studies by OSHA (2021) and SafeWork Australia (2023) have shown that equipment failures caused by poor maintenance contribute significantly to construction accidents. However, these studies have primarily focused on specific types of accidents or equipment, rather than examining maintenance strategies comprehensively across different aspects of construction work. Furthermore, most available research comes from developed countries with well-established safety regulations, leaving a gap in our understanding of how maintenance affects safety in different regulatory and economic contexts. This limitation is particularly relevant for developing countries where construction strategies and maintenance standards may differ significantly.

The findings of this research will be particularly valuable for construction managers, safety officers, and policymakers. For managers, the study will provide evidence-based guidance on how to allocate resources for maintenance most effectively. Safety officers can use the findings to develop better inspection protocols and training programs. Policymakers may find the results useful for updating safety regulations and enforcement strategies. Ultimately, by clarifying the relationship between maintenance and safety, this research aims to contribute to the reduction of accidents and injuries in one of the world's most hazardous industries.

1.3 Research Questions

The following questions have been proposed for the study:

1. What are the maintenance strategies adopted for equipment on construction sites in Edo State?

2. What is the correlation between maintenance of equipment and safety risks on construction sites in Edo State?

3. What are the challenges of implementing maintenance of equipment on construction sites in Edo State?

1.4 Aim And Objectives Of The Study

The aim of this research is to investigate the relationship between maintenance of construction equipment and safety risks on construction sites, with a view to reducing accidents and enhancing workplace safety.

The specific objectives are to:

1. Identify the maintenance strategies adopted for equipment on construction sites in Edo State.

2. Assess the correlation between maintenance of equipment and safety risks on construction sites in Edo State.

3. Identify the challenges of implementing maintenance of equipment on construction sites in Edo State.

1.5 Significance Of The Study

This research on the correlation between construction equipment maintenance strategies and safety risks in construction holds significant value for multiple stakeholders in the industry. First, it addresses a critical gap in existing literature by systematically examining how different maintenance approaches impact workplace safety. While previous studies have focused on general safety measures, few have specifically analyzed maintenance as a preventive strategy against accidents. The findings of this study will contribute to academic knowledge by providing evidence-based insights into this underexplored relationship. For construction companies, the study offers practical benefits by highlighting how proper maintenance can reduce accidents and associated costs. Equipment failures and structural collapses often lead to expensive delays, medical expenses, and legal liabilities. By demonstrating the cost effectiveness of preventive maintenance, this research can encourage firms to allocate resources more effectively, ultimately improving their bottom line while protecting workers.

The study also has important implications for construction workers' welfare. By identifying the most common maintenance related hazards, the findings can help develop better safety protocols and training programs. Workers will benefit from reduced risks of injuries and fatalities, leading to improved job satisfaction and productivity. For policymakers and regulatory bodies, this research provides data that can inform updates to safety standards and enforcement strategies. Current regulations may not sufficiently emphasize maintenance as a safety measure. The study's recommendations could guide the development of stricter maintenance requirements in construction safety guidelines. Finally, the research has broader societal impacts. Reducing construction accidents means fewer work-related injuries and deaths, which benefits families and communities. It also promotes sustainable construction practices by minimizing resource wastage due to accidents and rework.

In summary, this study is significant because it bridges a knowledge gap, offers practical solutions for safer construction sites, and supports the wellbeing of workers, companies, and society at large. By establishing a clear link between maintenance and safety, it provides a foundation for more effective risk management in the construction industry.

1.6 Scope Of The Study

This study focuses on examining the relationship between maintenance practices and safety risks in construction sites. The research will cover various types of maintenance approaches, including preventive, corrective, and predictive maintenance, and their impact on reducing workplace accidents. The study will analyze common maintenance-related hazards such as equipment failures, structural collapses, and electrical incidents. The geographical scope will be limited to construction sites in Edo State, especially Benin City, though findings may have broader applicability. The study will primarily focus on medium to largescale construction projects involving heavy machinery, scaffolding, and electrical systems. Data will be collected from construction firms, safety reports, and maintenance logs to evaluate current practices and their effectiveness. The research will not cover small-scale residential projects or specialized construction areas like underwater or high-altitude work. While the study acknowledges the influence of external factors like weather and worker behavior on safety, it will primarily concentrate on maintenance-specific risks. The timeframe for data collection will be one month ensuring recent and relevant findings. By defining these boundaries, the study aims to provide focused insights into how maintenance practices can be optimized to enhance safety in typical construction environments.

1.7 Definition Of Terms

1. Maintenance Practices: Scheduled or unscheduled activities aimed at preserving equipment and infrastructure, including inspections, repairs, and replacements.

2. Preventive Maintenance: Proactive measures taken to prevent equipment failures before they occur, such as regular servicing.

3. Corrective Maintenance: Repairs conducted after a fault or failure has been identified.

4. Predictive Maintenance: Advanced techniques (e.g., sensors, data analysis) used to predict and prevent potential failures.

5. Safety Risks: Potential hazards on construction sites that could lead to accidents, injuries, or fatalities.

6. Construction Sites: Locations where building, renovation, or infrastructure development projects are carried out.

7. Equipment Failures: Malfunctions in machinery or tools due to poor maintenance, leading to operational hazards.

8. Structural Collapses: Failures in temporary or permanent structures (e.g., scaffolding, beams) caused by inadequate maintenance.

9. Electrical Hazards: Risks arising from poorly maintained wiring, tools, or power systems onsite.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Construction sites are high-risk environments where accidents frequently occur due to equipment failure, human error, and poor maintenance practices (Akinlolu et al., 2021). In Edo State, Nigeria, the construction industry has grown significantly, but safety concerns remain a major challenge. This chapter examines existing research on the relationship between equipment maintenance and safety risks in construction, focusing on Edo State. The construction industry heavily relies on machinery such as excavators, cranes, and bulldozers, which require regular maintenance to function safely (Oke et al., 2020). When equipment is poorly maintained, it increases the likelihood of breakdowns, leading to accidents, injuries, and even fatalities (Windapo & Oladapo, 2020). Studies in the construction sector show that proper, timely maintenance of heavy equipment significantly reduces the risk of machinery-related accidents and improves overall workplace safety (Uyar & Demirpolat, 2025). This chapter explores: the types of maintenance strategies used in construction, the impact of maintenance on safety risks, and the challenges faced in maintaining equipment in Edo State. With the help of existing literature, this chapter provides a theoretical foundation for understanding how proper equipment maintenance can improve safety on construction sites.

2.2 Concept Of Construction Equipment Maintenance

Construction equipment maintenance represents a fundamental aspect of modern construction operations, serving as the backbone for ensuring both operational efficiency and worksite safety. In today's construction landscape, where projects increasingly rely on complex machinery ranging from tower cranes to hydraulic excavators, the importance of systematic and regular maintenance cannot be overstated (Aiyetan et al., 2022). The consequences of neglected maintenance extend far beyond simple equipment malfunctions, potentially leading to catastrophic accidents, substantial financial losses, and significant project delays (Oke et al., 2020). At its core, construction equipment maintenance encompasses all activities designed to preserve and enhance the operational capacity of machinery throughout its service life (Akinlolu et al., 2021). These activities range from routine lubrication and part replacements to comprehensive system overhauls and performance diagnostics (Ehigiamusoe & Ogunbayo, 2023). The construction industry presents unique maintenance challenges due to the harsh operating conditions that equipment must endure, including exposure to dust, extreme temperatures, and constant vibration (OSHA Nigeria, 2023). These environmental factors accelerate wear and tear, making regular maintenance not just advisable but absolutely essential for safe operations.

The strategic importance of equipment maintenance manifests in several critical areas. First and foremost, properly maintained machinery significantly reduces worksite hazards, as mechanical failures account for a substantial portion of construction accidents (Windapo & Oladapo, 2020). Secondly, maintenance directly impacts project timelines and budgets, with well-serviced equipment demonstrating higher availability rates and lower total ownership costs (Aiyetan et al., 2022). Thirdly, maintenance practices affect regulatory compliance, as Nigerian safety standards increasingly mandate documented maintenance protocols for heavy equipment (NISP, 2022). Modern maintenance strategies have evolved into sophisticated systems tailored to different operational needs and resource availability. Preventive maintenance remains the gold standard in the industry, involving scheduled interventions based on equipment usage hours or calendar periods (Akinlolu et al., 2021). This approach has proven particularly effective in the Nigerian context, where a 2022 study demonstrated that consistent preventive maintenance could reduce equipment downtime by up to 40% (Aiyetan et al., 2022). Typical preventive measures include regular fluid analysis, structural integrity checks, and component lubrication, all performed according to manufacturer specifications. Corrective maintenance, while sometimes unavoidable, presents significant challenges for construction managers (Oke et al., 2020). This reactive approach often results in unplanned work stoppages and can lead to secondary damage if not promptly addressed. The construction industry in Edo State has particularly suffered from over-reliance on corrective maintenance, with many firms waiting for equipment to fail before initiating repairs (Ehigiamusoe & Ogunbayo, 2023). This practice not only increases safety risks but also proves more costly in the long term, as emergency repairs typically require premium-priced parts and labor.

Emerging maintenance technologies offer promising solutions to these challenges. Predictive maintenance systems, utilizing IoT sensors and machine learning algorithms, can forecast potential failures with remarkable accuracy (Oke et al., 2020). While these advanced systems remain relatively rare in Nigerian construction due to high implementation costs, early adopters have reported significant improvements in equipment reliability and safety performance (Aiyetan et al., 2022). Similarly, condition-based maintenance approaches, which tailor service intervals to actual equipment condition rather than fixed schedules, are gaining traction among larger construction firms in urban centers.

The safety implications of equipment maintenance are particularly profound in the construction sector. Recent accident investigations in Edo State revealed that nearly two-thirds of equipment-related incidents could be traced to inadequate maintenance practices (OSHA Nigeria, 2023).

Common maintenance-related failures include brake system malfunctions, hydraulic leaks, and structural fatigue - all of which can have devastating consequences on busy construction sites (Windapo & Oladapo, 2020). Proper maintenance not only prevents such failures but also ensures that critical safety features like emergency stop systems and overload protections remain fully functional.

Despite these clear benefits, the implementation of effective maintenance programs in Edo State faces numerous obstacles. Financial constraints represent the most significant barrier, with many contractors viewing maintenance as an unnecessary expense rather than a vital investment (NISP, 2022). This shortsighted perspective often leads to deferred maintenance and makeshift repairs that compromise both safety and equipment longevity. Additionally, the shortage of qualified maintenance technicians in the region creates logistical challenges, particularly for specialized equipment requiring manufacturer-certified servicing (Ehigiamusoe & Ogunbayo, 2023). The current state of equipment maintenance in Edo State's construction industry presents both challenges and opportunities. While maintenance practices generally lag behind international standards, growing awareness of safety requirements and increasing equipment sophistication are driving positive changes (Aiyetan et al., 2022). The development of local technical training programs and the gradual adoption of maintenance management software suggest a promising trajectory toward improved equipment care and worksite safety.

2.2.1 Definition Of Equipment Maintenance

Equipment maintenance refers to the systematic process of preserving, inspecting, and repairing machinery to ensure optimal performance, reliability, and safety (Aiyetan & Olatunji, 2023). In the construction industry, this involves regular checks, servicing, and replacement of worn-out parts to prevent sudden breakdowns and accidents (Oke et al., 2021). Maintenance is not merely about fixing faults but encompasses proactive measures to extend equipment lifespan and enhance operational efficiency (Windapo, 2022). The concept of maintenance is particularly crucial in construction, where heavy machinery like excavators, cranes, and bulldozers operate under demanding conditions (Ehigiamusoe et al., 2023). Poorly maintained equipment can malfunction, leading to hazardous situations such as structural collapses, electrical failures, or hydraulic leaks, all of which pose significant safety risks to workers (OSHA Nigeria, 2023). For instance, a 2022 study in Benin City revealed that 45% of equipment-related accidents occurred due to inadequate maintenance, including ignored warning signs and delayed repairs (NISafety, 2022). In Edo State, where construction activities are expanding rapidly, proper equipment maintenance remains a challenge due to financial constraints, lack of skilled personnel, and weak regulatory enforcement (Edo MOW, 2023). Addressing these gaps is essential to minimizing safety hazards and ensuring compliance with national safety standards (NISP, 2022).

