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DEPARTMENT OF CONSTRUCTION TECHNOLOGY AND MANAGEMENT

CONSTRUCTION EQUIPMENT MANAGEMENT PRACTICE IN ETHIOPIAN AIRLINES EXPANSION PROJECTS; A CASE OF CHINA COMMUNICATION CONSTRUCTION COMPANY IN ADDIS ABABA

BY: YESHI TEDLA W/MARIAM

SEPTEMBER 2025

ADDIS ABABA ETHIOPIA

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A Thesis Submitted to Addis College School of Graduate Studies in Partial Fulfillment for Degree of Masters of Science in Construction Technology and Management

BY: YESHI TEDLA

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DECLARATION

I, the undersigned, declare that the study entitled "Assesses the construction equipment management practice in Ethiopian Airlines expansion project; the case of CCCC (China communication construction company)'' is the result of my own effort and study prepared under the guidance of Yetnayet Bihone (PhD. Candidate). This study not been submitted for any degree in any other university. All sources of material used for this thesis has been fully acknowledged and conducted for the partial fulfillment of the Degree of Master of Science in Construction Technology and Management.

Name- Yeshi Tedla

Signature ___________________

Date ___________________

Addis Ababa, Ethiopia

STATEMENT OF CERTIFICATION

This is to certify that Yeshi Tedla W/Mariam has carried out her project work entitled "Assesses the construction equipment management practice in Ethiopian Airlines expansion projects; the case of CCCC (China communication construction company)''. This work is original and is suitable for submission for the award of Master of Science in Construction Technology and Management.

Yetnayet Bihone (PhD Candidate)	________________	_________________
Advisor	Signature	Date

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ABSTRACT

Construction equipment is a critical asset in the delivery of modern infrastructure projects, representing a substantial share of overall costs and directly influencing productivity, safety, and quality outcomes. In large-scale projects such as the Ethiopian Airlines expansion in Addis Ababa, managed by China Communication Construction Company (CCCC), effective Construction Equipment Management (CEM) is vital for achieving time, cost, and performance targets. This study evaluates current CEM practices, examines factors affecting performance, measures time efficiency, and proposes best practices for improvement. A mixed-methods research approach was employed, combining quantitative and qualitative data to obtain a comprehensive understanding of CEM. Quantitative data were collected through structured questionnaires administered to purposively selected participants directly involved in equipment management, including project managers, engineers, and supervisors. Qualitative data were gathered through semi-structured interviews with key informants and supplemented by case study observations from Ethiopian Airlines expansion works. Quantitative data were analyzed using the Statistical Package for Social Sciences (SPSS) and Excel, while qualitative data were examined through thematic content analysis. The results show that while CCCC applies structured procedures for equipment selection, procurement, and maintenance, challenges persist in preventive maintenance scheduling, operator training, spare parts availability, and real-time utilization tracking. Time efficiency is often reduced by unplanned downtime, logistical delays, and misalignment between equipment deployment and project schedules. The study recommends adopting integrated fleet management systems, enhancing preventive maintenance programs, improving operator capacity building, and incorporating total cost of ownership analysis in equipment-related decisions. Strengthening coordination among management, operators, and maintenance teams is essential to optimize utilization and reduce delays. This research addresses a gap in empirical studies on CEM in Ethiopian aviation infrastructure projects and provides practical insights for contractors, policymakers, and stakeholders seeking to improve equipment productivity and project outcomes.

Keywords*: - Construction Equipment Management, Time Efficiency, Preventive Maintenance, Ethiopian Airlines Expansion, CCCC*

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LIST OF ACRONYMS

AD – Anno Domin

BIM- Building Information Modeling

CAD – Computer-Aided Design

CCCC – China Communication Construction Company

CCECC – China Civil Engineering Construction Corporation

CEM – Construction Equipment Management

CFHEC – China First Highway Engineering Company

CHEC-China Barbour Engineering Company

CRBC-China Road and Bridge Corporation

CPCS – Construction Plant Competence Scheme

CSA – Central Statistical Agency

EAEP-Ethiopian Airlines Expansion Projects

ETB – Ethiopian Birr

GDP – Gross Domestic Product

GPS- Global Positioning System

HDM – Highway Development and Management

ICT – Information and Communication Technology

IFH – Institute of Federal Highways

MEP – Mechanical, Electrical, Plumbing

MEWC – Machinery, Equipment and Work Control

SPSS – Statistical Package for Social Sciences

TCO – Total Cost of Ownership

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter covers background of the study introducing the topic entails putting the study to context and touching key considered issues, statement of the problem showing a situation whereby major observable gaps, general and specific objectives considering what the study seeks to accomplish. In addition, research questions, scope of the study, limitations of the study and significance of the study.

1.2 Background of the Study

The construction sector requires a significant investment in construction equipment facilities. It is the main economic sector in both developed and developing nations. More than 10% of the growth in domestic product is attributed to the building industry in several different countries throughout the world. Large-scale and intricate building projects require a lot of equipment. A wide range of construction equipment has been employed in construction, and large sums of money from construction corporations are invested in equipment (Yeo & Ning, 2016).

Equipment in construction projects plays an important role in construction development. Yet the management of construction equipment faces many challenges. Due to this, project schedule slips, budget overruns, compromised quality, resulting claims, and counter-claim happened. Previous researches have dealt much with the problems of equipment management. Construction industry is one of the most important service industries, which touch the lives of millions of people in Ethiopia. As a result, it is firmly believed that construction industries need effective resource management practice to retain their profitability and continue their contribution for the growth of the country. Construction is a business sector that relies primarily on high utilization of construction equipment. Equipment is thus one of the key factors for improving contractor's capability in performing their work more effectively and efficiently (Gransberg et al., 2016).

According to the study made by (Khot & Patil, 2020), construction equipment costs 5% to 10% of the direct cost incurred in building construction. It reaches 40% of the direct costs incurred in construction projects. In this construction, equipment was considered as outstanding important in these constructions. Though, construction equipment is covering high percent of direct cost in construction industry, management of construction equipment does not get emphasis yet.

According to (Bhoye, 2018) equipment manager's main task is to reduce downtime, achieve optimum equipment utilization and increase production at minimum cost. The cost analysis and the will of adopting proper techniques suited to the situation are the basic factors for the success and therefore, there is a need for a rational planning, proper selection, and judicious deployment of equipment in relation to the conditions so as to achieve optimum utilization. Equipment engineer should coordinate with various wings of the organization in discharging their job of equipment planning, balancing, selection of equipment and its utilization, personnel selection and training, financial planning, preventive maintenance and general supervision. Thus, equipment management integrates and continuously interacts with human, technical, financial, and production system in order to achieve top efficiency and cost effectiveness.

Effective equipment management practice of construction equipment is crucial for the success of construction projects. Inadequate management practices of construction equipment and the subjective decisions on equipment leads to a major loss in the construction industry. On the contrary, effective construction equipment management can make the difference for construction companies. This is true because most of these companies are always looking forward, by the end of the day, to increase profits, reduce maintenance and operating expenses, and optimize utilization and minimize down time (Abiy, 2015). This can be achieved by placing better equipment management practice, proper equipment management system that provides information to make decisions on planning, procuring, and replacing the equipment. Since, the primary goal of construction equipment management is to enhance competitive performance and decrease different costs associated with equipment by closely integrating the internal operation within enterprise policy.

In Ethiopia airline expansion projects are one of the extensive equipment demanding construction sector relies primarily on high utilization of machinery. Thus, for airline expansion projects equipment is one of the key factors for improving their capability in performing construction activities more effectively and efficiently. Therefore, this research assesses the construction equipment management practices in Ethiopian airline expansion projects the case of CCCC (China Communication Construction Company) in Addis Ababa.

1.3 Problem statement

The use of construction equipment had been regarded as a crucial component of modern construction practices, since heavy machinery was increasingly relied upon for earthwork, material handling, concrete placement, and infrastructure development. In Ethiopia, demand for such equipment had risen due to rapid expansion of infrastructure projects. However, persistent challenges in construction equipment management (CEM) had been observed, and these had directly affected project outcomes in terms of cost, time, and quality. Poor management practices had reduced productivity and created delays. Among the critical challenges, equipment downtime had been widely reported. Machinery frequently became idle due to breakdowns, poor scheduling, or mobilization delays, resulting in wasted labor, financial losses, and delivery setbacks. Studies confirmed that Ethiopian road and building projects had suffered from such inefficiencies (Bekele, 2018), while international evidence also indicated that downtime was a major contributor to inefficiency (Mekonnen, 2019; Li et al., 2018).

Operator-related challenges had further constrained performance. Skilled operators had been essential for productivity, yet shortages of trained personnel were reported. Limited training and weak supervision had led to equipment misuse, accidents, and higher costs. It had been observed that unskilled operation accelerated wear and breakdowns (Tesfaye, 2020), while global studies confirmed that operator inefficiency accounted for a large share of productivity losses (Khan et al., 2017). Maintenance practices had also been inadequate, as many contractors relied on reactive approaches, repairing equipment only after failure. This practice had increased downtime, shortened equipment lifespan, and raised operating expenses. Preventive and predictive strategies, though widely recommended (Li et al., 2018), had not been consistently applied in Ethiopia, and inadequate programs had been identified as a major cause of inefficiency (Ayele, 2019).

Fuel-related challenges had also been experienced. Since construction machinery was highly fuel dependent, fluctuations in supply and price had disrupted operations. Local contractors relying on public fuel stations had been particularly vulnerable, whereas international contractors such as CCCC had reduced risks through bulk fuel storage on site. Environmental and site-related conditions had further contributed to inefficiencies, as harsh weather, rough terrain, and seasonal rains frequently left machinery idle and resources wasted (Asrat, 2021). Similar findings had been reported in international contexts, where environmental variability added uncertainty to construction projects (Zhang & Xie, 2019). Despite these recurring challenges, limited scholarly attention had been given to construction equipment management in Ethiopia. Most studies had narrowly focused on cost or productivity, while the combined factors affecting efficiency remained underexplored. Furthermore, little had been known about how international contractors, particularly China Communications Construction Company (CCCC), had managed equipment in complex Ethiopian projects. This gap had created the need for research aimed at examining the factors influencing equipment management efficiency and providing insights to guide contractors, policymakers, and stakeholders toward improved practices and better project outcomes.

1.4 Research Objectives

1.4.1 General Objectives

The general objective of this study is to assess the Construction Equipment Management Practices in Ethiopian airline projects in Addis Ababa, Ethiopia

1.4.2 Specific Objective

The specific objective of this study are;

- To assess the current construction equipment management practice in Ethiopian airline expansion projects in Addis Ababa.
- To identify the factors that affect construction equipment management practice in Ethiopian airline expansion projects in Addis Ababa.
- To evaluate the construction equipment management efficiency in terms of time management in Ethiopian airline expansion projects in Addis Ababa.