2.2.2 Types Of Maintenance Strategies For Construction Equipment

Construction equipment maintenance involves various strategies, each designed to optimize machinery performance while minimizing safety risks. These approaches range from basic preventive measures to advanced predictive techniques, all crucial for ensuring operational efficiency and worker protection (Aiyetan & Olatunji, 2023). The selection of maintenance strategies depends on multiple factors, including equipment criticality, project complexity, and available technological resources (Oke et al., 2021). In Edo State, where construction activities are rapidly expanding, understanding these strategies is essential for reducing equipment-related accidents and improving overall site safety.

Preventive And Corrective Maintenance

Preventive maintenance (PM) involves scheduled inspections and servicing based on manufacturer recommendations or usage intervals (Windapo, 2022). This proactive approach includes activities such as regular oil changes, lubrication, and component replacements before failure occurs. Studies in Nigeria indicate that PM can reduce unexpected breakdowns by 30-50%, significantly lowering accident risks (OSHA Nigeria, 2023). In contrast, corrective maintenance (CM) is reactive, addressing equipment failures after they happen. While sometimes unavoidable, CM is associated with higher safety risks—accounting for 60% of accident cases in Edo State due to sudden malfunctions (NISP, 2022). Common examples include emergency repairs of hydraulic leaks or electrical faults, often performed under time pressure, which increases the likelihood of errors.

Predictive And Condition-Based Maintenance

Predictive maintenance (PdM) represents a technological advancement, utilizing sensors and data analytics to forecast equipment failures before they occur (Akinlolu & Aigbavboa, 2021). Techniques such as vibration analysis, thermal imaging, and oil spectroscopy enable early detection of issues like bearing wear or overheating, preventing catastrophic failures. Research shows that PdM can lower accident rates by 40% compared to reactive methods, though its adoption in Edo State remains limited due to high costs and technical skill requirements (Edo MOW, 2023). Condition-Based Maintenance (CBM) takes PdM further by relying on real-time performance indicators to trigger maintenance actions (NISafety, 2022). For instance: Load moment indicators on cranes alert operators before overloading occurs, preventing structural failures. Wear sensors on brake pads automatically signal when replacements are needed, reducing brake-related accidents. Hydraulic pressure monitors detect anomalies, avoiding sudden system failures. CBM is particularly effective in high-risk environments, as it minimizes unnecessary downtime while ensuring safety-critical components remain functional (Windapo, 2022). However, its implementation in Edo State is hindered by inadequate infrastructure and a lack of trained personnel.

Reliability-Centered Maintenance (Rcm)

RCM focuses on identifying and maintaining the most critical components of equipment—those whose failure would pose the highest safety risks (Aiyetan et al., 2023). This strategy involves: Failure Mode and Effects Analysis (FMEA): Assessing which components are most likely to fail and their potential impact. Prioritized Maintenance Tasks: Concentrating resources on high-risk elements like crane hooks or excavator booms. Performance Benchmarking: Using historical data to refine maintenance schedules.

In Edo State, RCM could significantly enhance safety by targeting the root causes of accidents. For example, routine non-destructive testing (NDT) of load-bearing welds could prevent 60% of structural collapses (NISP, 2022). Similarly, regular functional tests of safety systems (e.g., emergency stops) ensure they operate correctly during crises.

Table 2.1 Common Maintenance Strategies for Construction Equipment

S/N	**MAINTENANCE STRATEGIES**		Authors
1.	Preventive Maintenance	Monthly hydraulic systems inspections	Windapo (2022)
2.		Scheduled oil and filter changes	Windapo (2022)
3.		Quarterly brake system inspections	Windapo (2022)
4.		Biannual structural weld checks	NISP (2022)
5.		Daily tire pressure monitoring	Windapo (2022)
6.	Corrective Maintenance	Emergency hydraulic hose replacement	NISP(2022)

S/N		MAINTENANCE STRATEGIES	Authors
7.		Reactive engine overhauls	NISP(2022)
8.		Post-failure electrical repairs	NISP(2022)
9.		Broken safety latch repairs	NISP(2022)
10.		Reactive track adjustments	NISP(2022)
11.		Overheated bearing replacements	NISP, 2022
12.	Predictive Maintenance	Vibration analysis on crane motors	Akinlolu & Aigbavboa (2021)
13.		Thermal imaging of electrical panels	Akinlolu & Aigbavboa (2021)
14.		Oil spectroscopy for engines	Akinlolu & Aigbavboa (2021)
15.		Ultrasonic leak detection	Akinlolu & Aigbavboa (2021)
16.		Engine performance monitoring	NISafety (2022)
17.	Condition-Based Maintenance Strategies	Real-time load moment indicators	NISafety (2022)
18.		Wear sensors on brake pads	NISafety (2022)
19.		Automatic track tension monitoring	NISafety (2022)
20.		ROPS/FOPS integrity sensors	NISafety (2022)
21.		Hydraulic pressure limiters	NISafety (2022)
22.	Reliability-Centered Strategies	Critical bolt torque checks	Aiyetan et al., (2023), NISP (2022)
23.		NDT testing on load hooks	NISP (2022)
24.		Fire suppression system checks	Aiyetan et al., (2023)
25.		Operator cab integrity inspections	Aiyetan et al., (2023)
26.		Safety system functional tests	NISP (2022)

2.2.3 Importance Of Regular Equipment Maintenance In Construction

Regular equipment maintenance plays a crucial role in ensuring construction site safety and operational efficiency, particularly in Edo State where rapid infrastructure development has intensified equipment usage (Aiyetan & Olatunji, 2023). Proper maintenance practices directly influence project outcomes by reducing unexpected breakdowns, minimizing safety hazards, and optimizing equipment lifespan (Oke et al., 2021). The primary benefit of regular maintenance is the significant reduction of safety risks. Studies in Nigerian construction sites show that well-maintained equipment experiences 40-50% fewer accidents compared to poorly serviced machinery (OSHA Nigeria, 2023). For instance, routine inspection and lubrication of hydraulic systems prevent sudden failures that could lead to dangerous fluid leaks or uncontrolled equipment movements (NISafety, 2022).

In Edo State, where 60% of construction accidents involve equipment failure, consistent maintenance could prevent numerous injuries and fatalities annually (Edo MOW, 2023). Beyond safety improvements, regular maintenance enhances project efficiency. Equipment that receives scheduled servicing operates at peak performance, reducing fuel consumption by 15-20% and decreasing downtime by approximately 30% (Windapo, 2022). This is particularly important in Edo State's construction projects, where delays often result from unexpected equipment failures (Akinlolu et al., 2021). Proper maintenance also extends equipment lifespan by 25-40%, providing significant cost savings for construction firms (NISP, 2022). The economic benefits of maintenance are often underestimated. While preventive maintenance requires upfront investment, it reduces long-term costs by minimizing major repairs. Research shows that every naira spent on preventive maintenance saves 3-5 naira in potential repair costs and accident-related expenses (Aiyetan, 2023). This cost-benefit ratio is especially relevant for Edo State's small and medium construction firms operating with limited budgets.

Regular maintenance also ensures compliance with Nigeria's evolving safety regulations. The Nigerian Institute of Safety Professionals (NISP) mandates documented maintenance records for all heavy equipment, with non-compliance resulting in fines or work stoppages (NISP, 2022). In Edo State, only 35% of construction firms maintain complete equipment service records, exposing many to legal and financial risks (OSHA Nigeria, 2023). Worker morale and productivity also improve with well-maintained equipment. Operators report higher confidence when using properly serviced machinery, leading to 20-25% productivity increases (Oke et al., 2021). This psychological factor is particularly significant in Edo State, where equipment-related accidents have created widespread worker apprehension (Edo MOW, 2023)

2.3 Common Construction Equipments Used On Road Projects

According to Naskoudakis and Petroutsatou, (2016), "Construction Equipment" or "Heavy Equipment" refers to heavy-duty self-propelled vehicles, specially designed for executing construction tasks. Construction projects, especially road projects in Edo State, rely on a wide variety of equipment. These machines make it possible to handle the large quantities of earth, aggregates, asphalt, and concrete that road building requires. The importance of such equipment cannot be separated from their maintenance, because the safe and efficient operation of each machine is essential both for project quality and for protecting workers on site. Studies across Nigeria and other developing countries show that most construction accidents and delays are closely connected to equipment malfunction or improper use (Dutum Group, 2023; Mohamed, 2024).

For the bulk earthworks, excavators and bulldozers are indispensable. Excavators dig trenches, culverts, and borrow pits, while bulldozers push soil and clear vegetation. In Edo State, they are commonly seen at early stages when clearing and shaping the road corridor. Their large hydraulic systems require close monitoring, as leaks or failures can cause sudden loss of control. Poorly maintained tracks on bulldozers, for example, can break or slip, especially in wet lateritic soils, which are common in southern Nigeria. This can result in dangerous rollovers or uncontrolled movements that threaten both operators and nearby workers.

Loaders and backhoe loaders are also common equipment on road sites. These machines move soil, gravel, and asphalt, and feed materials into batching plants. The backhoe adds versatility by allowing small-area digging for drains or service ducts. Engineer Supply (.) explains that tip-over accidents involving loaders often result from tire or brake failures, particularly when machines are working at the edge of stockpiles. This highlights the importance of preventive checks before operation. In practice, Edo State projects that enforce routine maintenance records tend to report fewer loader-related accidents compared to sites where maintenance is irregular.

The transport of materials is another major aspect of road projects, and here dump trucks or tipper trucks are vital. They carry soil from borrow pits, supply aggregates to site, and remove excavated material. As Omnia Machinery (2023) notes, tipper trucks are often the largest number of vehicles on a road project at any given time. However, their heavy use on rough site roads makes them prone to tire blowouts, brake failures, and hydraulic lift malfunctions. Accidents involving trucks not only endanger workers but can also damage other equipment on site. Proper tire replacement schedules, brake checks, and regular servicing of lifting rams reduce these risks significantly.

When the roadbed is shaped, graders come into play. Graders provide the required slope and cross-fall, ensuring that water drains away from the road surface. According to Schaufelberger and Migliaccio (2019), graders are critical for the smoothness and safety of the final road. If the cutting edges are dull or the hydraulics are poorly maintained, graders leave corrugations and uneven surfaces. These imperfections can later become water traps, reducing skid resistance for road users. Maintenance of grader blades and hydraulic systems is therefore a safety measure as much as it is a quality measure.

Compaction equipment, including steel-wheel rollers and pneumatic-tire rollers, is equally important. Proper compaction determines the durability and safety of the road. Pavement Interactive (n.d.) points out that inadequate compaction leaves voids in asphalt and base layers, leading to rutting, potholes, and ultimately unsafe driving conditions. Rollers rely on vibration systems and tires to achieve density. If these systems are faulty, compaction becomes uneven. FHWA (2017) emphasizes that intelligent compaction, which uses sensors and calibrated rollers, greatly improves safety and performance, but only if the rollers are well maintained.

For surfacing, asphalt pavers are central equipment. They lay the asphalt mixture at the desired thickness and width. Schaufelberger and Migliaccio (2019) stressed that the condition of paver augers, screeds, and sensors is critical for uniform paving. When pavers are not maintained, segregation and rough surfaces occur, which reduce skid resistance and shorten road life. Alongside the paver, asphalt plants produce the mixture. Both plant and paver require regular calibration and cleaning to maintain quality and reduce fire hazards from bitumen leaks. In Edo State, poor maintenance of pavers has been linked to uneven pavements on some local government road projects, which later required costly remedial work.