1.5 Research Questions

1. What are the current construction equipment management practice in Ethiopian airline expansion projects?

2. What factors can affect construction equipment management practice in Ethiopian airline expansion projects?

3.How efficient is the use of construction equipment management in terms of time management in Ethiopian airlines expansion projects?

1.6 Scope of the Study

The scope of this study was delimited by concept, context, and time. Conceptually, the research was restricted to construction equipment management, with particular emphasis on selection, maintenance, and replacement. Other aspects of construction management, such as financial administration, human resources, and project design, were excluded. Contextually, the study was confined to the Ethiopian Airlines expansion projects in Addis Ababa, which included roads, runways, buildings, and hangars. International contractors, especially Chinese firms such as CCCC and CCECC, were taken as the main focus, while local contractors were included only in terms of their subcontracted roles in interior finishing, local supply, and support services. In terms of time, the study was limited to the period during which the Ethiopian Airlines expansion projects were undertaken, and practices outside this timeframe were not considered. Through these delimitations, the study was maintained as focused, manageable, and relevant to the assessment of equipment management practices.

1.7 Limitation of the Study

In this study, a case study approach was employed, and data were collected through questionnaires, interviews, and document reviews. One limitation was related to the use of questionnaires, as variations in how respondents understood the questions may have affected the accuracy of the responses. Since information was obtained indirectly through respondents' views, the possibility of misinterpretation could not be avoided. Although interviews and document reviews were used to complement the data, another limitation arose from the extent to which participants clearly understood the technical terms and requirements of project management and equipment management practices. Furthermore, because the study was based on a relatively small sample size, the generalization of findings to the broader construction industry was restricted. Consequently, the validity and transferability of the results were considered as limitations of this research.

1.8 Significance of the Study

The research benefited all stakeholders and academicians by providing useful information about construction equipment management in the expansion projects of Ethiopian Airlines and its practice. The research was also used as an initiation for those who were interested to conduct a detailed and comprehensive study regarding the practice of construction equipment management in the Ethiopian Airlines' expansion projects in Addis Ababa. In addition, it helped the governing body, specifically the higher responsible body, and the managements of Ethiopian Airlines expansion projects to be aware of the perceived and actual practices of construction equipment management and gave insight on how to adopt the different aspects of construction equipment management most effectively and efficiently. It was also very important for future research in academic purpose by indicating information in regard to different aspects of construction equipment management in expansion projects.

1.9 Organization of the Study

The study organized in to five chapters. The first chapter discussed the introduction part that contains the background of the study, statement of the problem, scope of the study, general objectives of the study, specific objective of the study, research questions, and limitation of the study, and Significance of the study and organization of the study. The second chapter contains the literature review, which deals with theoretical and empirical aspects of the study. The third chapter is research methodology under this chapter; described the type and design of the research; the subjects/participant of the study; the sources of data; the data collection tools/instruments employed; the procedures of data collection; and the methods of data analysis used. The fourth chapter deals on Results and discussion/Data presentation, analysis and interpretation: - This chapter should summarize the results/findings of the study, and interpret and/or discuss the findings. The last chapter includes summary, conclusion and recommendation part.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this section review of related works have been addressed and the literature review is prepared in sections includes theoretical review and empirical review research gap. Under the theoretical and empirical review, sub headings have been included. The study focused on assessment on construction equipment management practice in Ethiopian airlines expansion projects in Addis Ababa.

2.2 Theoretical Review

2.2.1 Construction Industry

The construction industry is one of the largest sectors worldwide, contributing significantly to economic growth, infrastructure development, and employment. It covers diverse activities such as the construction of buildings, roads, bridges, airports, dams, and other public and private infrastructure. Because of its scale and complexity, the industry is often described as both a driver of development and a challenging environment for management and productivity.

Globally, the construction sector is recognized as a major contributor to GDP. In many countries, it accounts for 5–10% of the total economy and provides employment to millions of skilled and unskilled workers (Lauria, 2021). It plays a key role in enabling urbanization, industrial expansion, and public service delivery. However, the industry is also highly competitive, with companies ranging from small local firms to large multinational corporations, each striving to improve efficiency, reduce costs, and deliver projects on time.

Despite its importance, the construction industry faces several challenges. Scholars such as Shen et al. (2017) and Gransberg et al. (2016) identify critical issues including:

Shortage of skilled labor and an aging workforce,

Rising costs of materials, labor, and fuel,

Environmental regulations requiring sustainable practices,

Technological change that demands continuous adaptation, and

Intense global competition, especially from emerging economies.

These challenges highlight why construction management, and more specifically construction equipment management, has become increasingly important. Equipment is a core resource that influences project speed, cost, and quality. In fact, in large-scale infrastructure projects, equipment accounts for 10–30% of total costs (Abebe, 2016). Efficient use of equipment therefore determines not only the profitability of firms but also the competitiveness of the entire industry.

In the Ethiopian context, the construction industry is particularly vital. It is one of the fastest-growing sectors, driven by infrastructure investment, urbanization, and economic growth. Mega-projects such as airports, railways, highways, and housing schemes have expanded rapidly in recent years. This boom has created high demand for construction equipment but also exposed weaknesses in equipment management, including inadequate maintenance, shortages of spare parts, and limited skilled operators. These issues often lead to project delays, budget overruns, and reduced productivity.

Therefore, understanding the construction industry context provides the background for why studying construction equipment management is both timely and necessary. The sector's growth potential is enormous, but without effective equipment planning, operation, and maintenance, projects may fail to deliver expected benefits. By addressing these management challenges, the construction industry can achieve greater efficiency, sustainability, and long-term competitiveness.

2.2.2 Construction equipment

The concept of construction equipment has been a point of controversy for a long period of time. In its border sense, however, many authors in the field agree that construction equipment, as a construction terminology, refers to all kinds of machinery that are utilized to assist human labor

Construction equipment is a broad term that refers to the machines and tools used in the construction industry.

2.2.2.1 Types of Construction Equipment

Construction equipment can be categorized into several groups based on its primary function.

The first major group is earthmoving equipment, which is essential for the initial phases of construction to manipulate the terrain. This category includes versatile machines like excavators and backhoe loaders for digging and trenching, as well as bulldozers for pushing heavy materials and motor graders for creating precise level surfaces. Compact machines such as skid-steer loaders are also part of this group, valued for their maneuverability in confined spaces.

The second primary category is material handling equipment, which is used for the transportation and placement of heavy or bulky materials. This group features powerful machines like cranes and telehandlers, designed to lift loads to significant heights or hard-to-reach areas. For horizontal movement over shorter distances, forklifts are commonly used, while dump trucks are indispensable for hauling loose materials such as soil, gravel, and debris around the site or to disposal locations.

fundamental category of construction equipment is dedicated to working with concrete and creating finished surfaces. This includes concrete equipment, such as mixers for combining ingredients and pumps for transporting liquid concrete to precise locations on-site. Furthermore, compaction and paving equipment like rollers and asphalt pavers are used to establish solid, level foundations and lay down smooth surface layers for roads and other areas.

Finally, construction projects often require a range of specialized equipment for specific, critical tasks. This diverse category includes machines like trenchers for digging precise ditches for utilities, drilling rigs for boring holes into the ground, and generators to supply essential electrical power across the construction site, ensuring other equipment can operate effectively.

2.2.3 Equipment Management

The core concept of equipment management is the strategic process of planning, organizing, and controlling the use of construction equipment throughout its lifecycle. Its primary goal is to ensure that equipment is used in the most efficient and effective way possible to complete projects on time and within budget, all while minimizing operational costs and risks.

The projects are completed on time and within budget by focusing on the efficient use of equipment while minimizing costs. It encompasses key aspects such as equipment selection, acquisition, maintenance, repair, and disposal.

Effective equipment management provides several benefits, including:

1) Reduced Costs: It helps prevent costly equipment failures and unexpected expenses on repairs.

2) Increased Productivity: By ensuring machinery is available and in good working condition, it reduces downtime and improves project efficiency.

3) Enhanced Safety: A well-maintained fleet is less likely to break down and cause accidents.

4) Better Financial Planning: It allows companies to track the total cost of ownership and make informed decisions about whether to buy, rent, or dispose of equipment.

2.2.3.1 Key Principles of Equipment Management

The following principles guide effective equipment management

1.Lifecycle management: Effective equipment management is guided by the principle of lifecycle management, which involves overseeing a machine from acquisition to disposal. This comprehensive approach begins with a strategic decision on whether to purchase or rent equipment based on project-specific needs and a thorough cost analysis. Once in operation, its usage and performance are monitored to ensure optimal productivity. The lifecycle is sustained through proactive maintenance strategies and concludes with a data-driven decision on when to retire or dispose of the equipment, considering its total cost of ownership.

2.Proactive maintenance and inspection**:** A cornerstone of this management philosophy is the shift from reactive repairs to proactive maintenance and inspections. This involves implementing scheduled preventive maintenance to avoid unexpected failures and employing predictive techniques, such as data analysis from telematics, to anticipate issues before they cause breakdowns. Complementing this, regular daily checks and thorough inspections are conducted to identify early signs of wear, ensuring equipment reliability, safety, and longevity on the construction site.

3.Utilization and efficiency optimization: A fundamental principle of effective equipment management is the optimization of utilization and efficiency, ensuring that machinery is actively contributing to project goals rather than sitting idle. This involves meticulous tracking of assets to monitor their location and usage rates, allowing managers to identify underutilized equipment. Proper planning is essential to assign the right machine to the right task, preventing inefficiency and potential damage. Furthermore, investing in comprehensive operator training and strict safety protocols is crucial, as skilled operators not only enhance productivity but also use equipment correctly, which promotes safety and helps prevent costly repairs.

4.Data -driven decision making**:** Modern equipment management increasingly relies on data-driven decision-making to guide strategic choices. This approach utilizes centralized software systems to consolidate information on maintenance schedules, operational costs, and equipment usage. By analyzing key performance indicators (KPIs) from this data, managers can pinpoint inefficiencies, justify new investments, and make informed decisions that extend equipment lifecycles and improve the overall financial return on assets.

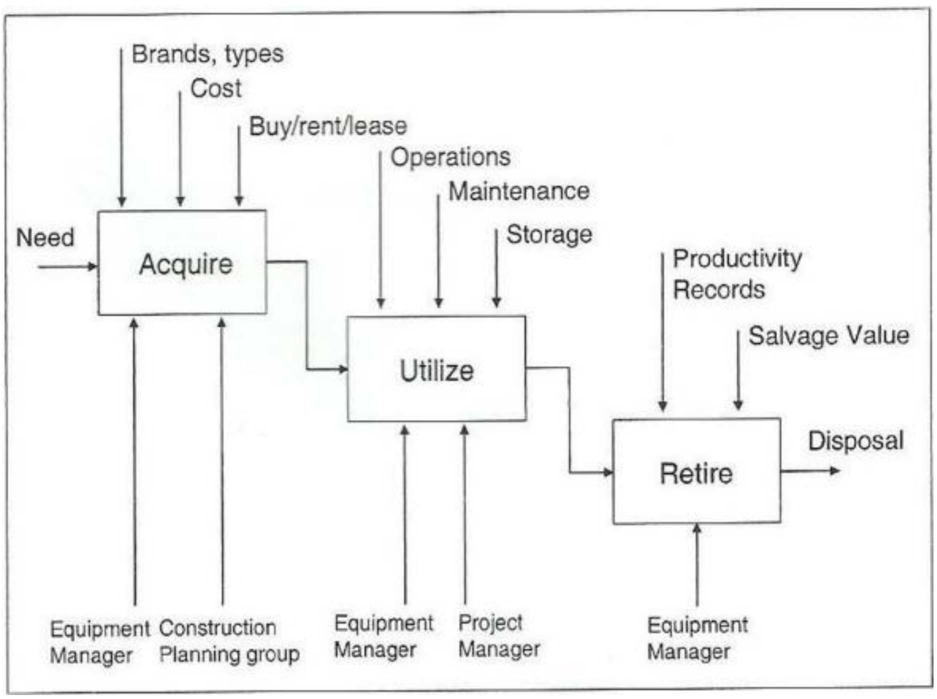

Figure 2.1 Construction equipment management process, source (Smith, 2016)

2.2.4 Construction equipment management cycle

Construction industry is one of the most important service industries which touch the lives of millions of people in Ethiopia. As a result, it is firmly believed that construction industries need effective resource management practice to retain their profitability and continue their contribution for the growth of the country. Construction is a business sector that relies primarily on high utilization of construction equipment. Equipment is thus one of the key factors for improving contractor’s capability in performing their work more effectively and efficiently (Shen et al., 2017). By enhancing the effectiveness of utilizing equipment extensive volume of work can be completed within a shorter period of time and more importantly, within the project schedule. They also suggested that one of the main reasons for project delays on construction projects in Thailand were equipment management problems, deficiencies in organization, shortages of construction materials, and inefficiencies in site workers (Gransberg et al., 2016).

The construction equipment used in an enterprise has a life cycle. It starts with the recognition of an opportunity, then progresses to feasibility and approval. If the idea is found worthwhile a full selection, equipment are purchased, installed and put into operation. The vast majority of the life cycle is its operation and this continues until the plant and equipment are eventually decommissioned and disposed (Gransberg et al., 2016) and (Abebe, 2016).

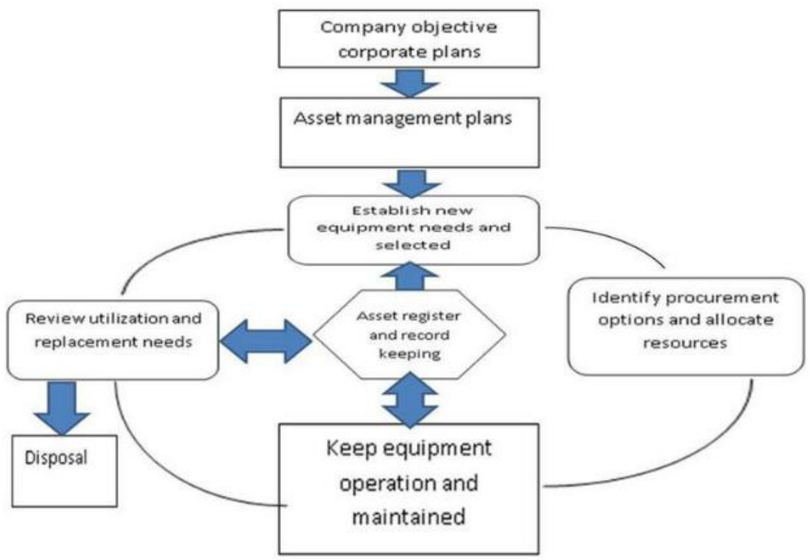

Figure 2.2 Management cycle of construction equipment (Abebe, 2016)

2.2.5 Historical development of equipment management

Equipment management is the process of planning, organizing, and controlling the use of equipment in an organization (Edwards & Holt, 2019). It includes activities such as identifying equipment needs, selecting and acquiring equipment, maintaining and repairing equipment, and disposing of obsolete equipment.

The historical development of equipment management can be traced back to the early days of industrialization. In the early 1800s, factories began to use machines to produce goods on a large scale. These machines were expensive and required careful maintenance to keep them running properly. As a result, factories began to develop systems for managing their equipment (Ohkawa, 2018).

In the early 1900s, the development of scientific management led to a more systematic approach to equipment management. Scientific management principles were applied to the design and operation of equipment, and new methods were developed for maintaining and repairing equipment (Edwards & Holt, 2019).

In the 1980s, the first mobile equipment management systems were developed (Gransberg et al., 2016). These systems were designed to track the location and condition of construction equipment in real time. In the 1990s, the first web-based equipment management systems were developed. These systems were designed to provide access to equipment management data from anywhere in the world.

In the mid-20th century, the development of computers led to a further revolution in equipment management. Computers were used to create computerized maintenance management systems (CMMS), which helped organizations to track and manage their equipment more effectively (Bogahawatta & Amarathunge, 2019).

The goal of equipment management is to ensure that equipment is available when it is needed and that it is used in a safe and efficient manner. Equipment management can help organizations to reduce costs, improve productivity, and protect the environment (Parveen & Khan, 2018).

The history of equipment management can be traced back to the early days of the construction industry. In the early days, construction equipment was relatively simple and inexpensive. As the construction industry grew, so did the complexity and cost of construction equipment. This led to the development of more sophisticated equipment management techniques (Khot & Patil, 2020).

According to the work stated by (Ohkawa, 2018), In the early 1900s, the first equipment management systems were developed. These systems were based on paper records and were designed to track the location and condition of construction equipment. In the 1950s, the first computerized equipment management systems were developed. These systems were more sophisticated than the early paper-based systems and were able to track a wider range of data.

Today, equipment management is a complex and sophisticated discipline. Organizations use a variety of tools and techniques to manage their equipment, including CMMS, asset management software, and predictive maintenance technologies (Lauria, 2021). There are also a number of different equipment management systems available. These systems vary in terms of their features and functionality (Jaijith, 2020). Some systems are designed for small, local construction companies, while others are designed for large, multinational corporations.

2.2.6 Equipment management in construction industry

Equipment management is a critical part of the construction process. By effectively managing equipment, contractors can save money, improve productivity, and reduce risk. There are a number of different equipment management strategies that can be used. The most effective strategy will vary depending on the specific needs of the construction company (Bogahawatta & Amarathunge, 2019).

However, equipment management can be a complex and challenging task. There are many factors to consider, including the type of equipment, the work environment, the availability of resources, and the cost of ownership (Shen et al., 2017).

Equipment manager's main task is to reduce downtime, achieve optimum equipment utilization and increase production at minimum cost. The cost analysis and the will of adopting proper techniques suited to the situation are the basic factors for the success and therefore, there is a need for a rational planning, proper selection, and judicious deployment of equipment in relation to the conditions so as to achieve optimum utilization (Khot & Patil, 2020). Equipment engineer should coordinate with various wings of the organization in discharging his job of equipment planning, balancing, selection of equipment and its utilization, personnel selection and training, financial planning, preventive maintenance and general supervision. Thus equipment management integrates and continuously interacts with human, technical, financial and production system in order to achieve top efficiency and cost effectiveness (Sjodin et al., 2016).

2.2.7 Organizational structure in construction equipment management

The organizational structure of a construction equipment management (CEM) system is a critical factor in its success. The structure should be designed to meet the specific needs of the organization and to ensure that the CEM system is effectively implemented and managed (Smith & Jones ,2020).

According to the work done by Abiy (2015), there are a number of different organizational structures that can be used for CEM. The most common structure is a centralized structure, in which the CEM function is located at the corporate level. This structure is often used in large organizations with multiple construction projects.

Another common structure is a decentralized structure, in which the CEM function is located at the project level (Lauria, 2021). This structure is often used in small and medium-sized organizations or in organizations with a single construction project.

The organizational structure of a CEM system should be designed to meet the specific needs of the organization. The following factors should be considered when designing the organizational structure. The size of the organization, the number of construction projects, the complexity of the construction projects (Oloke et al., 2021), the level of expertise required for CEM, and the budget for CEM.

The organizational structure of a CEM system should also be designed to ensure that the CEM system is effectively implemented and managed. The following are some key elements of an effective CEM system (Abebe, 2016). A clear definition of the roles and responsibilities of the CEM team, a well-defined process for managing the CEM system, a system for tracking and reporting on the performance of the CEM system and a system for training and developing the CEM team.

The organizational structure of a CEM system is a critical factor in its success. The structure should be designed to meet the specific needs of the organization and to ensure that the CEM system is effectively implemented and managed (Gransberg et al., 2016).

However, there are some common elements that are found in most construction equipment management departments (Zhang, 2022), As a general, the organizational structure of a construction equipment management department can vary depending on the size and complexity of the construction company. This organizational structure can have, a manager who is responsible for the overall operation of the department, a staff of technicians who are responsible for the day-to-day maintenance and operation of the equipment, a fleet manager who is responsible for the acquisition, disposal, and maintenance of the equipment, a parts manager who is responsible for the inventory and ordering of parts and a records manager who is responsible for the maintenance of records on the equipment (Bhoye, 2018).

2.2.8 Theoretical Framework

The theoretical framework forms the intellectual foundation of this study and connects the research problem construction equipment management practices in the Ethiopian Airlines expansion project with established theories, models, and principles in construction management, organizational studies, and operations management. It provides a lens through which the findings can be interpreted and justified in relation to prior knowledge.

1. Construction Industry and Resource Dependence

The construction industry is a resource-intensive sector where successful delivery of projects depends on the availability and efficient use of critical resources such as labor, materials, finance, and equipment. Equipment, in particular, accounts for a significant portion of total project cost. The Resource-Based View (RBV), as extended in contemporary strategic management literature (Barney, 2018; Kraaijenbrink, 2010), posits that sustainable competitive advantage is achieved by developing and deploying valuable, rare, and inimitable resources. In the construction sector, this translates to companies that optimize their equipment acquisition, utilization, and maintenance gaining significant productivity advantages, while poor management results in cost overruns and project delays. The principles of resource dependence are also reflected in modern project management bodies of knowledge that emphasize resource optimization as a key success factor (PMI, 2021).

2. Systems Theory and Project Complexity

Construction projects are often described as complex systems composed of interdependent subsystems: human resources, equipment, materials, and financial flows. Systems Theory provides a useful foundation for understanding equipment management as one subsystem whose inefficiency disrupts the entire project system. Contemporary applications of systems thinking in construction, such as the Last Planner System® from Lean Construction (Ballard, 2000) and the concept of Complexity Theory in Project Management (Bakhshi, Ireland, & Gorod, 2016), highlight how disruptions in one area create cascading effects. Equipment downtime, for instance, does not only delay specific activities but also causes labor idle time, affects materials handling, and disturbs overall workflow. By applying a systems perspective, this study emphasizes that effective equipment management is not isolated but part of an integrated management system that directly influences project success.