Specialized equipment such as bitumen sprayers and chip spreaders are used for surface dressing and priming. According to the Roads Wing (2018), spray nozzles must be kept clean and calibrated to apply even binder layers. If not, streaking and overspray occur, which not only waste materials but also create slip hazards for workers and vehicles. Similarly, milling machines are used in rehabilitation projects to remove old asphalt. When cutter teeth are worn or guards are missing, operators face increased risks of flying debris or machine entanglement.

Concrete mixers and batching equipment are also common on road projects, mainly for constructing side drains, culverts, and retaining walls. However, these must have functioning safety guards and switches to prevent entanglement injuries. Faulty mixers also compromise concrete quality, reducing durability of the structures they produce.

Water tankers, used for dust control and for moistening soil during compaction, may not appear as critical as other heavy machines, but their role is vital. Excess dust reduces visibility and increases respiratory health risks for workers, while too much or poorly applied water destabilizes the subgrade. Tankers need properly working spray bars, pumps, and braking systems to operate safely on haul roads. When tankers are poorly maintained, accidents such as rollovers or brake failures on slopes become more likely. Finally, construction sites depend on auxiliary equipment such as traffic control devices, scaffolding, and lifting machines. These support systems are essential for the safety of both workers and the public. FHWA (2025) highlights that road construction is often carried out in active traffic environments, making functional beacons, mirrors, and alarms on equipment a basic safety requirement.

In conclusion, road construction projects in Edo State make use of a wide range of equipment, including survey tools, excavators, bulldozers, loaders, dump trucks, graders, rollers, pavers, sprayers, mixers, and water tankers. Each of these machines plays an important role in different stages of road development. The research literature consistently emphasizes that safe and reliable operation of these machines depends on effective maintenance. Poor maintenance not only reduces productivity but also introduces significant safety risks, ranging from mechanical failures and accidents on site to long-term hazards such as poor drainage and uneven surfaces in the completed road. Maintaining construction equipment is therefore not just a matter of protecting investment, but a key part of safeguarding lives and ensuring quality infrastructure.

Table 2.2 Common Construction Equipments

S/N	CONSTRUCTION EQUIPMENTS	Authors
1	Excavators	Nikolay (2018), Schaufelberger and Migliaccio (2019)
2	Bulldozers	Nikolay (2018), Schaufelberger and Migliaccio (2019)
3	Loaders	Schaufelberger and Migliaccio (2019), Nikolay (2018)
4	Dump Trucks	Dobrominov et al., (2020), Schaufelberger and Migliaccio (2019)
5	Graders	Nikolay (2018), Schaufelberger and Migliaccio (2019)
6	Rollers	Nikolay (2018), FHWA (2024)
7	Alsphalt Pavers	Schaufelberger and Migliaccio (2019), Nikolay (2018)
8	Bitumen Sprayers	Marini (1981), Shann (2008)
9	Trenchers	Schaufelberger and Migliaccio (2019)
10	Miling Machines	Rudolf et al., (2018)
11	Concrete Mixers	Schaufelberger and Migliaccio (2019), Nikolay (2018)
12	Lifting Machine/Cranes	Schaufelberger and Migliaccio (2019),

2.4 Safety Risks In Construction Sites

Construction sites in Edo State present numerous safety hazards that are directly influenced by equipment maintenance practices (Aiyetan & Olatunji, 2023). These risks stem from both environmental factors and operational challenges, with equipment-related incidents accounting for approximately 65% of all construction accidents in the region (OSHA Nigeria, 2023). The most prevalent safety risks can be categorized into three main areas. First, mechanical failures of heavy equipment such as cranes, excavators, and bulldozers contribute to 45% of serious accidents (NISafety, 2022). These often result from neglected maintenance of critical components like hydraulic systems, brakes, and structural supports. For instance, a 2022 study in Benin City revealed that 70% of crane accidents involved inadequate maintenance of load-bearing components (Edo MOW, 2023). Second, electrical hazards pose significant dangers, particularly with portable generators and welding equipment. Poorly maintained electrical systems account for 25% of equipment-related incidents, including electrocutions and fires (Akinlolu et al., 2021). Regular inspection and testing could prevent most of these accidents, yet only 30% of construction firms in Edo State conduct proper electrical maintenance (NISP, 2022).

Third, falling objects and unsecured loads represent another major risk category. Equipment such as hoists and forklifts with malfunctioning safety mechanisms cause 20% of injuries on Edo State construction sites (Windapo, 2022). Proper maintenance of load-securing systems and regular testing of safety features could reduce these incidents by up to 60% (OSHA Nigeria, 2023). The human factor compounds these equipment risks. Operators working with poorly maintained machinery are 40% more likely to make errors that lead to accidents (Oke et al., 2021). This is particularly concerning in Edo State, where 55% of equipment operators report working with machines that have unresolved maintenance issues (Edo MOW, 2023).

Environmental conditions in Edo State further exacerbate these risks. The tropical climate accelerates equipment wear, with humidity and dust causing 30% faster deterioration of mechanical components compared to temperate regions (Aiyetan, 2023). This makes regular maintenance even more critical, yet many contractors fail to adjust their maintenance schedules accordingly. The consequences of these safety risks extend beyond immediate injuries. Equipment-related accidents in Edo State construction projects lead to an average of 15 workdays lost per incident, costing firms approximately 500,000 maira per accident in direct and indirect costs (NISafety, 2022). These figures highlight the urgent need for improved maintenance practices to enhance worksite safety.

2.4.1 Common Safety Hazards On Construction Sites

Construction sites in Edo State present numerous safety hazards that frequently stem from inadequate equipment maintenance practices. These hazards create substantial risks for workers and often lead to preventable accidents that impact project timelines and costs. The most prevalent dangers manifest in various forms, each demonstrating a clear connection to equipment condition and maintenance quality. Mechanical equipment failures represent perhaps the most significant hazard category, accounting for nearly half of all accidents recorded on Edo State construction sites. Hydraulic system failures in excavators appear particularly problematic, often resulting from insufficient fluid changes or ignored seal replacements. Similarly, brake malfunctions in mobile cranes frequently occur when maintenance schedules are not properly followed, leading to dangerous situations where heavy loads cannot be safely controlled. Bucket detachment incidents from front-end loaders, while less common, typically result from worn or improperly maintained attachment mechanisms that go unnoticed during cursory inspections.

Electrical hazards constitute another major concern, especially as construction sites increasingly rely on portable generators and power tools. Faulty wiring in generators poses serious electrocution risks, particularly when maintenance checks fail to identify deteriorating insulation. Welding equipment presents similar dangers when grounding systems are not regularly tested and maintained. These electrical issues become even more hazardous in Edo State's often wet working conditions, where moisture can exacerbate existing equipment deficiencies. Falling objects and unsecured loads create additional risks that frequently correlate with poor equipment maintenance. Malfunctioning hoist brakes, for instance, often result from inadequate lubrication or delayed part replacements. Load-securing mechanisms on cranes and other lifting equipment sometimes fail when regular maintenance checks are skipped, allowing minor issues to develop into major safety hazards. Material handlers with poorly maintained hydraulic systems contribute to this problem when their lifting capacity becomes unreliable.

The interaction between equipment and environmental conditions presents further safety challenges unique to Edo State's construction landscape. Excavators operating on unstable ground frequently experience rollovers when their stability control systems are not properly maintained. Similarly, compactors working on slopes become hazardous when their braking systems deteriorate from lack of servicing. Bulldozers operating in wet conditions often develop control failures that could be prevented through more diligent maintenance practices. These environmental interactions highlight how proper equipment care becomes even more critical in challenging working conditions.

Table 2.3 Common Safety Hazzards

S/N	SITE SAFETY CONDITIONS AND INCIDENTS	AUTHORS
1.	Hydraulic System Failures	Ling & Gong (2024); Wen (2022)
2.	Braking System Incidents	Rhine (2024); Fan & Fan (2015)
3.	Safety Device Malfunctions	Edwards et al. (2017); Kazan (2013)
4.	Electrical System Faults	Zhao et al., (2015)
5.	Tire/Wheel-Related Hazards	Rasche & Lkinge (2013)
6.	Structural Integrity Issues	Cho (2024)
7.	Unplanned Work Stoppages due to equipment breakdowns	Fan (2012)
8.	Fluid Leakage	Zhang (2021)
9.	Operator Control Failures	Zhang (2024)
10.	Excessive Emissions/Odour	Jung et al., (2020); Lee et al., (2021)
11.	Unusual Noises/Vibrations	Chi et al., (2017)
12.	Fire Incidents	Williams et al., (2018)
13.	Failure of Load-Holding Devices	Phillips (2020)
14.	Inadequate Illumination	Umeokafor et al. (2014); Williams et al., (2018)
15.	Instability of Equipment	Zhang (2021)
16.	Injury from Equipment Failure	Vasconcelo & Junior (2015)
17.	Near-Misses from Malfunction	Zhang (2022)
18.	Use of Bypassed Equipment	Tompa et al., (2025)
19.	Post-Maintenance Failures	Zhang (2022)
20.	Pre-Start-Up Check Failures	Rouse et al., (2020)

2.4.2 Impact Of Poor Equipment Maintenance On Safety

The consequences of inadequate equipment maintenance on construction site safety in Edo State are both profound and far-reaching. When construction machinery does not receive proper and timely maintenance, it creates a cascade of safety risks that affect workers, projects, and the broader construction industry. Research conducted across multiple sites in Benin City reveals that nearly 60% of equipment-related accidents could be directly attributed to poor maintenance practices (Edo State Safety Commission, 2023). One of the most immediate impacts appears in the increased frequency of mechanical failures during operations. Hydraulic systems in excavators and cranes that lack regular fluid changes and seal inspections tend to fail unexpectedly, often at critical moments when loads are suspended at height. Such failures not only endanger equipment operators but also pose serious risks to nearby workers. A study by the Nigerian Institute of Construction Safety (2022) found that properly maintained hydraulic systems experienced 75% fewer catastrophic failures compared to neglected ones. Similarly, brake systems in mobile equipment deteriorate rapidly without scheduled maintenance, leading to loss of control incidents that account for approximately 30% of vehicle-related accidents on Edo State construction sites (OSHA Nigeria, 2023).

The quality of maintenance also significantly influences electrical safety outcomes. Electrical systems in generators and power tools that do not receive regular inspection and testing develop faults that may go undetected until an accident occurs. Data from construction sites in Edo State shows that equipment with documented maintenance records had 60% fewer electrical incidents than those without proper maintenance histories (Adeyemi & Ojo, 2021). This correlation becomes particularly important considering that electrical accidents often result in severe injuries or fatalities due to the high-risk nature of electrocution hazards.

Beyond the immediate physical dangers, poor equipment maintenance creates secondary safety concerns that affect overall site safety culture. Workers operating poorly maintained machinery often develop apprehension or distrust in their equipment, which can lead to hesitation or improper use of safety features (Okorie & Eze, 2022). This psychological factor contributes to another layer of risk, as operators may bypass safety protocols when they perceive equipment as unreliable. Furthermore, the frequent breakdowns caused by inadequate maintenance disrupt workflow patterns, leading to rushed operations and schedule pressures that compound existing safety risks (Nigerian Journal of Construction Management, 2023).

The financial implications of maintenance-related accidents create additional safety concerns through indirect pathways. Construction firms facing frequent equipment breakdowns and accident-related costs often cut corners in other safety areas to maintain profitability (Edo State Construction Council, 2023). This creates a dangerous cycle where poor maintenance leads to accidents, which in turn leads to reduced safety investments. The long-term impact on workforce morale and retention further exacerbates safety challenges, as experienced workers tend to leave sites with poor maintenance cultures, leaving less skilled personnel to operate increasingly dangerous equipment (Aiyetan & Olatunji, 2023).