3. Operations and Maintenance Management Principles

Theories of operations management and total productive maintenance (TPM) are central to equipment management. Operations management emphasizes planning, scheduling, cost minimization, and resource optimization (Slack et al., 2016). TPM highlights preventive and predictive maintenance to maximize uptime and extend equipment lifespan. For example, Mike Vorster's work on lifecycle costing, and the distinction between operating costs vs owning costs, shows how maintenance and regular inspections can reduce total cost over time.

4. Equipment Lifecycle and Cost Theories

Equipment management is also framed by lifecycle costing theory and total cost of ownership (TCO) principles. Gransberg & Jahren's "Major Equipment Life Cycle Cost Analysis" provides empirical models to evaluate equipment acquisition, operation, maintenance, and ultimate disposal costs. Similarly, Tse, Mathew, Wong, and Lam detailed the role of lifecycle cost in engineering asset management, emphasizing decisions about repair vs replacement and ownership costs.

These works argue that decisions made at each stage of the equipment lifecycle (selection, operation, maintenance, disposal) have significant implications for cost efficiency and productivity.

5. Efficiency and Sustainability Perspectives

Efficiency is often measured through indicators such as utilization rate, downtime, maintenance costs, and productivity ratios. The work of Cheung et al. (in studies of product lifecycle costing models) shows how acquisition cost, operating cost, and ownership costs should all be considered when designing cost-efficient asset strategies. Sustainability theory adds that equipment efficiency should also account for environmental and safety outcomes: proper maintenance reduces fuel consumption and emissions, and safe operations reduce accident risk.

2.3 Empirical Literature Review

2.3.1 Construction equipment management practice in Ethiopia

Ethiopia has been experiencing rapid economic growth in recent years, which has led to an increase in the demand for construction equipment. As a result, the construction equipment management practice in Ethiopia has evolved significantly (Mulugeta, 2016).

In the past, construction equipment was often managed in a haphazard manner. Equipment was not properly maintained, and there was little coordination between different construction projects. This led to a number of problems, including equipment breakdowns, delays in construction projects, and increased costs (Lauria, 2021).

Despite the fact that Ethiopia is currently involved in wider construction activity, the concept of construction equipment management, in most cases, has been left of the minds of contractors in their project designing. This significantly affected the effectiveness of the construction equipment companies and the problem appeared to persistently contaminate the whole process of construction. This is difficult to waiting the scarce resources of the nation for mismanagement of available construction equipment would definitely affect values of time, quality, safety and efficiency of construction companies (Tadesse, 2015).

In recent years, there has been a growing awareness of the need for better construction equipment management. A number of companies have begun to implement more systematic and efficient management practices. This has led to a number of benefits, including improved equipment reliability, reduced costs, and shorter construction times (Abiy, 2015). There are a number of factors that have contributed to the improvement of construction equipment management in Ethiopia. One factor is the increasing availability of information and technology. There are now a number of software programs and online resources that can help companies to manage their equipment more effectively (Edwards & Holt, 2019).

Another factor is the growing demand for construction equipment. As the economy continues to grow, the demand for construction equipment is expected to increase (Mulugeta, 2016). This will create opportunities for companies to invest in new equipment and to develop more efficient management practices.

The future of construction equipment management in Ethiopia looks bright. With the continued growth of the economy and the increasing availability of information and technology, companies are expected to continue to improve their management practices (Edwards & Holt, 2019). This will lead to a number of benefits, including improved equipment reliability, reduced costs, and shorter construction times.

2.3.2 Equipment management strategies and practices in other nations

Equipment management is a critical part of any organization's success. It ensures that equipment is properly maintained and that repairs are made in a timely manner. This can help to prevent costly downtime and ensure that equipment is always available when needed (Abebe, 2016).

There are many different equipment management strategies and practices that can be used. The best approach will vary depending on the specific needs of the organization. However, there are some general principles that can be applied to any equipment management program. One of the most important aspects of equipment management is preventive maintenance. This involves regularly inspecting and servicing equipment to identify potential problems before they cause downtime (Azmi & Danish, 2017). Preventive maintenance can also help to extend the life of equipment and reduce the need for costly repairs. In addition, another important aspect of equipment management is corrective maintenance. This involves repairing equipment that has already failed. Corrective maintenance should be done as quickly as possible to minimize downtime. In addition to preventive and corrective maintenance, organizations should also have a plan for disposing of old equipment. This plan should take into account the environmental impact of disposing of equipment and the cost of recycling or disposing of it properly (Abebe, 2016).

There are many different equipment management strategies and practices that can be used. The best approach will vary depending on the specific needs of the organization (Shen et al., 2017). However, by following some general principles, organizations can develop an effective equipment management program that will help to keep their equipment in good condition and prevent costly downtime.

In Japan, there is a strong focus on preventive maintenance. This is due in part to the country's high population density, which makes it difficult to find space for large-scale repairs (Ohkawa, 2018). Japanese companies also tend to have long-term relationships with their suppliers, which makes it easier to coordinate preventive maintenance activities.

In Germany, there is a strong focus on quality control. This is due in part to the country's history of manufacturing excellence. German companies have a reputation for producing high-quality products, and they invest heavily in quality control to ensure that their products meet the highest standards (Sjodin et al., 2016).

In the United States, there is a strong focus on cost-effectiveness, driven by the country's highly competitive economy. American companies are consistently seeking ways to reduce costs, and equipment management is a key area for optimization. A common strategy is the outsourcing of equipment management to specialized third-party providers, which allows firms to convert fixed capital expenses into variable operational costs and leverage the provider's expertise for greater efficiency (Sodhi & Tang, 2021).

These are just a few examples of equipment management strategies and practices from other nations. There are many other approaches that can be used, and the best approach will vary depending on the specific needs of the organization (Oloke et al., 2021).

2.3.3 Performance indicators of best construction equipment management

There are many performance indicators that can be used to measure the effectiveness of construction equipment management (Thomas, 2023). In the construction industry, equipment management is a critical component of overall project success. Effective equipment management can help to improve productivity, reduce costs, and ensure the safety of workers.

There are a number of performance indicators that can be used to measure the effectiveness of equipment management. As stated by the work done by Jaijith (2020) on his work entitled “Construction Equipment Management in Project Site”, equipment utilization is one case. This is the percentage of time that equipment is actually being used. A high equipment utilization rate indicates that equipment is being used efficiently. Good project management in construction must vigorously pursue the efficient utilization of labor, material, and equipment. The use of new equipment and innovative methods has made possible wholesale changes in construction technologies in recent decades (Jaijith, 2020). The selection of the appropriate type and size of construction equipment often affects the required amount of time and effort and thus the jobsite productivity of a project.

To improve productivity, it is essential to improve the performance of the construction systems. The desired production output is achieved through high equipment availability, which is influenced by equipment reliability and maintainability (Parveen & Khan, 2018). This is the percentage of time that equipment is available for use. A high equipment availability rate indicates that equipment is well-maintained and in good working order.

According to (Azmi & Danish, 2017), while it may be tempting to go for the equipment with low initial price, it is preferable to optimize for standard equipment. Such equipment's manufactured in large numbers by the manufacturers, and their spare parts are easily available, which would ensure minimum downtime. Besides, they can also fetch good salvage money at the time of their disposal. This is the amount of time that equipment is not available for use due to breakdowns or other problems. A low equipment downtime rate indicates that equipment is well-maintained and reliable.

The work done by Thomas (2023) studied and observed that, Retirement and replacement models for construction equipment have been based on the notion that there is an optimum time to sell a piece of equipment to the competition. One problem with these models is that they do not explain why one's competition may have a need for the equipment when one does not. The model presented here looks at the consequential costs of downtime for each piece of equipment when assigned to specific applications. Old and unreliable equipment therefore carries a significant consequential downtime cost when used in a key production application. Likewise, new and reliable equipment carries a significant capital recovery cost, which makes it less desirable in applications where consequential costs of downtime are low. Equipment costs includes the cost of purchasing, operating, and maintaining equipment. A low equipment cost indicates that equipment is being used efficiently and effectively.

2.3.4 Factors Influencing Construction Equipment Management

Construction equipment management is essential for ensuring efficiency, productivity, and cost-effectiveness in construction projects. Several internal and external factors influence the management of equipment, shaping the success of project delivery.

Internal Factors refer to elements under the control of construction companies, including equipment selection, maintenance practices, and operator training. The choice of equipment is critical, as appropriate machinery can significantly reduce time and cost, whereas poor selection may result in inefficiencies, delays, or accidents (Edwards & Holt, 2019). For example, bulldozers are effective in land clearing, while cranes are indispensable for lifting heavy materials. Using equipment mismatched to project requirements often leads to wasted resources and reduced output (Jaijith, 2020).

Regular and systematic maintenance is another core factor. Equipment that is neglected is prone to breakdowns and costly repairs, leading to downtime and missed deadlines. Preventive maintenance including lubrication, oil changes, and part replacement not only prolongs equipment life but also enhances site safety (Bogahawatta & Amarathunge, 2019). A well-maintained machine runs more efficiently, consumes less fuel, and reduces the likelihood of project delays.

The training and competence of operators also play a major role. Operators who understand the equipment they handle are less likely to misuse it, more likely to adhere to safety standards, and more efficient in carrying out tasks. Shen et al. (2017) emphasize that effective training should combine classroom-based theoretical instruction with practical field experience. Inadequate training increases risks of accidents, equipment misuse, and excessive wear and tear.

External Factors are largely outside the contractor’s control, yet they significantly affect equipment management. Weather is one of the most influential external variables. Heavy rainfall, snow, or extreme heat can halt construction, damage machinery, or limit accessibility to sites (Thomas, 2023). For instance, wet weather disrupts concrete curing and soil compaction, while snow and ice can immobilize heavy machinery. Having contingency measures is critical to managing such risks.

The availability of equipment is another external concern. During peak construction seasons, shortages often occur, leading companies to rent at premium prices or delay work schedules (Jaijith, 2020). Additionally, fuel costs which fluctuate according to global markets have a direct impact on operational costs. Heavy construction equipment typically consumes large volumes of fuel, meaning even small price changes can inflate project budgets.

In short, effective management demands balancing controllable internal factors like selection, maintenance, and training with external challenges, including weather, market conditions, and resource availability. Companies that plan proactively can enhance productivity and mitigate the risks of delays and cost overruns.

2.3.5 Challenges and Problems in Construction Equipment Management

Despite advances in construction technology, contractors frequently face challenges in equipment management that undermine efficiency, cost control, and safety.

Downtime is a persistent issue in equipment management. It results from mechanical failures, lack of maintenance, or operator error, and leads to costly project delays (Gransberg et al., 2016). Preventive and predictive maintenance programs can minimize such disruptions, but many firms underinvest in systematic upkeep.

Another widespread issue is theft and vandalism. Construction sites are often vulnerable, and theft of machinery, parts, or handheld tools can be financially damaging (Abiy, 2015). Vandalism similarly disrupts work progress and results in unplanned repair costs. Strengthening site security and adopting tracking technologies can mitigate these risks.

Equipment damage is another problem affecting project budgets and schedules. Improper use, overloading, and environmental exposure often cause machinery failures. As Prajeesh & Sakthivel (2016) note, accidents, harsh climates, or poor handling practices contribute to breakdowns. This problem highlights the importance of regular inspection and proper operator training.

Linked to this is the issue of equipment misuse, which occurs when machinery is used for tasks it was not designed for. This not only damages the equipment but also compromises safety and reduces productivity. Bogahawatta & Amarathunge (2019) emphasize that misuse is frequently tied to insufficient training and weak enforcement of safety protocols. Establishing a strong safety culture can minimize these risks.

Obsolescence is a growing problem as technology rapidly evolves. Older machines often fail to meet efficiency, safety, or environmental standards. Gransberg et al. (2016) point out that obsolete equipment reduces productivity, increases maintenance costs, and creates difficulties in sourcing spare parts. In addition, outdated equipment may not comply with environmental regulations, leading to higher emissions and legal liabilities. Investing in modern, fuel-efficient, and environmentally friendly equipment ensures long-term competitiveness.

Finally, improper selection of equipment remains a common root cause of management issues. Selecting machinery unsuited to project needs reduces efficiency and increases the risks of breakdowns and accidents. Contemporary research emphasizes that inappropriate equipment allocation not only delays progress but also significantly raises operating costs over the asset's lifecycle (PMI, 2021; El-Abbasy et al., 2019). Proper planning, informed decision-making, and thorough lifecycle cost analysis are therefore essential to avoid this fundamental problem.

In summary, challenges such as downtime, theft, misuse, obsolescence, and poor selection undermine equipment management in construction. Addressing these issues requires a combination of preventive maintenance, enhanced security, operator training, and strategic investment in modern technologies. By implementing these measures, construction firms can improve performance, ensure safety, and maintain cost efficiency.

2.3.6 Efficiency of Construction Equipment

Efficient management of construction equipment is essential for optimizing resource utilization and enhancing overall project performance. Studies indicate that effective equipment management practices can lead to significant improvements in productivity and cost reduction. For instance, a comprehensive evaluation of equipment efficiency reveals that proactive maintenance protocols and optimized usage aligned with project needs are crucial for enhancing construction productivity (Shen et al., 2017). The efficiency of construction equipment management practices encompasses various aspects, including the optimization of equipment utilization, maintenance strategies, cost management, and the impact of technology on equipment management.

Efficient equipment utilization is crucial for minimizing costs and maximizing productivity on construction sites. Studies indicate that underutilization of equipment can lead to significant financial losses. Various metrics, such as utilization rates, downtime, and productivity ratios, are used to assess equipment efficiency. Research suggests that a utilization rate of 60-70% is often considered optimal for heavy machinery (Bogahawatta & Amarathunge, 2019). Literature highlights the importance of maintenance strategies in prolonging equipment life and ensuring operational efficiency. Preventive maintenance is often favored for its cost-effectiveness, while predictive maintenance, supported by IoT and data analytics, is gaining traction for its ability to reduce unexpected breakdowns. Studies show that effective maintenance practices can reduce equipment downtime by up to 30%, significantly improving overall project timelines.

Various researches emphasized the need to consider the total cost of ownership, which includes acquisition, operation, maintenance, and disposal costs. Effective management practices can lead to a reduction in total cost of ownership by optimizing these factors (Shen et al., 2017). The decision between renting and owning equipment is a critical aspect of cost management. Literature suggests that renting can be more cost-effective for short-term projects, while ownership may be beneficial for long-term operations. Telematics and IoT: The integration of telematics and IoT in construction equipment management has been shown to enhance efficiency. These technologies provide real-time data on equipment performance, usage patterns, and maintenance needs, enabling better decision-making. Software Solutions: Various software solutions for equipment management, such as fleet management systems, have been developed to streamline operations, track usage, and manage maintenance schedules effectively.

The efficiency of equipment management is also influenced by the skill level of operators. Studies indicate that well-trained operators can improve equipment performance and reduce the likelihood of accidents and breakdowns (Abebe, 2016). Workforce Planning: Effective workforce management practices, including scheduling and resource allocation, are essential for maximizing equipment utilization and minimizing idle time.

The literature increasingly addresses the importance of sustainable practices in equipment management. Efficient equipment management can lead to reduced fuel consumption and lower emissions, contributing to environmental sustainability. Compliance with environmental regulations is becoming a critical aspect of equipment management, influencing the choice of equipment and operational practices (Lauria, 2021).

2.3.7 Methodological Literature Review

The methodological literature review examines how past researchers have studied construction equipment management, focusing on their research designs, data collection tools, and analytical techniques. Reviewing these approaches not only identifies strengths and limitations but also justifies the methodological choices adopted in this study.

1. Quantitative Approaches: Surveys and Questionnaires

A significant body of construction equipment management research has employed quantitative methods, particularly structured questionnaires distributed to contractors, site engineers, and project managers. For example, Jaijith (2020) designed surveys to measure utilization rates, availability, and downtime across multiple project sites. Similarly, Thomas (2023) used structured questionnaires to capture numerical data on performance indicators such as equipment availability, cost efficiency, and operator training. These approaches allow for statistical analysis (descriptive statistics, correlation, and regression), providing objective measures of efficiency. The limitation, however, is that surveys often capture perceptions rather than detailed contextual realities.

2. Qualitative Approaches: Interviews and Case Studies

Other scholars have adopted qualitative approaches to explore deeper insights. Tadesse (2015) and Ohkawa (2018) used semi-structured interviews with project managers and operators to understand challenges such as spare parts shortages, training gaps, and theft. Case studies have also been widely applied to examine large-scale projects in detail. For instance, Lauria (2021) analyzed equipment management practices within multinational projects, while Mulugeta (2016) examined Ethiopian practices in selected infrastructure works. These methods provide rich, contextual data but may lack generalizability compared to large-scale surveys.

3. Mixed Methods Approaches

Recent research increasingly combines quantitative and qualitative methods to balance breadth and depth. For example, Sjodin et al. (2016) combined questionnaires with follow-up interviews, enabling them to quantify equipment utilization while also exploring underlying managerial strategies. This approach aligns with the current study, which integrates questionnaires (breadth), interviews (depth), and a case study (practical validation) to ensure triangulation and strengthen reliability.

4. Measurement Metrics and Indicators

Across methodologies, scholars consistently employ certain performance indicators. Common metrics include:

Utilization rate – percentage of time equipment is actively in use.

Availability rate – percentage of time equipment is in working condition.

Downtime rate – time lost due to breakdowns or repairs.

Maintenance frequency and cost – preventive vs. corrective maintenance analysis.

Total cost of ownership (TCO) – acquisition, operation, repair, and disposal.

These indicators provide a standardized methodological basis for comparison across studies (Parveen & Khan, 2018; Bogahawatta & Amarathunge, 2019).

5. Technology-Enhanced Methodologies

Recent methodological innovations integrate digital tools such as telematics, GPS, Building Information Modeling (BIM), and IoT sensors. Lauria (2021) notes that telematics systems allow real-time tracking of fuel consumption, idle time, and machine health, providing more accurate data than traditional self-reported surveys. These approaches indicate a methodological shift towards data-driven, technology-enabled monitoring. However, such methods are not yet widely applied in Ethiopia due to infrastructure and cost limitations, highlighting the value of using traditional but robust survey, interview, and case study methods in this research.

Methodologies in equipment management research have evolved from quantitative surveys, to qualitative case studies, to mixed methods and technology-enhanced approaches. The study adopts a mixed-methods design (questionnaires, interviews, case study), which is both consistent with international best practice and contextually appropriate for Ethiopia, where triangulation strengthens validity given limited data infrastructure.

2.3.8 Research Gap

In Ethiopia, existing studies on construction equipment management (CEM) have largely concentrated on estimating productivity losses and calculating operating costs of heavy-duty machinery such as loaders, bulldozers, graders, and excavators. While these studies provide useful insights, they remain limited in scope and fail to address the broader operational and managerial factors that consistently undermine efficiency across large construction projects. In practical terms, most contractors give greater emphasis to visible construction outputs, while systematic management of equipment is often neglected. This gap in attention has resulted in several recurring challenges that hinder overall project performance. One major issue is equipment downtime, frequently caused by poor scheduling, delays in mobilization, and recurrent machinery breakdowns. Downtime leads to resource underutilization, idle labor, and costly project delays. A second problem is operator-related inefficiency, which stems from inadequate technical training, low skill levels, and weak supervision. Such human factors reduce the productivity of expensive equipment and increase the risk of accidents or misuse. A further challenge is the prevalence of irregular, reactive maintenance practices and poor spare-part planning. Instead of preventive approaches, many firms rely on corrective maintenance, which accelerates equipment deterioration, shortens lifespan, and raises operating costs. The sector is also highly vulnerable to fuel price fluctuations and shortages, which disrupt day-to-day operations, extend project timelines, and inflate overall budgets. Additionally, environmental and site-related constraints, including unpredictable weather, soil instability, and site accessibility, aggravate the inefficiencies of equipment utilization. Although international contractors play a leading role in Ethiopia's infrastructure development, little empirical research has investigated how they manage these challenges. Notably, there is no prior study that evaluates the equipment management practices of CCCC, a dominant Chinese firm executing complex projects such as the Ethiopian Airlines expansion projects. This study, therefore, fills an important knowledge gap by examining the factors, challenges, and practices influencing CEM efficiency within CCCC's operations in Ethiopia.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

A study on construction equipment management practices in the China Communication Construction Company (CCCC) is introduced in this chapter. The research design, methods, and procedures used to gather and analyze data are outlined in this methodology section. The research approach, sampling method, and data collection methods are also revealed, along with a review of statistical tools. Finally, it is explained how the data collected through questionnaires and semi-structured interviews were analyzed. Additionally, a case studies section was included to provide an overview of the research objectives within a selected Ethiopian Airlines expansion project (EAEP).