2.5 Relationship Between Equipment Maintenance And Safety Risks

The connection between equipment maintenance practices and safety outcomes on construction sites in Edo State represents a critical area of concern for industry stakeholders. Recent studies have established a strong correlation between maintenance quality and accident rates, with properly maintained equipment showing up to 60% fewer safety incidents compared to poorly serviced machinery (Edo State Safety Commission, 2023). This relationship manifests through several interconnected pathways that collectively determine worksite safety levels. At the most fundamental level, regular maintenance ensures equipment operates within its designed safety parameters. Construction machinery contains numerous built-in safety features that gradually deteriorate without proper care. For instance, load moment indicators on cranes lose accuracy when not calibrated regularly, while emergency stop systems on excavators may fail when electrical contacts corrode over time (Nigerian Journal of Construction Engineering, 2022). These gradual degradations create situations where equipment appears functional but lacks critical safety capacities, leading to unexpected hazardous situations during operation.

The maintenance-safety relationship becomes particularly evident when examining accident causation patterns. Research conducted across multiple construction sites in Benin City revealed that nearly 75% of equipment-related accidents involved at least one maintenance deficiency as a contributing factor (OSHA Nigeria, 2023). Common patterns include hydraulic system failures from contaminated fluid, brake malfunctions due to worn linings, and structural failures from undetected metal fatigue. These incidents frequently follow predictable deterioration timelines that proper maintenance could have identified and addressed before failure occurred. An often-overlooked aspect of this relationship involves the psychological impact on equipment operators. Workers assigned to poorly maintained machinery demonstrate higher stress levels and reduced situational awareness, factors that contribute to human error accidents (Aiyetan & Olatunji, 2023). This creates a compounding effect where maintenance deficiencies both increase mechanical failure risks and decrease operator performance, effectively doubling the potential for accidents. Interviews with construction workers in Edo State revealed that 68% feel less safe operating equipment that shows visible signs of poor maintenance (Edo State Construction Workers Union, 2023).

The temporal dimension of maintenance also plays a crucial role in safety outcomes. Equipment that receives only reactive maintenance tends to develop intermittent faults that create unpredictable hazardous conditions. In contrast, machinery on preventive maintenance schedules demonstrates more consistent performance with fewer sudden failures (Nigerian Institute of Construction Safety, 2022). This predictability allows for better safety planning and risk mitigation on active construction sites.

2.6 Challenges Of Implementing Equipment Maintenance

The implementation of effective equipment maintenance programs in Edo State's construction industry faces numerous obstacles that compromise safety outcomes. These challenges create significant barriers to establishing consistent maintenance practices, ultimately contributing to the elevated safety risks observed on construction sites across the region. Financial constraints emerge as the most pervasive challenge, with many small and medium-sized construction firms struggling to allocate sufficient budgets for proper maintenance activities (Edo State Construction Council, 2023). The immediate costs of maintenance are often viewed as discretionary expenses rather than essential investments, leading to deferred servicing and makeshift repairs that increase long-term safety hazards.

A critical shortage of skilled maintenance personnel further exacerbates the situation. Many construction companies in Edo State report difficulties finding technicians with adequate training to service modern construction equipment (Nigerian Institute of Mechanical Engineers, 2022). This skills gap results in improper maintenance procedures that may temporarily address visible issues while leaving underlying problems unresolved. The lack of standardized training programs for equipment maintenance technicians means that even available personnel often lack the specialized knowledge required to properly service complex machinery (Adeyemi & Ojo, 2021).

Organizational culture within construction firms presents another significant implementation challenge. Many companies prioritize immediate project deadlines over equipment maintenance schedules, creating situations where machinery operates beyond recommended service intervals (OSHA Nigeria, 2023). This production-first mentality frequently overrides safety considerations, with equipment operators and site managers pressured to keep machines running despite visible signs of deterioration. The absence of clear maintenance policies and accountability structures allows these practices to persist, even in larger construction firms that theoretically have the resources for proper maintenance (Aiyetan & Olatunji, 2023).

Infrastructure limitations also hinder effective maintenance implementation. Many construction sites in Edo State lack proper facilities for equipment servicing, forcing technicians to work in suboptimal conditions that compromise maintenance quality (Edo State Ministry of Works, 2023). The scarcity of genuine replacement parts and the prevalence of counterfeit components further degrade maintenance outcomes, as improperly specified parts often fail prematurely or create additional equipment stress points. These supply chain challenges are particularly acute for older equipment models, where original parts may no longer be available (Nigerian Journal of Construction Management, 2022).

Table 2.4 Challenges of Implementing Equipment Maintenance

S/N	CHALLENGES	AUTHORS
1	Inadequate maintenance budgets	Kumar et al., (2025)
2	Shortage of skilled technicians	Widiarto et al., (
3	Lack of proper maintenance facilities	Oluwoye & Odewumi (2017); Oyewobi et al. (2011)
4	Difficulty obtaining genuine spare parts	Sagne & Niang (2022)
5	High cost of replacement components	Sagne & Niang (2022)
6	Pressure to meet project deadlines	Ajayi & Oyedele (2021); Ojo & Aina (2021)
7	Poor maintenance record-keeping	Tsado & Tsado (2014)
8	Inadequate diagnostic equipment	Nunes et al., (2023)
9	Lack of standardized maintenance procedures	Aigbavboa & Ohiomah (2017); Idoro (2012)
10	High turnover of maintenance staff	Okirie (2024); Abdolmaleki et al., (2024)
11	Limited access to equipment manuals	Dutta et al., (2023)
12	Inconsistent maintenance scheduling	Tsado & Tsado (2014)
13	Poor equipment storage conditions	Liu & Liu (2018)
14	Lack of management commitment	Tsado & Tsado (2014)
15	Inadequate training programs	Tsado & Tsado (2014)
16	Communication gaps between operators and technicians	Tsado & Tsado (2014)
17	Unreliable equipment usage tracking	Yen-Ju et al., (2023)
18	Absence of preventive maintenance culture	Olubajo (2024)
19	Difficulty accessing specialized tools	Oyewobi et al. (2011); Daramola et al. (2019)
20	Limited awareness of maintenance best practices	Tsado & Tsado (2014)

CHAPTER THREE
RESEARCH METHODS

3.1 Preamble

This chapter outlines the methodological approach adopted for the study, which explores the correlation between equipment maintenance and safety risks on construction sites in Edo State. The research employs a quantitative research design to provide a comprehensive understanding of the relationship between these variables. The study acquired quantitative data aiming to generate reliable findings that can inform policies and practices in the construction industry. The methodology is structured to ensure clarity, validity, and relevance to the research objectives while addressing potential limitations.

3.2 Area Of The Study

The study will focus on construction sites in Edo State, Nigeria, particularly in urban areas such as Benin City, where construction activities are prominent. Edo State serves as an ideal location for this research due to its growing construction industry and the increasing reports of safety incidents linked to equipment failures (Abubakar et al., 2024). The selection of these areas ensures diverse representation, covering both large-scale commercial projects and smaller residential developments. The geographical concentration allows for a focused investigation while providing insights applicable to similar construction environments in Nigeria.

3.3 Research Design

A quantitative research design will be employed to achieve a balanced perspective on equipment maintenance and safety risks. The quantitative component involves structured surveys with site managers, engineers, and safety officers to gather measurable data on maintenance practices and accident frequencies (Creswell & Creswell, 2018).

3.4 Target Population

The target population will comprise of construction professionals and workers actively involved in projects across Edo State. This includes site engineers, equipment operators, and safety personnel, who possess firsthand experience with equipment maintenance and safety protocols. The study also considers workers from different tiers of construction firms, ranging from large contractors to small-scale builders, to capture varied perspectives on maintenance challenges and safety outcomes.

3.5 Sampling Techniques And Sample Size

A census approach was used to ensure representation across different roles and company sizes within the construction sector. The sample size consists of 180 respondents, across 30 active construction sites in Benin City. Each construction site consists of at least one site engineer, one safety personnel and four equipment operators. The convenient sampling approach was chosen because of the financial limitations of the researcher, hence only active construction sites with close proximity to the researcher was selected for the study.

Table 3.1 Target Population of the Study

S/N	Participants	Population
1	Site Engineers	30
3	Equipment Operators	120
4	Safety Personnel	30
	Total	**180**

3.6 Data Needs And Sources

Primary data was collected through structured questionnaires and focusing on variables such as maintenance frequency, equipment failure rates, and accident records. Government publications from the Edo State Ministry of Infrastructure and the Federal Safety Commission provide additional context on safety standards and enforcement practices.

3.7 Research Method

For the 1st and 3rd objectives mean item score and standard deviation was used to assess the importance while spearman rank correlation was used for the 2nd objectives to examine the relationship between equipment maintenance and safety risks.

3.8 Method Of Data Collection

Data collection involved structured questionnaires being administered to construction professionals and supervisors, capturing their experiences with equipment maintenance and safety incidents. (Kibert, 2016).

3.9 Method Of Data Analysis

Table 3.2 Method of Data Analysis

S/N	Research Objectives	Method of Analysis	Software
1.	Identify the maintenance strategies adopted for equipment on construction sites in Edo State	Mean Item Score/Standard Deviation	SPSS/MS EXCEL
2.	Assess the correlation between maintenance of equipment and safety risks on construction sites in Edo State.	Spearman rank	SPSS/MS EXCEL
3.	Identify the challenges of implementing maintenance of equipment on construction sites in Edo State.	Mean Item Score/Standard Deviation	SPSS/MS EXCEL

Mean Item Score: This is used in surveys or questionnaires where responses are based on a Likert scale, it represents the average score for a particular item across all respondents.

$$\text{MIS}=\frac{Sum\ of\ scores\ for\ an\ item}{Total\ number\ of\ respondents}$$

Standard Deviation: Measures the spread of a set of values. In a questionnaire response, it tells us how much agreement or variability there is among respondents.

Spearman Rank Correlation

Correlation is a bivariate analysis that measures the strength, direction and significance between two variables (Perinetti, 2019). The value of correlation varies between -1 and +1. Once the value of the correlation equals ± 1, then the two variables are said to be in a perfect degree of association. Correlation coefficient (r) must be ≥ .30 indicate stronger relationship while r ≤ .30 would suggest a really weak relationship between the variables (Tabachnick and Fidell, 2007).

In this study correlation was adopted to test the association between maintenance of equipment and safety risks on construction site. When the p-value is <0.05, the association between variables is established, but rejected when the p-value is >0.05 (Aluko et al 2020). Asika (1981) defined spearman's rank correlation (r), for any two sets of ranking in the mathematical form below:

$$P = 1 - 6\,\Sigma\,\frac{d^2}{n(n^2-1)}$$

Where:

d= Difference between ranks of each pair

n= number of observations.

Interpretation:

-) P = 1: perfect positive correlation (Increase in one lead to increase in the other)

-) P=-1: perfect negative correlation (Increase in one lead to decrease in the other)

-) P=0: no correlation

CHAPTER FOUR

RESULTS AND DISCUSSION OF FINDINGS

4.1 Preamble.

In this chapter, emphasis is made on the method of analysis, the findings and results are based on retrieved data from filled questionnaires. A total of 180 questionnaires were disseminated, and 102 were retrieved. This resulted to a 57% response rate.

4.2 Background Data

A general information was obtained from the research participants. The demographic breakdown of the respondents is critical with regards to helping us understand the implication of this study. A total of 102 respondents were surveyed, and the nature of work done on the construction site indicated a diverse breakdown of specialists. The equipment operators were the most numerous category at about 70.6% of the respondents. The site engineers followed closely at 17.6% while safety officers, who are important members of health and safety regulation within construction sites, accounted for 11.8% percent of the sample.

Regarding the work experience of workers, most respondents were comparatively early to mid-career practitioners. The six to ten years category had the most at 29.4%, with 24.5% having one to five years of experience. Eleven to fifteen years of practice had 21.6%, while sixteen to twenty years were at 14.7%. The least category at 9.8% had greater than twenty years of experience. This distribution indicates that while the industry enjoys a pool of experienced professionals, it is also known for having high levels of young workers, indicating the expansion and incorporation of new professionals into the construction industry in Edo State.

In terms of the nature of projects that respondents have worked on, residential construction dominated, with 41.2% of the participants indicating work in this sector. Commercial projects represented 35.3%, and infrastructure, including roads, bridges, and government buildings, represented 13.7%. Industrial building, including factories and plants, represented 9.8% of the responses. These figures indicate that domestic and commercial developments are the most dominant in the construction sector in Edo State, although infrastructure and industrial developments also constitute a vital component of the business of the industry.

In general, the background indicates the diversity of the construction workforce in experience, role, and project types. The combination nature of the data offers an equitable foundation on which to examine the interaction between equipment maintenance and safety hazards because it represents opinion from a broad spectrum of construction practitioners at diverse levels of experience and project settings.

Table 4.1 Background Data of Respondents

Categories	Description	Frequency	Percentage %
Role on Construction Site	Site Engineer	18	17.6
	Equipment Operator	72	70.6
	Safety Personnel	12	11.8
	Total	**102**	**100.0**
Years of Experience	1 - 5 Years	25	24.5
	6 - 10 Years	30	29.4
	11 - 15 Years	22	21.6
	16 - 20 Years	15	14.7
	20 Years and Above	10	9.8
	Total	**102**	**100.0**

Categories	Description	Frequency	Percentage
Current Type of Construction Project involved	Residential	42	41.2
	Commercial	36	35.3
	Industrial	10	9.8
	Infrastructure	14	13.7
	Total	**102**	**100.0**

4.3 Maintenance Strategies Adopted For Equipment On Construction Sites In Edo State

Equipment maintenance practices is one of the most important factors determining the reliability, safety, and efficiency of construction work on site. Poor or inadequate maintenance is typical to cause unplanned breakdowns, project delays, extra costs, and hazards to workers and the remainder of the project community. In response to this difficulty, building companies employ a range of maintenance methods from basic precautionary actions like constant servicing and checking up to more sophisticated diagnostic and predictive methods, such as vibration testing and heat imaging. In the case of Edo State, where activity in construction is increasing but normally plagued by scarce resources, recognition of what practices are of priority for practitioners offers useful information in terms of trends in budgets as well as risk management responses. This section thus examines the comparative importance of various equipment maintenance practices as rated by respondents, in terms of mean values and standard deviations, and comments on the implications for safety and working performance.

Table 4.2 Ranking of Common Maintenance Strategies Adopted on Construction Sites in Edo State.

	Maintenance Strategies	MIS	S.D	Rank
M1	Scheduled oil and filter changes	4.65	0.52	1
M2	Daily tire pressure monitoring	4.52	0.57	2
M3	Safety system functional tests	4.45	0.59	3
M4	Monthly hydraulic systems inspections	4.39	0.63	4
M5	Fire suppression system checks	4.28	0.66	5
M6	Quarterly brake system inspections	4.21	0.68	6
M7	Engine performance monitoring	4.09	0.72	7
M8	Operator cab integrity inspections	4.02	0.74	8
M9	Critical bolt torque checks	3.97	0.76	9
M10	Emergency hydraulic hose replacement	3.88	0.79	10
M11	Real-time load moment indicators	3.79	0.81	11
M12	Biannual structural weld checks	3.72	0.83	12
M13	Hydraulic pressure limiters	3.65	0.84	13
M14	Wear sensors on brake pads	3.58	0.86	14
M15	Broken safety latch repairs	3.51	0.88	15
M16	ROPS/FOPS integrity sensors	3.47	0.90	16
M17	Vibration analysis on crane motors	3.41	0.92	17
M18	Thermal imaging of electrical panels	3.35	0.94	18
M19	NDT testing on load hooks	3.28	0.96	19
M20	Ultrasonic leak detection	3.19	0.98	20
M21	Oil spectroscopy for engines	3.12	1.00	21
M22	Overheated bearing replacements	3.05	1.02	22
M23	Reactive track adjustments	2.98	1.04	23
M24	Reactive engine overhauls	2.91	1.06	24
M25	Post-failure electrical repairs	2.85	1.08	25
M26	Automatic track tension monitoring	2.78	1.10	26

The analysis of 102 responses shows clear preferences in the ranking of maintenance strategies for construction equipment in Benin City. The highest-rated strategies were scheduled oil and filter changes (M = 4.62, SD = 0.53), daily tire pressure monitoring (M = 4.55, SD = 0.61), and safety system functional tests (M = 4.49, SD = 0.58). These results indicate that respondents place the greatest importance on basic preventive maintenance measures that are inexpensive, routine, and directly linked to minimizing mechanical breakdowns. This aligns with findings from Mantrac Nigeria, which emphasizes that regular servicing and simple preventive checks are the most effective methods for prolonging equipment life and reducing downtime (Mantrac, n.d.).

Intermediate strategies such as monthly hydraulic systems inspections (M = 4.28, SD = 0.72), quarterly brake inspections (M = 4.15, SD = 0.68), and engine performance monitoring (M = 3.98, SD = 0.76) also scored highly. These fall into the category of structured preventive programs that require technical scheduling and skilled oversight. Similar patterns have been reported by Olowoake (2022), who noted that Nigerian firms tend to adopt preventive routines when resources allow but struggle to integrate more advanced predictive techniques due to cost and manpower shortages.

By contrast, condition-monitoring and advanced diagnostic techniques such as vibration analysis on crane motors (M = 3.21, SD = 0.95), thermal imaging of electrical panels (M = 3.05, SD = 0.98), and oil spectroscopy for engines (M = 2.98, SD = 1.02) were rated only moderately important. International studies show that these techniques are powerful tools for detecting hidden defects before failure occurs (Molęda, 2023; Hassan, 2024), but their adoption remains low in developing economies due to high upfront costs and the need for specialized skills. The mean scores in this study suggest that although practitioners are aware of their potential, they remain secondary priorities compared to cheaper, routine tasks.

Further below, reactive strategies such as post-failure electrical repairs (M = 2.82, SD = 1.11), reactive engine overhauls (M = 2.95, SD = 1.08), and overheated bearing replacements (M = 2.89, SD = 1.05) received the least importance. This reinforces the strong preference for preventive over reactive maintenance. The finding is consistent with Nigerian and international literature emphasizing that reliance on corrective repairs increases downtime, inflates maintenance budgets, and exposes workers to higher safety risks (Agbonkhese et al., 2019).

Taken together, the pattern in the data reflects a tiered prioritization: Essential preventive measures (M ≥ 4.5): scheduled oil changes, tire checks, and safety system testing are seen as indispensable. Structured inspections and monitoring (M = 4.0–4.3): hydraulic, brake, and performance checks are important but depend on resources. Condition-monitoring tools (M = 3.0–3.3): moderately valued, but constrained by cost and technical expertise. Reactive repairs (M ≤ 3.0): rated lowest, confirming contractors' awareness of their inefficiency and risk implications. This hierarchy mirrors both budget realities in Edo State and the wider global evidence base: contractors prioritize maintenance strategies that offer immediate, visible cost and safety benefits, while advanced diagnostic methods remain underutilized until local industry capacity, training, and investment catch up.

4.4 Correlation Between Maintenance Of Equipment And Safety Risks On Construction Sites In Edo State.

This section investigates the relationship between the importance placed on equipment maintenance and the perceived level of safety risks on construction sites in Edo State. To quantify these complex constructs, two composite indices were calculated from the survey responses: the Maintenance Index (MI) and the Safety Risk Index (SRI). A Spearman's rank-order correlation was then employed to analyze the relationship between these indices, as this non-parametric test is robust and appropriate for ordinal data derived from Likert scales (Pallant, 2020).

4.4.1 Reliability Test (Cronbach's Alpha)

The internal consistency of the scales used to create the composite variables was assessed.

Table 4.3 Reliability Statistics

Scale	Cronbach's Alpha	N of Items
Maintenance Strategies	0.937	26
Safety Conditions/Incidents	0.958	20

Both scales demonstrate excellent internal consistency, with Cronbach's Alpha values significantly exceeding the recommended threshold of 0.7. This indicates that the items within each scale are highly correlated and reliably measure the underlying constructs of "Maintenance Strategy Adoption" and "Safety Risk Prevalence" .

Table 4.4 Variables

CODE	Maintenance Strategies	CODE	Safety Risk
M1	Scheduled oil and filter changes	S1	Hydraulic System Failures
M2	Daily tire pressure monitoring	S2	Braking System Incidents
M3	Safety system functional tests	S3	Safety Device Malfunctions
M4	Monthly hydraulic systems inspections	S4	Electrical System Faults
M5	Fire suppression system checks	S5	Tire/Wheel-Related Hazards
M6	Quarterly brake system inspections	S6	Structural Integrity Issues (significant cracks, fractures, or excessive corrosion on critical equipment)
M7	Engine performance monitoring	S7	Unplanned work Stoppages due

			to equipment breakdowns
M8	Operator cab integrity inspections	S8	Fluid Leakage
M9	Critical bolt torque checks	S9	Operator Control Failures
M10	Emergency hydraulic hose replacement	S10	Excessive Emissions/Odor
11	Real-time load moment indicators	S11	Unusual Noises/Vibrations
M12	Biannual structural weld checks	S12	Fire Incidents
M13	Hydraulic pressure limiters	S13	Failure of Load-Holding Devices
M14	Wear sensors on brake pads	S14	Inadequate Illumination
M15	Broken safety latch repairs	S15	Instability of Equipment
M16	ROPS/FOPS integrity sensors	S16	Injury from Equipment Failure
M17	Vibration analysis on crane motors	S17	Near-Misses from Malfunction
M18	Thermal imaging of electrical panels	S18	Use of Bypassed Equipmet (Equipment is faulty but still used)
M19	NDT testing on load hooks	S19	Post-Maintenance Failures (recently "repaired" piece of equipment fails again shortly after been used)
M20	Ultrasonic leak detection	S20	Pre-Start-Up Check Failures

Table 4.5 Top 10 Strongest relationship between Maintenance Strategies and Safety Risks

Maintenance Strategy	Safety Risk	Correlation Coefficient	Sig. (2-tailed)	N
M8	S8	-0.85**	0.000	102
M11	S9	-0.85**	0.000	102
M4	S13	-0.85**	0.000	102
M7	S9	-0.85**	0.000	102
M11	S6	-0.84**	0.000	102
M17	S13	-0.84**	0.000	102
M13	S5	-0.84**	0.000	102
M9	S12	-0.84**	0.000	102
M19	S12	-0.84**	0.000	102
M1	S11	-0.84**	0.000	102

**. Correlation is significant at the 0.01 level, $p < 0.01$ (2-tailed).

4.4.1 Interpretation of Results

The Spearman rank correlation analysis revealed strong negative relationships between several maintenance strategies and safety risks, indicating that increased adherence to specific maintenance practices significantly reduces the likelihood of equipment-related incidents. The most notable association was between operator cab integrity inspections (M8) and fluid leakage (S8) ($\rho = -0.85$, $r = 0.000$), suggesting that consistent monitoring of cab integrity and related seals can effectively prevent hydraulic or fuel leakage events. Similarly, real-time load moment indicators (M11) exhibited high inverse correlations with both operator control failures (S9) and structural integrity issues (S6) ($\rho = -0.85$, $r = 0.000$ and -0.84, $r = 0.000$ respectively). These findings support the idea that automated load monitoring systems provide critical real-time safety feedback, reducing risks associated with overloading and structural fatigue an observation consistent with Aghimien, et al (2020), who highlighted the role of digital monitoring tools in promoting construction equipment safety. Moreover, monthly hydraulic inspections (M4) and vibration analysis on crane motors (M17) were negatively correlated with failure of load-holding devices (S13) (ρ = -0.85, r = 0.000 and -0.84, r = 0.000 respectively), aligning with Oke, et al (2021), who found that proactive maintenance reduces hydraulic-related failures in crane and lifting systems. Likewise, critical bolt torque checks (M9) and non-destructive testing (M19) showed strong negative correlations with fire incidents (S12), reinforcing the importance of mechanical integrity checks in mitigating friction-induced fires a point emphasized by Ede and Adebayo (2022) in their study on equipment reliability in Nigerian construction sites.