3.2 Research Design

A framework or plan of action for the research is provided by a research design (Kothari, 2004). A mixed method research design was employed in order to capture and triangulate both quantitative and qualitative data. Numerical data were collected through a quantitative approach using closed-ended questionnaires. These questionnaires contained assessment items that were measured by Likert scales and were distributed to participants from Ethiopian Airlines expansion projects (EAEPs), such as contractors and consultants. Additionally, a qualitative approach was used. Data consisting largely of words were collected through semi-structured interviews, which rely on participants' views and questions were asked to collect the data. These words were then described and analyzed for themes, and the inquiry was conducted in a subjective manner. This data was collected from key construction equipment management participants. Moreover, in-depth insights into a specific project were gained through the inclusion of a case study. This allowed the selected project to be examined as per the designed research questions. This study was aimed at conducting an investigation into current practices and factors that can affect equipment management practices and machinery efficiency in terms of time management in the China Communication Construction Company (CCCC). A descriptive research design was used for this purpose.

3.3 Research Approach

Plans and procedures for research, which span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation, are known as research approaches (Careswell, 2018). A mixed approach was used for this study. Qualitative data were collected through interviews and a case study, while quantitative data were collected using a questionnaire from participants directly related to construction equipment management in Ethiopian Airlines expansion projects (EAEPs). The collected questionnaire data were then analyzed by SPSS, and the interview and case study data were analyzed by content analysis and narrative analysis, respectively.

3.4 Study Area

The study area is focused on the Ethiopian Airlines Expansion Projects in Addis Ababa, which are managed by the China Communication Construction Company (CCCC). These projects involve large-scale construction activities such as terminal buildings, runway extensions, and infrastructure development. Extensive use of construction equipment is required for this project, making it an ideal case for assessing equipment management practices. Valuable insights into equipment productivity, downtime, planning, and maintenance are offered by the site within a complex and high-demand environment. The involvement of an international contractor like CCCC also allows the study to examine how global standards are integrated with local challenges. The evaluation of best practices and areas for improvement in construction equipment management is supported by this.

3.5 Target Population

The inclusive group in this study includes Ethiopian Airlines expansion projects participants who are directly involved in equipment management practices and participate in management activities in CCCC. This was done to assess factors affecting construction equipment management practices and to answer all research questions without biasing the information. Therefore, target respondents were taken from the projects, such as contractors and consultants.

3.6 Sampling Techniques

Sampling is the strategy or the method by which data are collected from a populace. Therefore, sampling can be referred to as a process for obtaining a representative sample from a population (Sriworrarat, 2016). Since the data were collected from a specific population of Ethiopian

Airlines Expansion Projects participants, the researcher tried to select the sample based on its specific relevance to the study. Hence, a purposive sampling technique was the method selected. The participants directly involved in equipment management, including project managers, engineers, and supervisors.

3.7 Sample Size Determination

A sample size refers to a subset of individuals selected from a population to represent the whole group in a study (Cooper & Schindler, 2006). In this study, the sample size was determined from among employees of the China Communication Construction Company (CCCC) who were engaged in the Ethiopian Airlines expansion projects. Since the study focused on construction equipment management, the target participants included project managers, construction managers, project coordinators, team leaders, site engineers, office engineers, resident engineers, material engineers, safety engineers, foremen, and document control staff. The total population of the study consisted of 90 employees, of which 15 were consultants and 75 were employees of CCCC (Contractor). To determine the representative sample size, Yamane's simplified formula for sample size determination was applied at a 95% confidence level with a 5% margin of error (e = 0.05). The formula is given as:

$$n = \frac{\mathbf{N}}{\mathbf{1+N(e)^2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ equation 3.1}$$

Where

n = Sample size

N = Population size of the study

e = Margin of error (in this case, 0.05, corresponding to a 95% confidence level)

$$n = \frac{90}{1+90(0.05)^2} = 73$$

Therefore, the calculated sample size was 73 respondents. This means that questionnaires were distributed to 73 employees, ensuring that the sample adequately represented the total study population of 90 employees involved in the Ethiopian Airlines expansion projects.

3.8 Sources of Data

The origins from which information is gathered for research or analysis are referred to as sources of data. An understanding of different data sources is essential for ensuring the reliability and validity of research findings. Both primary and secondary sources of data were used in this study.

3.8.1 Primary sources

Primary sources of data included semi-structured interviews and a structured questionnaire, which were used to describe the title's objectives. The primary data were collected from participants in the Ethiopian Airlines expansion projects using a survey questionnaire. Other primary documents and files were also collected from the project office. The professional employees from the two categories (contractors and consultants) or companies who work on the projects were chosen to fill out the questionnaire. Because of this, unbiased and more accurate responses were guided and received. Moreover, a case study analysis was used to reach the real context on a selected project to obtain the current practice of construction equipment management in the selected projects.

3.8.2 Secondary sources

This was data that had already been collected and published by others. It was used for analysis or to support primary sources. It was gained from academic journals, books, government reports, datasets, and websites and online resources. Generally, various literature reviews were taken as secondary data sources.

3.9 Collection Tool

To provide a comprehensive understanding, a mixed methods approach was used to capture both quantitative and qualitative data. The quantitative data were collected through questionnaires that were comprised of closed-ended questions and were gathered from Ethiopian Airlines expansion projects (EAEPs) participants, such as contractors and consultants. Additionally, a semi-structured interview was used to gather qualitative data from key informants to explore their perspectives on construction equipment management. Participants included project managers, site engineers, and foremen from the Ethiopian Airlines expansion projects (EAEP). Furthermore, the efficiency of earthwork equipment was checked by a case study by recording the operational hours of the earthwork equipment in different projects. Field data that were collected were used to check the efficiency of the equipment and to strengthen the assessment in identifying the factors that affect the productivity of the equipment.

3.9.1 Questionnaires

Questionnaires provide first-hand information for the subject matter of research as they are focused on issues that further serve as a survey to understand the main concerns and attitudes of respondents towards the problems (Kasiem, 2008). In this thesis, a questionnaire was distributed to participants from Ethiopian Airlines expansion projects (EAEPs), including contractors and consultants. The questionnaire consists of closed-ended questions, including those about practices, factors and time efficiency for problems encountered in construction equipment management practices.

3.9.2 Interviews

Personal interviews were among the basic methods used for the collection of qualitative data. Thus, based on the basic research question, leading questions were prepared. The interviews were essentially used to obtain relevant data that could not be handled through questionnaires and for counter-checking purposes. For this purpose, semi-structured interview questions that inquire about existing practices, major gaps observed with regard to current practices, factors, machinery efficiency, and best practices in construction equipment management adoption in CCCC were prepared.

3.9.3 Case Study

A case study is the most optimal research method when a researcher is trying to find answers to "how" and "why" questions and the focus is on a present phenomenon within a real-life context. A case study can be divided into two types: intensive and extensive. The objective of intensive case study research is to understand a unique case from inside by presenting a thick, holistic, and contextualized description, whereas the goal of an extensive case study is at elaboration, testing, or the generation of generalizability theoretical constructs by replicating a number of cases (Eriksson & Kovalainen, 2008). The case study section was developed to have a deep understanding regarding the real application and outcome of equipment management results for the construction supervision of the CCCC hangar Project. This was done to assess practices, factors, and time efficiency, and to recommend best practices for the problems that were raised to meet the objectives of construction equipment management practices in the Ethiopian Airlines expansion projects.

3.10 Data Analysis

Mixed methods using both quantitative and qualitative analysis methods were provided by the study. The quantitative data that were collected through questionnaires from 73 participants from the EAEPs (CCCC) were analyzed by descriptive statistics. Simple statistical tools like mean, standard deviation, frequency, and percent were used and presented in figures and tables using Statistical Package for Social Science (SPSS) version 26 software. The qualitative data that were collected through personal semi-structured interviews were focused on participants' understanding to answer the research questions. These data were analyzed by content analysis, and the case study, which was based on a specific project, was analyzed and its outcomes were presented through narrative analysis.

3.11 Validity and Reliability

Validity and reliability are conceptualized as trustworthiness, rigor, and quality in a research study (Yin, 2014). It is suggested that triangulation is mainly applied to ensure the validity and reliability of a research study. In this research, triangulation was realized by literature reviews, a case study, questionnaires, and semi-structured interviews from Ethiopian Airlines expansion projects (EAEPs) participants. This helps to confirm the validity and reliability of the results through the convergence of evidence from different angles.

3.11.1 Reliability

Reliability alludes to the precision and consistency of data acquired in an examination and is connected with the methods used to measure research factors (Politad Beck, 2004).The consistency of a measurement is assessed by reliability through the conducting of a pilot study or the administering of a research instrument to a subset of participants. Internal consistency reliability ensures that the items within measurement scales and data collection procedures are implemented using standardized data collection protocols to minimize errors and biases. This is done through closed-ended questionnaires containing assessment items measured by Likert scales to provide clear instructions to participants and to ensure the uniform administration of research instruments. The Cronbach's alpha testing mode is mainly used for the internal consistency test. In this study, a reliability test was performed using SPSS version 26 through the Chronbach's alpha coefficient. According to William and Barry (2010), scales exhibiting a coefficient alpha between 0.8 and 0.96 are considered to have very good reliability. A value between 0.70 and 0.80 is considered to have good reliability, and an alpha value between 0.6 and

0.7 indicates fair reliability. When the coefficient alpha is below 0.60, the scale has poor reliability. In this study, reliability was tested using SPSS version 26 through the Cronbach's alpha coefficient. Internal reliabilities were computed for ten items of current construction equipment practices in CCCC, and a Cronbach's Alpha value of 0.724 was obtained.

Reliabilities were computed for twenty-five items of construction equipment factors in CCCC, and a Cronbach's Alpha value of 0.721 was obtained. Reliabilities were also tested for five items for construction equipment time efficiency in CCCC, and a Cronbach's Alpha value of 0.745 was obtained. Furthermore, reliabilities were tested for forty items for All Variables (Entire Questions), and a Cronbach's Alpha value of 0.73 was obtained. This result shows that the research instrument appears to have good reliability.

Table 3.1 Results of Reliability Test

Variable	N of Items	Cronbach's Alpha
Construction equipment management current practices in CCCC	10	0.724
Construction equipment management factors in CCCC	25	0.721
Construction equipment management time efficiency in CCCC	5	0.745
All Variables (Entire Questions)	45	0.73

Source: (own survey, 2025)

3.11.2 Validity

The quality of procedures used in research is referred to as data validity if it is accurate, true, and meaningful (Kothari, 2004). The research ensures that data were collected from reliable sources within the target population using research instruments, which include closed-ended questionnaires, semi-structured interviews, and case study analysis. Thus, pre-testing was conducted through validity attained from an assigned advisor, and the data collection tools' answers for intended research questions. To guarantee the validity of the data acquired, mean scores of 1.00 to 1.5 are considered Excellent or Very Good, 1.51 to 2.50 are Good, 2.51 to 3.50 are Average or Moderate, 3.51 to 4.50 are Fair, and 4.51 to 5.00 are Poor for a scale rate of 1 = Strongly Agree and 5 = Strongly Disagree (Asefa, 2018). Thus, for this research, 1-1.5 = strongly agree, 1.51-2.5 = agree, 2.51-3.5 = neutral, 3.51-4.5 = disagree, and >4.21 = strongly disagree. Moreover, the sample size is adequate to draw a conclusion, as 65 of the 73 distributed survey questionnaires were responded to by EAEPs participants (CCCC). Additionally, the selected participants are relevant to the study, and no data were missed during data entry.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

The objective of this research study is to assess the construction equipment management practice in Ethiopian airlines expansion projects. This chapter covers respondent's demographic information, an assessment of practices, factors and time efficiency for major problems within construction equipment management.