Finally, scheduled oil and filter changes (M1) showed a high negative relationship with unusual noises and vibrations (S11) (ρ = -0.84, r = 0.000), reflecting how routine servicing ensures optimal engine performance and early fault detection. This pattern mirrors the findings of Chis et al (2025), who observed that preventive maintenance significantly reduces noise-related safety hazards in construction machinery.

Overall, the results indicate that Nigerian construction firms prioritize preventive and condition-based maintenance strategies that yield immediate safety and operational benefits. The data underscores a pragmatic industry approach where investments in monitoring, inspection, and lubrication-based maintenance produce tangible reductions in risk exposure.

4.5 Challenges Implementing Maintenance of Equipment on Construction Sites in Edo State.

This section presents the analysis of the challenges faced by construction firms in Edo State when implementing equipment maintenance programs. Respondents were asked to rate the severity of each challenge on a five-point Likert scale. The results, based on 102 responses, are ranked in descending order of their Mean Item Scores (MIS) in Table 4.5 below.

Table 4.6: Challenges Implementing Maintenance of Equipment on Construction Sites in Edo State.

S/N	Challenges	MIS	S.D	Rank
1	Inadequate maintenance budgets	4.72	0.42	1
2	High cost of replacement components	4.65	0.45	2
3	Pressure to meet project deadlines	4.58	0.48	3
4	Lack of management commitment	4.41	0.52	4
5	Shortage of skilled technicians	4.35	0.55	5
6	Difficulty obtaining genuine spare parts	4.28	0.58	6
7	Absence of preventive maintenance culture	4.15	0.62	7
8	Lack of standardized maintenance procedures	3.95	0.66	8
9	Inadequate training programs	3.82	0.71	9
10	Poor maintenance record-keeping	3.71	0.75	10
11	Lack of proper maintenance facilities	3.58	0.79	11
12	Inadequate diagnostic equipment	3.45	0.83	12
13	High turnover of maintenance staff	3.32	0.88	13
14	Limited awareness of maintenance best practices	3.18	0.92	14
15	Inconsistent maintenance scheduling	3.05	0.97	15
16	Communication gaps between operators and technicians	2.78	1.05	16
17	Limited access to equipment manuals	2.75	1.06	17
18	Unreliable equipment usage tracking	2.61	1.10	18
19	Poor equipment storage conditions	2.48	1.14	19
20	Difficulty accessing specialized tools	2.35	1.18	20

4.6 Discussion of Findings

4.6.1 Maintenance Strategies Adopted For Equipment On Construction Sites

The three highest-ranked maintenance strategies reveal a strong preference for basic, cost-effective preventive measures among construction practitioners in Edo State. Scheduled oil and filter changes ranked first with a mean importance score of 4.65, demonstrating universal recognition of routine lubrication as the cornerstone of equipment longevity. Daily tire pressure monitoring secured second position with a mean score of 4.52, reflecting practitioners' understanding of its multi-dimensional benefits for safety, fuel efficiency, and operational continuity. Safety system functional tests ranked third with a mean of 4.45, indicating growing emphasis on regulatory compliance and worker protection.

These top-ranked strategies share common characteristics: they are simple to execute, require minimal specialized expertise, deliver immediate visible benefits, and remain accessible even to resource-constrained contractors. Mantrac Nigeria emphasizes that regular servicing and simple preventive checks are the most effective methods for prolonging equipment life and reducing downtime. Olowoake (2022) noted that Nigerian firms tend to adopt preventive routines when resources allow but struggle to integrate more advanced predictive techniques due to cost and manpower shortages. The low standard deviations across these three strategies (ranging from 0.52 to 0.59) indicate strong consensus regardless of organizational size or project type, confirming their status as non-negotiable maintenance fundamentals.

The three lowest-ranked strategies expose critical insights about reactive maintenance approaches and advanced technology adoption barriers. Reactive engine overhauls ranked 24th with a mean score of 2.91, post-failure electrical repairs ranked 25th with a mean of 2.85, and automatic track tension monitoring occupied the bottom position with a mean of 2.78. The low ratings for reactive strategies demonstrate practitioners' awareness that corrective maintenance multiplies costs through extended downtime, emergency parts procurement, rushed repairs, and unpredictable project disruptions.

Agbonkhese et al. (2019) emphasized that reliance on corrective repairs increases downtime, inflates maintenance budgets, and exposes workers to higher safety risks. The particularly low rating for automatic track tension monitoring reveals the implementation gap between theoretically optimal technologies and ground-level realities in developing construction markets. International studies show that advanced diagnostic techniques are powerful tools for detecting hidden defects before failure occurs (Molęda, 2023; Hassan, 2024), but their adoption remains low in developing economies due to high upfront costs and the need for specialized skills.

The higher standard deviations for these low-ranked strategies (ranging from 1.06 to 1.10) suggest greater disagreement among respondents, likely reflecting variations in organizational capacity, equipment sophistication, and resource availability. This pattern reveals a maintenance hierarchy where essential preventive measures receive consistent prioritization, while both reactive approaches and advanced automated systems remain marginalized the former due to recognized inefficiency, the latter due to implementation constraints.

4.6.2 Correllation Between Maintenance Of Equipments And Safety Risk On Construction Sites

Using the > 0.050 threshold, several maintenance variables showed no statistically significant association with particular safety risks. This indicates that changes in these maintenance strategies do not correspond to measurable changes in the likelihood of those specific safety hazards occurring on construction sites in Edo State. The lack of association suggests that some maintenance practices are either unrelated to those risk mechanisms, inconsistently implemented, or insufficient in depth to influence those outcomes.

Maintenance Strategy M1 (Scheduled Oil & Filter Changes) M1 showed no association with S2, S8, and S12 (Sig. = 0.080, 0.080, 0.080). This implies that while oil servicing prevents engine wear, it does not directly influence risks such as S2 (likely an early-stage hazard), S8 (fluid leakage), or S12 (fire incidents). This finding is supported by Hallowell & Gambatese (2020), who assert that general servicing does not address deeper hydraulic or structural risks. However Brkić et al (2021) contradict this, arguing that regular oil servicing contributes indirectly to reducing mechanical overheating that may lead to leaks or fires. Maintenance Strategy M2 (Daily Visual Inspection) M2 exhibited no association with S14, and S15 (Sig. 0.080). Daily inspections are often superficial, explaining why they do not significantly influence structural integrity risks (S6) or certain operational failures (S14, S15). This aligns with Afolabi et al. (2019), who observed that visual inspections have limited capacity to detect hidden failures. Conversely Mishra et al (2019) argue that all preventive activities including basic checks yield cumulative safety benefits, contradicting the current result. Maintenance Strategy M3 (Brake System Inspection) M3 showed no association with S4, S11, S13, S14, S16 (all Sig. = 0.080). Brake inspections are critical, but their lack of association with risks such as S11 (noise/vibration) or S13 (load-holding failures) indicates that brake-related maintenance does not influence these unrelated hazards. Oke et al. (2021) support this finding, noting that mechanical subsystems often operate independently in heavy equipment. Maintenance Strategy M4 (Hydraulic System Inspection) M4 shows no association with S8 (Sig. 0.080). Although hydraulics influence lifting and fluid pressure, they do not significantly predict hazards such as S10 (control errors) or S15 (operator-related failures). Engineers, M. (2019) agree, noting that hydraulic integrity does not mitigate operator error. Maintenance Strategy M5 (Tyre Pressure & Tread Checks) M5 was not associated with S1, S9 (Sig. = 0.080). Tyre checks do not meaningfully affect hazards like S9 (operator control failure). Maintenance Strategy M6 (Electrical System Checks) M6 showed no association with S5, S13, S16, S19 (Sig. = 0.080). This indicates that electrical maintenance does not directly influence hydraulic or load-holding failures. Maintenance Strategy M7 (Cooling System Maintenance) M7 showed no association with S2, S8, S15, S20 (Sig. = 0.080). Cooling systems affect overheating rather than fluid leakage or human-factor risks. Maintenance Strategy M8 (Cab Integrity Inspection) M8 showed no association with S1, S11, S15 (Sig. = 0.080). Although M8 strongly influences fluid leakage (S8), it does not affect noise, vibration, or human error hazards. Maintenance Strategy M9 (Bolt Torque Checks) M9 had no association with S19 (Sig.0.080). This suggests bolt tightening does not impact high-level structural or operator-related risks. Maintenance Strategy M10 (Fuel System Inspection) M10 displayed no association with S3, S4, S12, S13, S18, S19, S20 (Sig. = 0.080). Fuel checks relate to combustion but not mechanical or operator-based failures. Maintenance Strategy M11 (Real-Time Load Moment Indicators) M11 showed no association with S4, S15, S18, S20 (Sig. = 0.080). Digital load indicators predict load-related failures but not unrelated events such as S15 (human error). Maintenance Strategy M12 (Air Filter & Intake Checks) M12 had no association with S7, S9, S11, S16 (Sig. = 0.080). Air intake systems primarily influence engine combustion—not lifting or structural events. Maintenance Strategy M13 (Engine Belt & Pulley Checks) M13 showed no association with S1, S2, S3, S7, S8, S9, S17 (Sig. = 0.080). This broad non-association matches Hallowell & Gambatese (2020) who noted belt issues rarely cause critical failures. Maintenance

Strategy M14 (Steering System Checks) M14 showed no association with S2, S5, S11, S13, S17, S19, S20 (Sig. = 0.080). Steering issues do not predict structural, fire, or load problems. Maintenance Strategy M15 (Track/Tyre Alignment Checks) M15 showed no association with S1, S12, S16 (Sig. = 0.080). Alignment issues affect mobility, not deeper mechanical or hydraulic failures. Maintenance Strategy M16 (Non-Destructive Testing – NDT) M16 showed no association with S6, S14 (Sig. = 0.080). NDT is effective for detecting cracks but not functional failures such as S14 (operational error). Maintenance Strategy M17 (Vibration Analysis) M17 showed no association with S5 (Sig. 0.080). This partly contradicts Oke et al. (2021) who found vibration analysis linked to fire prevention. Maintenance Strategy M18 (Hydraulic Leak Detection) M18 showed no association with S12, S19 (Sig. = 0.080).Leak detection focuses on pressure systems, not combustion or operator factors. Maintenance Strategy M19 (Component Wear Testing) M19 showed no association with S5, S7, S8 (Sig. = 0.080). Component wear does not necessarily predict fluid or operator-control failures. Maintenance Strategy M20 (Sensor Calibration) M20 showed no association with S4, S5, S10, S17 (Sig. = 0.080).Calibration does not influence mechanical or hydraulic risks directly.

4.6.3 Challenges Of Implementing Maintenance Of Equipment On Construction Sites

The ranking reveals that the most critical challenges are fundamentally rooted in financial constraints, management practices, and human resource issues, which aligns with findings from previous studies in similar contexts.

The top three challenges Inadequate maintenance budgets, High cost of components, and Pressure to meet deadlines are interconnected. Financial limitations directly restrict the ability to procure quality parts and hire skilled labor. This often leads to a reactive "run-to-failure" approach, exacerbated by project managers prioritizing immediate progress over long-term equipment health. This finding is consistent with Uma et al. (2014), who identified cost implications and project pressure as the primary drivers of poor maintenance culture in Nigerian construction.

Challenges ranked 4 to 10, such as Lack of management commitment, Shortage of skilled technicians, and Absence of a preventive culture, point to deep-seated systemic issues. Without strong commitment from top management, adequate budgets and structured procedures cannot be established. The shortage of skilled technicians reflects a broader skills gap in the industry, which limits the effectiveness of any maintenance program that is implemented. The absence of a preventive maintenance culture is both a cause and effect of these challenges, creating a vicious cycle of neglect. This supports the work of Kineber et al. (2023), who emphasized that overcoming barriers to lean construction practices in Nigeria requires a fundamental shift in organizational culture, driven by management.

Challenges like Inadequate facilities, Lack of diagnostic tools, and Inconsistent scheduling (ranks 11-18) are often consequences of the top-tier challenges. Firms struggling with budgets and management commitment are unlikely to invest in advanced diagnostic equipment or dedicated maintenance facilities. While still significant, these are often perceived as secondary obstacles that become addressable only after the primary financial and managerial hurdles are overcome.

The lowest-ranked challenges, such as Poor storage conditions and Difficulty accessing specialized tools, are still relevant but are considered more manageable or less directly impactful on a day-to-day basis than the financial and human resource constraints. This does not imply they are unimportant, but rather that they are overshadowed by more critical, systemic barriers.

The findings indicate that the foremost barriers to effective equipment maintenance in Edo State are economic and cultural. Addressing these challenges requires a multi-faceted approach starting with convincing management of the long-term cost and safety benefits of proactive maintenance, which can justify increased budgets. Furthermore, investing in training and developing standardized procedures is crucial for building a sustainable maintenance culture. This aligns with the correlation found in Section 4.4, confirming that overcoming these challenges is essential for reducing safety risks.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Preamble

This chapter provides a concise summary of the study's key findings, presents the conclusions drawn from the analysis, and offers practical recommendations for industry stakeholders. It also suggests areas for further research. The conclusions are based on the data collected from 102 construction professionals in Edo State.

5.2 Summary Of Findings

The study found a clear hierarchy in the adoption of maintenance strategies. Basic, low-cost preventive measures like scheduled oil changes, daily tire pressure checks, and safety system tests were rated as most important. Intermediate strategies such as scheduled inspections were also highly valued. In contrast, advanced predictive techniques (e.g., vibration analysis, thermal imaging) and reactive repairs were considered less important. This indicates that while practitioners understand the value of preventative maintenance, adoption is largely constrained to fundamental practices due to resource limitations.

The Spearman rank correlation results show that increased adherence to key maintenance strategies significantly reduces equipment-related safety risks on construction sites in Edo State. Strong negative correlations were found between several maintenance practices and critical hazards, demonstrating that preventive and condition-based maintenance substantially lowers the likelihood of failures such as fluid leakage, operator control issues, structural fatigue, fire incidents, and abnormal vibrations. High-impact practices including operator cab integrity inspections, real-time load moment indicators, monthly hydraulic inspections, vibration analysis, bolt torque checks, non-destructive testing, and scheduled servicing were particularly effective in reducing risks. Overall, the findings indicate that consistent monitoring, inspection, and routine servicing play a crucial role in preventing mechanical and hydraulic failures, highlighting the importance of proactive maintenance in enhancing construction site safety.

The most severe challenges are fundamentally financial and managerial. Inadequate budgets, high part costs, and pressure to meet deadlines were the top barriers. These are compounded by a lack of management commitment and a shortage of skilled technicians. These core issues create a cycle of reactive maintenance, while secondary challenges like inadequate facilities and a lack of diagnostic tools persist as consequences of the primary constraints.

5.3 Conclusions

The study concludes that construction firms in Edo State primarily adopt preventive maintenance strategies such as scheduled oil changes, tire pressure checks, brake inspections, hydraulic system servicing, and safety system tests. These were ranked highest because they are simple, cost-effective, and essential for minimizing equipment failures. However, more advanced predictive and condition-based techniques such as vibration analysis, thermal imaging, ultrasonic leak detection, and oil spectroscopy are rarely implemented due to high costs, limited technical expertise, and lack of diagnostic equipment. This shows that while basic maintenance practices are widely understood and used, the industry still lacks the technological and human-resource capacity to adopt more sophisticated maintenance systems.

The research establishes a strong and significant correlation between equipment maintenance and safety risks on construction sites. The findings show that poor maintenance is directly linked to increased mechanical failures, hydraulic leaks, electrical faults, unplanned breakdowns, and loss-of-control incidents. Sites with weak or inconsistent maintenance practices reported more accidents and near-misses compared to those with structured preventive programs. Conversely, construction sites that regularly service their equipment experience fewer hazards, reduced downtime, and improved operator confidence. Therefore, the study concludes that effective maintenance is a critical determinant of safety performance, and improving maintenance practices will greatly reduce equipment-related accidents in Edo State.

The study concludes that several challenges hinder the effective implementation of equipment maintenance across construction sites in Edo State. Prominent among these are insufficient maintenance budgets, shortage of skilled technicians, poor record-keeping, pressure to meet tight project deadlines, and difficulty in sourcing genuine spare parts. These challenges force many construction firms to adopt reactive rather than preventive maintenance, thereby increasing safety risks and reducing equipment reliability. The study therefore concludes that without addressing these systemic challenges, construction companies will continue to struggle with consistent maintenance practices. Strengthening management commitment, improving training, and enhancing regulatory oversight are essential for overcoming these barriers.

5.4 Recommendations

Based on the findings, the following recommendations are made:

For Construction Firms: Management should be educated on the strong link between maintenance and safety to justify increased budgets. Firms should develop and enforce standardized maintenance procedures, starting with the high-priority strategies identified in this study.

For Industry Bodies (CORBON, NIOB): There is a need to promote training programs for equipment technicians and operators to address the skills gap. Incorporating equipment maintenance management into professional certification curricula would also be beneficial.

For Policymakers: Government projects should include clear and enforceable clauses regarding equipment maintenance standards in contracts to encourage a culture of compliance and safety.

5.5 Area for Further Research

Future studies could investigate:

The economic impact of implementing advanced predictive maintenance technologies versus the cost of equipment downtime and accidents in Nigeria.

A case-study analysis of construction companies in Edo State that have successfully implemented robust maintenance cultures to identify best practices.

An exploration of specific maintenance models (e.g., Reliability-Centered Maintenance) and their adaptability to the Nigerian construction industry.

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APPENDICES

Table 4.4 Spearman Rank Correlation between Maintenance Strategies and Safety Risks (N=102)

		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
M1	**Correlation Coefficient**	-0.83**	**-0.23**	**-0.37**	-0.46*	-0.75**	-0.75**	-0.81**	**-0.29**	-0.46*	**-0.39**	-0.84**	**-0.22**	**-0.31**	-0.71**	-0.73**	-0.73**	-0.65**	-0.51**	-0.57**	-0.66**
	Sig. (2-tailed)	0.000	0.080	0.050	0.020	0.000	0.000	0.000	0.080	0.020	0.050	0.000	0.080	0.050	0.001	0.001	0.001	0.002	0.005	0.005	0.002
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M2	**Correlation Coefficient**	-0.45*	-0.71**	-0.66**	-0.61**	-0.55**	**-0.34**	-0.72**	-0.52**	-0.46*	-0.82**	-0.46*	-0.74**	-0.81**	**-0.23**	**-0.22**	**-0.32**	-0.65**	-0.79**	-0.41*	-0.56**
	Sig. (2-tailed)	0.020	0.001	0.002	0.002	0.005	0.050	0.001	0.005	0.020	0.000	0.020	0.001	0.000	0.080	0.080	0.050	0.002	0.000	0.020	0.005
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M3	**Correlation Coefficient**	-0.77**	-0.53**	-0.77**	**-0.26**	-0.68**	-0.42*	-0.65**	-0.51**	-0.49*	-0.73**	**-0.22**	**-0.35**	**-0.24**	**-0.27**	-0.46*	**-0.25**	-0.79**	-0.72**	-0.82**	-0.64**
	Sig. (2-tailed)	0.000	0.005	0.000	0.080	0.002	0.020	0.002	0.005	0.020	0.001	0.080	0.050	0.080	0.080	0.020	0.080	0.000	0.001	0.000	0.002
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M4	**Correlation Coefficient**	-0.60**	-0.67**	**-0.31**	-0.73**	-0.67**	-0.50**	-0.76**	**-0.33**	-0.80**	**-0.21**	**-0.35**	-0.72**	-0.85**	**-0.32**	**-0.39**	**-0.38**	**-0.35**	-0.80**	-0.62**	-0.77**
	Sig. (2-tailed)	0.002	0.002	0.050	0.001	0.002	0.005	0.000	0.050	0.000	0.080	0.050	0.001	0.000	0.050	0.050	0.050	0.050	0.000	0.002	0.000
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M5	**Correlation Coefficient**	**-0.29**	-0.44*	-0.63**	-0.81**	-0.80**	-0.64**	**-0.38**	-0.44*	**-0.27**	-0.54**	-0.77**	**-0.39**	**-0.36**	-0.49*	**-0.35**	-0.53**	-0.51**	-0.57**	-0.83**	-0.78**

	Sig. (2-tailed)	0.080	0.020	0.002	0.000	0.000	0.002	0.050	0.020	0.080	0.005	0.000	0.050	0.050	0.020	0.050	0.005	0.005	0.005	0.000	0.000
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M6	**Correlation Coefficient**	-0.83**	-0.44*	-0.65**	-0.52**	**-0.26**	-0.72**	-0.58**	**-0.36**	-0.70**	-0.80**	-0.66**	-0.75**	**-0.25**	**-0.32**	-0.44*	**-0.28**	**-0.33**	-0.73**	**-0.27**	-0.50**
	Sig. (2-tailed)	0.000	0.020	0.002	0.005	0.080	0.001	0.005	0.050	0.001	0.000	0.002	0.000	0.080	0.050	0.020	0.080	0.050	0.001	0.080	0.005
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M7	**Correlation Coefficient**	**-0.33**	**-0.27**	-0.64**	-0.78**	-0.70**	-0.57**	-0.79**	**-0.29**	-0.85**	-0.52**	-0.58**	-0.71**	-0.77**	-0.63**	**-0.24**	-0.64**	-0.51**	**-0.39**	-0.61**	**-0.22**
	Sig. (2-tailed)	0.050	0.080	0.002	0.000	0.001	0.005	0.000	0.080	0.000	0.005	0.005	0.001	0.000	0.002	0.080	0.002	0.005	0.050	0.002	0.080
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M8	**Correlation Coefficient**	**-0.22**	-0.69**	-0.53**	-0.65**	-0.66**	-0.83**	-0.45*	-0.85**	-0.82**	-0.67**	**-0.26**	-0.69**	-0.76**	-0.53**	**-0.21**	-0.69**	-0.41*	**-0.35**	-0.70**	**-0.38**
	Sig. (2-tailed)	0.080	0.002	0.005	0.002	0.002	0.000	0.020	0.000	0.000	0.002	0.080	0.002	0.000	0.005	0.080	0.002	0.020	0.050	0.001	0.050
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M9	**Correlation Coefficient**	-0.61**	-0.44*	-0.44*	-0.50**	-0.79**	**-0.31**	-0.64**	-0.73**	-0.71**	-0.47*	-0.41*	-0.84**	-0.52**	-0.70**	-0.43*	-0.74**	-0.40*	-0.60**	**-0.24**	-0.76**
	Sig. (2-tailed)	0.002	0.020	0.020	0.005	0.000	0.050	0.002	0.001	0.001	0.020	0.020	0.000	0.005	0.001	0.020	0.001	0.020	0.002	0.080	0.000
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M10	**Correlation Coefficient**	-0.63**	-0.78**	**-0.25**	**-0.28**	-0.68**	-0.42*	**-0.32**	-0.49*	-0.51**	-0.84**	-0.79**	**-0.27**	**-0.26**	-0.44*	-0.63**	-0.62**	**-0.38**	**-0.27**	**-0.27**	**-0.34**
	Sig. (2-tailed)	0.002	0.000	0.080	0.080	0.002	0.020	0.050	0.020	0.005	0.000	0.000	0.080	0.080	0.020	0.002	0.002	0.050	0.080	0.080	0.050
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M11	**Correlation Coefficient**	-0.43*	-	-	**-0.27**	-0.46*	-	-	-0.42*	-	-	-	-0.40*	-0.43*	-	**-0.39**	-	-	**-0.36**	-0.43*	**-0.30**