This chapter presents, analyzes, and interprets the data obtained from primary and secondary data sources. The primary data obtained from the questionnaire, semi-structured interview, and case study, which designed to collect the necessary data to answer the research question from respondents who directly related to construction equipment management.

4.2 Questionnaire Response Rate

The questionnaire response is key metric that reflects the percentage of completed questionnaire received from distributed questionnaire to intended participants. Thus, out of 73 distributed surveys questionnaire 65 was filled and then returned back about 89.04 percent response rate.

Table 4. 1 Questionnaire Response Rate

Response Rate	Frequency	Percent (%)	Cumulative Percent
Responded	65	89.04	89.04
Not Responded	8	10.96	100
Sample Size	73	100	

4.3 General Information of Respondents

In the questionnaire survey each respondent asked to their demographic profile including; gender, educational background, work experience and job title in tables and figures to show variability of respondents.

4.3.1 Gender

Table 4.2 and Figure 4.1 shows that out of total 65 valid respondents the number of male respondents was 51 which is 78.5 percent and the remaining number of female respondents was 14 which is 21.5 percent. The obtained result shows there were a large number of male respondents who have responded to the study than female.

Table 4. 2 Respondents Gender

Respondents Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	51	78.5	78.5	78.5
	Female	14	21.5	21.5	100.0
	Total	65	100.0	100.0	

Source: (Survey Result, 2025)

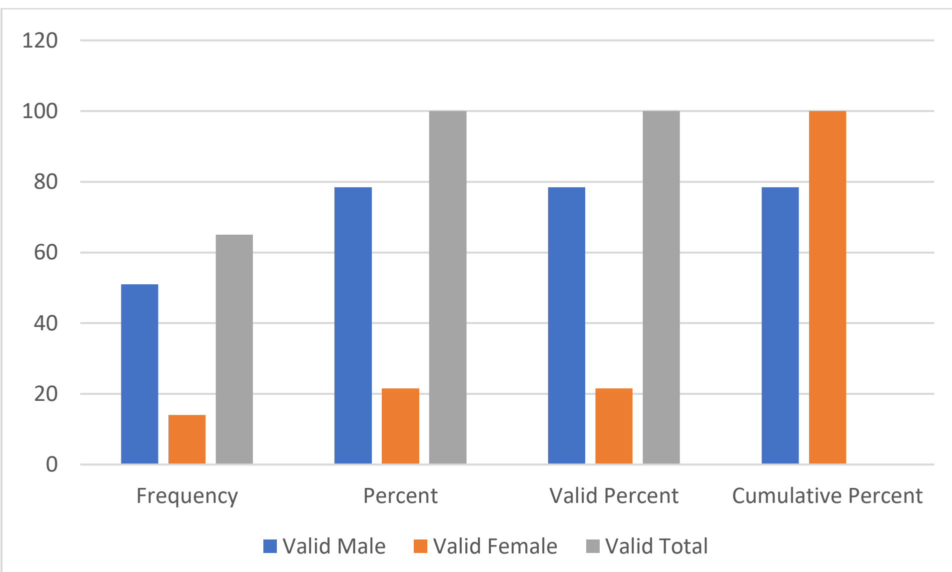

Figure 4. 1 Respondents Gender

4.3.2 Educational Background Respondents

The findings educational background in Table 4.3 and figure 4.2 shows that of respondents. There are 4 respondents equivalent to 6.2 percent who were responded the questionnaire hold Diploma, 49 respondent equivalents to 75.4 percent who were respondent the BSC/BA degree, 12 respondents' equivalent to 18.5 percentage having MSc. The analysis revealed that majority of respondents hold BSC/MBA. Degree showing the composition of education is relatively better also construction equipment management carried by well-educated professionals having positive outcome for organizational performance.

Table 4. 3 Educational Background Respondents

Educational Background Respondents					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Diploma	4	6.2	6.2	6.2
	BSC/BA	49	75.4	75.4	81.5
	MSC/MBA	12	18.5	18.5	100.0
	Total	65	100.0	100.0	

Source: (Survey Result, 2025)

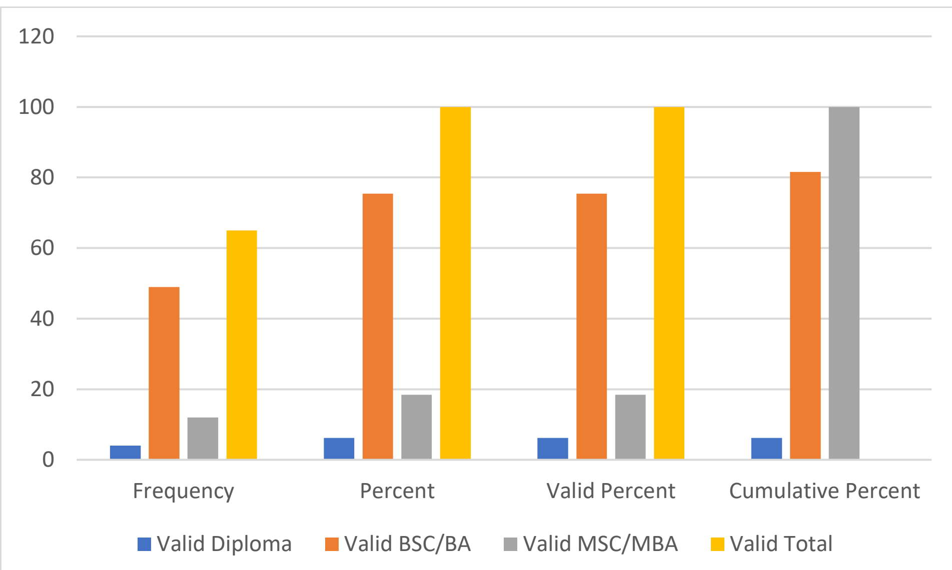

Figure 4. 2 Respondents Educational Background

4.3.3 Work Experience

The findings presented in table 4.4 and figure 4.3 indicate that the work experience of respondents is distributed as follows: 46.2% have less than 5 years of experience, 32.3% have 5-10 years of experience, 16.9% have 11-15 years of experience, and 4.6% have over 15 years of experience. These results demonstrate that the majority of respondents have less than 5 years of experience in working on the Ethiopian airline expansion project's construction department. This suggests that the company's staffed with young manpower contributed to better outcomes in construction equipment management practices.

Table 4. 4 Work Experience Respondents

Respondents Work Experience					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<5 years	30	46.2	46.2	46.2
	5-10 years	21	32.3	32.3	78.5
	11-15 years	11	16.9	16.9	95.4
	>15 years	3	4.6	4.6	100.0
	Total	65	100.0	100.0	

Source: (Survey Result, 2025)

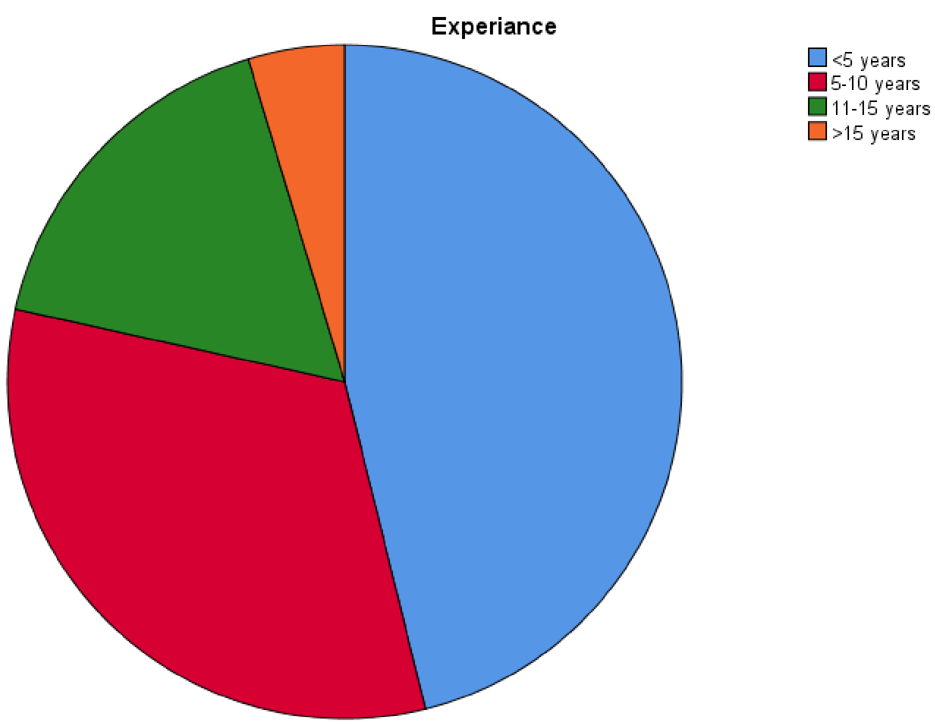

Figure 4. 3 Respondents Work Experience

4.3.4 Respondents of Job Title

The table 4.5 and figure 4.4 shows that provides a detailed breakdown of the job titles of the 65 respondents involved in the study, with site engineers forming the largest group at 43.1%. This dominant representation suggests that the findings are heavily influenced by individuals who are directly involved in day-to-day site operations and equipment handling. Office engineers account for 10.8%, while team leaders (7.7%) and material engineers and safety engineers (both 9.2%) also contribute significantly, offering perspectives related to coordination, safety, and resource management. Smaller proportions were observed for roles like foremen, project coordinators, resident engineers, and construction managers, each comprising 3.1%, indicating that top-level and supervisory input is limited compared to mid-level technical roles. The inclusion of diverse job roles enhances the breadth of the data by incorporating operational, managerial, and administrative viewpoints.