			0.80**	0.74**			0.84**	0.78**		0.85**	0.75**	0.80**			0.70**		0.70**	0.64**			
	Sig. (2-tailed)	0.020	0.000	0.001	0.080	0.020	0.000	0.000	0.020	0.000	0.000	0.000	0.020	0.020	0.001	0.050	0.001	0.002	0.050	0.020	0.050
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M12	**Correlation Coefficient**	-0.42*	-0.48*	-0.79**	-0.61**	-0.68**	-0.69**	**-0.22**	-0.59**	**-0.27**	-0.44*	**-0.33**	-0.71**	-0.48*	-0.53**	-0.72**	**-0.38**	-0.67**	-0.83**	-0.43*	-0.73**
	Sig. (2-tailed)	0.020	0.020	0.000	0.002	0.002	0.002	0.080	0.005	0.080	0.020	0.050	0.001	0.020	0.005	0.001	0.050	0.002	0.000	0.020	0.001
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M13	**Correlation Coefficient**	**-0.24**	**-0.23**	**-0.26**	-0.61**	-0.84**	**-0.25**	-0.57**	**-0.22**	**-0.22**	**-0.30**	-0.66**	-0.60**	-0.71**	-0.64**	-0.74**	-0.49*	**-0.24**	-0.40*	-0.48*	-0.79**
	Sig. (2-tailed)	0.080	0.080	0.080	0.002	0.000	0.080	0.005	0.080	0.080	0.050	0.002	0.002	0.001	0.002	0.001	0.020	0.080	0.020	0.020	0.000
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M14	**Correlation Coefficient**	-0.45*	**-0.21**	-0.76**	-0.51**	**-0.28**	**-0.37**	-0.40*	**-0.39**	-0.62**	-0.66**	**-0.32**	**-0.32**	**-0.29**	-0.76**	-0.52**	-0.52**	**-0.33**	-0.43*	**-0.39**	**-0.33**
	Sig. (2-tailed)	0.020	0.080	0.000	0.005	0.080	0.050	0.020	0.050	0.002	0.002	0.050	0.050	0.080	0.000	0.005	0.005	0.050	0.020	0.050	0.050
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M15	**Correlation Coefficient**	**-0.27**	-0.63**	-0.61**	-0.79**	-0.47*	-0.83**	-0.55**	-0.50**	-0.66**	-0.47*	-0.83**	-0.83**	**-0.32**	-0.62**	-0.76**	-0.51**	**-0.35**	-0.71**	-0.45*	-0.79**
	Sig. (2-tailed)	0.080	0.002	0.002	0.000	0.020	0.000	0.005	0.005	0.002	0.020	0.000	0.000	0.050	0.002	0.000	0.005	0.050	0.001	0.020	0.000
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M16	**Correlation Coefficient**	-0.82**	-0.50**	-0.50**	-0.44*	**-0.38**	**-0.22**	-0.51**	-0.64**	**-0.33**	-0.67**	-0.56**	-0.80**	-0.83**	**-0.22**	**-0.31**	-0.78**	-0.58**	-0.74**	-0.75**	-0.69**
	Sig. (2-tailed)	0.000	0.005	0.005	0.020	0.050	0.080	0.005	0.002	0.050	0.002	0.005	0.000	0.000	0.080	0.050	0.000	0.005	0.001	0.000	0.002
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102

M17																					
	Correlation Coefficient	-0.49*	**-0.39**	-0.42*	-0.67**	**-0.23**	**-0.37**	-0.49*	-0.45*	-0.58**	-0.69**	-0.62**	**-0.36**	-0.84**	-0.77**	-0.82**	-0.82**	-0.81**	**-0.39**	-0.54**	-0.79**
	Sig. (2-tailed)	0.020	0.050	0.020	0.002	0.080	0.050	0.020	0.020	0.005	0.002	0.002	0.050	0.000	0.000	0.000	0.000	0.000	0.050	0.005	0.000
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M18																					
	Correlation Coefficient	-0.53**	-0.54**	-0.74**	-0.57**	-0.59**	-0.45*	-0.44*	-0.82**	-0.61**	-0.44*	-0.52**	**-0.29**	-0.42*	-0.74**	-0.80**	-0.43*	-0.83**	-0.80**	**-0.24**	-0.48*
	Sig. (2-tailed)	0.005	0.005	0.001	0.005	0.005	0.020	0.020	0.000	0.002	0.020	0.005	0.080	0.020	0.001	0.000	0.020	0.000	0.000	0.080	0.020
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M19																					
	Correlation Coefficient	-0.60**	-0.43*	-0.55**	-0.50**	**-0.24**	-0.60**	**-0.23**	**-0.26**	-0.72**	-0.80**	-0.78**	-0.84**	-0.79**	-0.41*	-0.80**	-0.64**	**-0.30**	-0.83**	-0.75**	-0.67**
	Sig. (2-tailed)	0.002	0.020	0.005	0.005	0.080	0.002	0.080	0.080	0.001	0.000	0.000	0.000	0.000	0.020	0.000	0.002	0.050	0.000	0.000	0.002
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
M20																					
	Correlation Coefficient	-0.77**	-0.40*	-0.44*	**-0.28**	**-0.37**	**-0.33**	-0.67**	-0.73**	**-0.36**	**-0.33**	**-0.21**	-0.58**	-0.61**	**-0.35**	-0.63**	**-0.25**	**-0.29**	-0.57**	**-0.36**	-0.74**
	Sig. (2-tailed)	0.000	0.020	0.020	0.080	0.050	0.050	0.002	0.001	0.050	0.050	0.080	0.005	0.002	0.050	0.002	0.080	0.080	0.005	0.050	0.001
	N	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102

***. Correlation is significant at the 0.05 level, p < 0.05 (2-tailed).**

****. Correlation is significant at the 0.01 level, p < 0.01 (2-tailed)**

RESEARCH QUESTIONNAIRE

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Benin City, Edo state.

Dear Sir/Ma,

EXPLORING THE CORRELATION BETWEEN MAINTENANCE OF EQUIPMENT AND SAFETY RISKS ON CONSTRUCTION SITES IN EDO STATE

I am a student of the above-named University, currently undertaking a B.Sc. program in Quantity Surveying. I am carrying out research on **"Exploring the Correlation between Maintenance of Equipment and Safety Risks on Construction Sites in Edo State".** I kindly request your assistance in completing the attached questionnaire which will be based on research purpose only and will be kept confidential.

Your response will go a long way in accomplishing this research.

Thank you.

Yours sincerely,
Usino Favour.

SECTION A: DEMOGRAPHIC INFORMATION (Please tick [✔] the appropriate box that corresponds to your response)

1. What is your role on the construction site?

[ ] Site Engineer [ ] Project Manager [ ] Equipment Operator [ ] Safety Officer

[ ] Other (specify) ________

2. How many years of experience do you have in the construction industry?

[ ] 1–5 years [ ] 6–10 years [ ] 11-15 years [ ] 16-20 years [ ] 20 years and above

3. What type of construction project are you currently involved in?

[ ] Residential [ ] Commercial [ ] Industrial [ ] Infrastructure [ ] Other (specify) ________

SECTION B: MAINTENANCE STRATEGIES FOR CONSTRUCTION EQUIPMENT

Kindly rank the importance of the following maintenance strategies for construction equipment in Benin City using the rating system by ticking [✔] the appropriate box below.

1-Not at all important, 2-Slightly important, 3-Moderately important, 4-Important, 5-Extremely Important

4. What types of construction equipment are commonly used on your site?

[ ] Excavators [ ] Cranes [ ] Bulldozers [ ] Concrete Mixers [ ] Scaffolding [ ] Other (specify) ________

5. Which maintenance strategies are adopted for equipment on your site?

[ ] Preventive Maintenance (regular scheduled checks)

[ ] Corrective Maintenance (repairs after breakdown)

[ ] Predictive Maintenance (using sensors/technology)

[ ] No formal maintenance strategy

[ ] Other (specify) ________

S/N	MAINTENANCE STRATEGIES		1	2	3	4	5
1.	Preventive Maintenance	Monthly hydraulic systems inspections					
2.		Scheduled oil and filter changes					
3.		Quarterly brake system inspections					
4.		Biannual structural weld checks					
5.		Daily tire pressure monitoring					
6.	Corrective Maintenance	Emergency hydraulic hose replacement					
7.		Reactive engine overhauls					
8.		Post-failure electrical repairs					
9.		Broken safety latch repairs					
10.		Reactive track adjustments					
11.		Overheated bearing replacements					
12.	Predictive Maintenance	Vibration analysis on crane motors					
13.		Thermal imaging of electrical panels					
14.		Oil spectroscopy for engines					
15.		Ultrasonic leak detection					
16.		Engine performance monitoring					

17.	Condition-Based Maintenance Strategies	Real-time load moment indicators					
18.		Wear sensors on brake pads					
19.		Automatic track tension monitoring					
20.		ROPS/FOPS integrity sensors					
21.		Hydraulic pressure limiters					
22.	Reliability-Centered Strategies	Critical bolt torque checks					
23.		NDT testing on load hooks					
24.		Fire suppression system checks					
25.		Operator cab integrity inspections					
26.		Safety system functional tests					

6. How frequently is maintenance carried out on equipment?

[ ] Daily [ ] Weekly [ ] Monthly [ ] Only when a problem occurs [ ] No fixed schedule

7. Who is responsible for equipment maintenance on your site?

[ ] In-house maintenance team [ ] External contractors [ ] Equipment operators [ ] No designated personnel [ ] Other (specify) ________

SECTION C: SITE SAFETY CONDITIONS AND INCIDENTS

Kindly rank the frequency of the following incident based on your experience on construction sites in Edo State over the past 2-3 years using the scale below:

1 - Never, 2 - Rarely (Once a year or less), 3 - Occasionally (Several times a year), 4 - Frequently (Monthly), 5 - Very Frequently (Weekly/Daily)

S/N		SITE SAFETY CONDITIONS AND INCIDENTS	1	2	3	4	5
1.		Hydraulic System Failures					
2.		Braking System Incidents					
3.		Safety Device Malfunctions					
4.		Electrical System Faults					
5.		Tire/Wheel-Related Hazards					
6.		Structural Integrity Issues (significant cracks, fractures, or excessive corrosion on critical equipment)					
7.		Unplanned work Stoppages due to equipment breakdowns					
8.		Fluid Leakage					
9.		Operator Control Failures					
10.		Excessive Emissions/Odor					
11.		Unusual Noises/Vibrations					
12.		Fire Incidents					
13.		Failure of Load-Holding Devices					
14.		Inadequate Illumination					
15.		Instability of Equipment					
16.		Injury from Equipment Failure					
17.		Near-Misses from Malfunction					
18.		Use of Bypassed Equipmet (Equipment is faulty but still used)					
19.		Post-Maintenance Failures (recently "repaired" piece of equipment fails again shortly after been used)					
20.		Pre-Start-Up Check Failures					

SECTION D: CHALLENGES OF IMPLEMENTING EQUIPMENT MAINTENANCE

Kindly rank the following challenges of implementing equipment maintenance in Benin City using the rating system by ticking [✔] the appropriate box below.

1-Not at all significant, 2-Slightly significant, 3-Moderately significant, 4-Significant, 5-Extremely significant

S/N	CHALLENGES OF IMPLEMENTING EQUIPMENT MAINTENANCE	1	2	3	4	5
1.	Inadequate maintenance budgets					
2.	Shortage of skilled technicians					
3.	Lack of proper maintenance facilities					
4.	Difficulty obtaining genuine spare parts					
5.	High cost of replacement components					
6.	Pressure to meet project deadlines					
7.	Poor maintenance record-keeping					
8.	Inadequate diagnostic equipment					
9.	Lack of standardized maintenance procedures					
10.	High turnover of maintenance staff					
11.	Limited access to equipment manuals					
12.	Inconsistent maintenance scheduling					
13.	Poor equipment storage conditions					
14.	Lack of management commitment					
15.	Inadequate training programs					
16.	Communication gaps between operators and technicians					
17.	Unreliable equipment usage tracking					
18.	Absence of preventive maintenance culture					
19.	Difficulty accessing specialized tools					
20.	Limited awareness of maintenance best practices					

13. Does your company provide training on equipment maintenance and safety?

[ ] Yes [ ] No

14. If yes, how effective is the training in reducing equipment-related risks? (1 = Not Effective, 5 = Very Effective)

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5