Table 4. 5 Respondents Job Title

Job Title					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Forman	2	3.1	3.1	3.1
	site engineer	28	43.1	43.1	46.2
	office engineer	7	10.8	10.8	56.9
	team leader	5	7.7	7.7	64.6
	document control	3	4.6	4.6	69.2
	construction manager	2	3.1	3.1	72.3
	project coordinator	2	3.1	3.1	75.4
	resident engineer	2	3.1	3.1	78.5
	material engineer	6	9.2	9.2	87.7
	safety engineer	2	3.1	3.1	90.8
	other	6	9.2	9.2	100.0
	Total	65	100.0	100.0	

Source: (Survey Result, 2025)

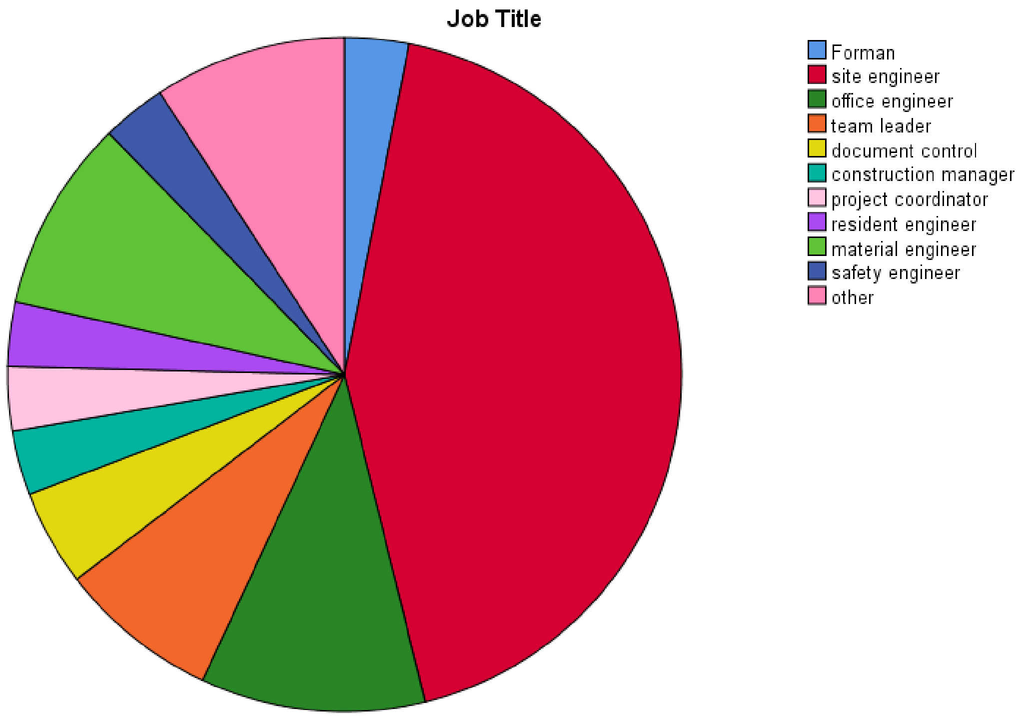

Figure 4. 4 Respondents of job Title

4.4 Results of Questionnaire Response

4.4.1 Results of construction equipment management current practices

The descriptive statistics table 4.7 shows that respondents generally expressed agreement across most aspects of current construction equipment practices in CCCC. Specifically, they agreed that project objectives are clearly defined and communicated (mean = 1.68), regular inspections are conducted (mean = 1.68), adequate financial resources are allocated for maintenance and operation (mean = 1.60), and management makes timely decisions on equipment procurement and utilization (mean = 1.82). Effective communication between management and operators was also agreed upon (mean = 1.91), and regular maintenance was acknowledged as being carried out (mean = 2.11). The availability of skilled operators was strongly agreed to significantly affect productivity (mean = 1.58). Respondents agreed that current equipment management practices minimize downtime (mean = 2.11) and moderately agreed on the utilization of technology for managing equipment (mean = 2.42). They also agreed that delays in project timelines occur due to equipment-related issues (mean = 2.23). Overall, the findings indicate generally positive practices, with technology integration and delay reduction remaining as key areas for improvement.

Table 4. 6 Descriptive Statistics on current construction equipment management practices

Current construction equipment management practice in CCCC	N	Mean	Std. Deviation
The project objectives are clearly defined and communicated to all team members.	65	1.68	0.752
Regular inspections of construction equipment are conducted to ensure optimal performance.	65	1.68	0.793
The project has adequate financial resources allocated for equipment maintenance and operation.	65	1.60	0.806
Management makes timely decisions regarding equipment procurement and utilization.	65	1.82	0.705
There is effective communication between management and equipment operators regarding equipment needs.	65	1.91	1.042
How do you rate that regular maintenance of construction equipment in your organization?	65	2.11	0.970
To what extent do you agree that the availability of skilled operators significantly affects the productivity of construction equipment?	65	1.58	1.014
How do you rate the efficiency of the current equipment management practices in minimizing downtime during construction projects?	65	2.11	0.921
How do you rate the utilization of technology in your organization (e.g., tracking systems, maintenance software) for managing construction equipment?	65	2.42	0.827
How do you rate the experience of delays in project timelines due to equipment-related issues?	65	2.23	0.965
Valid N (listwise)	65		

Source:(Survey Result, 2025)

4.4.2 Results of Construction equipment management factors

4.4.2.1 Response-on material related factors

The descriptive statistics result on table 4.8 indicate that respondents generally agreed on all aspects related to construction equipment maintenance and material management in CCCC. They agreed that construction equipment is maintained regularly to prevent breakdowns (mean = 1.95) and that spare parts are readily available when needed (mean = 2.15). Minimal delays in the supply of construction materials required for operations were also acknowledged (mean = 2.20). The quality of materials used was agreed to positively impact equipment performance (mean = 1.89), and the inventory management system was considered effective in tracking the availability of construction materials (mean = 1.86). Overall, the findings reflect positive practices in maintenance, spare parts availability, material supply, and inventory control, with some room for further improvement in ensuring consistent and timely supply of materials.

Table 4. 7 Descriptive Statistics on -Material related factors

Material -related factors	N	Mean	Std. Deviation
The construction equipment maintained regularly to prevent breakdowns.	65	1.95	1.192
Spare parts for construction equipment are readily available when needed.	65	2.15	1.093
There are minimal delays in the supply of construction materials required for operations.	65	2.20	0.905
The quality of materials used in construction positively impacts equipment performance.	65	1.89	1.048
The inventory management system effectively tracks the availability of construction materials.	65	1.86	0.899
Valid N (listwise)	65		

Source:(Survey Result, 2025)

4.4.2.2 Response-on labor -related factors

The descriptive statistics result on table 4.9 indicates that mixed perceptions regarding equipment management on the construction site. The mean score for "Skilled operators are available to handle construction equipment efficiently" is 1.78, suggesting a general agreement that skilled operators are available. This is a positive finding. However, the mean score for "Regular training programs are conducted for equipment operators to enhance their skills" is 2.86. This indicates a more neutral or moderate agreement, suggesting that training programs may not be as frequent or widespread as they could be. A similar sentiment is observed with the statement "Equipment-related issues do not hinder labor productivity," which has a mean of 2.94.

This also points to a more neutral or moderate view, indicating that equipment problems might be a moderate impediment to productivity. The mean score for "There is effective communication among workers regarding equipment usage and safety" is 2.29, suggesting that communication on these topics is generally effective. Lastly, the mean score for "Operators are motivated and engaged in their work, leading to better equipment management" is 2.11. This indicates a general agreement that operators are motivated, which is a positive factor for equipment management. In summary, while there is a positive outlook on the availability of skilled operators, communication, and motivation, there is a clear opportunity for improvement in the areas of regular training and the reduction of equipment-related issues that may be hindering productivity.

Table 4. 8 Descriptive Statistics on -Labor related factors

Labor -related factors	N	Mean	Std. Deviation
Skilled operators are available to handle construction equipment efficiently.	65	1.78	0.976
Regular training programs are conducted for equipment operators to enhance their skills.	65	2.86	1.345
Equipment-related issues do not hinder labor productivity.	65	2.94	1.248
There is effective communication among workers regarding equipment usage and safety.	65	2.29	1.100
Operators are motivated and engaged in their work, leading to better equipment management.	65	2.11	0.970
Valid N (listwise)	65		

Source:(Survey Result, 2025)

4.4.2.3 Response-on technical-related factors

The descriptive statistics result on table 4.10 indicates that a generally positive perception of equipment management practices on the construction site. The mean score for "Equipment is scheduled effectively to maximize productivity on the construction site" is 1.94, suggesting a strong agreement that equipment scheduling is effective. This is further supported by the mean score of 1.98 for "Established construction procedures are followed to ensure the proper use of equipment," which also indicates a strong agreement. The mean score for "New technologies are implemented to improve equipment management practices" is 2.28, suggesting a positive but slightly less strong agreement. This indicates that while some new technologies may be in use, there may be room for more widespread implementation. A very strong positive finding is the mean score of 1.48 for "The equipment used is compatible with the specific requirements of the project." This indicates a high degree of agreement that the selected equipment is well-suited to project needs. Finally, the statement "There are systems in place to monitor the performance of construction equipment regularly" has a mean score of 2.18, indicating a general agreement that monitoring systems are in place. In summary, the data suggests that equipment management is largely effective, with strong points in equipment scheduling, procedural compliance, and compatibility with project requirements. While the implementation of new technologies and regular performance monitoring are also viewed positively, they show slightly less consensus and may represent areas for potential improvement.

Table 4. 9 Descriptive Statistics on -Technical related factors

Technical -related factors	N	Mean	Std. Deviation
Equipment is scheduled effectively to maximize productivity on the construction site.	65	1.94	0.966
Established construction procedures are followed to ensure the proper use of equipment.	65	1.98	0.838
New technologies are implemented to improve equipment management practices.	65	2.28	0.960
The equipment used is compatible with the specific requirements of the project.	65	1.48	0.640
There are systems in place to monitor the performance of construction equipment regularly.	65	2.18	1.029
Valid N (listwise)	65		

Source:(Survey Result, 2025)

4.4.2.4 Response-on environmental -related factors

The descriptive statistics result on table 4.11 shows that varied perceptions regarding the site conditions and environmental factors affecting equipment operation. The mean score for "The site conditions are conducive to the effective operation of construction equipment" is 2.05, suggesting a general agreement that site conditions are favorable. This is further supported by the mean score of 2.05 for "The construction site is easily accessible for transporting equipment and materials," which also indicates a general agreement on site accessibility. A notable finding is the mean score of 3.46 for "Weather conditions (e.g., rain, wind) do not significantly disrupt equipment operations." This score suggests a neutral or moderate agreement, indicating that weather conditions may, in fact, cause some disruption to equipment operations. This is a point that warrants closer attention.

The mean score for environmental regulations are adhered to, ensuring safe equipment operation is 2.45, suggesting a moderate agreement on this point. This indicates that while regulations are generally followed, there may be room for stricter adherence. A similar moderate agreement is seen in the statement "Workers receive training on environmental considerations related to equipment usage," which has a mean score of 3.05. This suggests that such training may not be as frequent or comprehensive as it could be, highlighting a potential area for improvement. In summary, while site conditions and accessibility are generally viewed as favorable, the data suggests that weather poses a moderate challenge to operations. Furthermore, there is a moderate consensus on the adherence to environmental regulations and the provision of relevant training, indicating that these areas could be strengthened to ensure safer and more efficient equipment use.

Table 4. 10 Descriptive Statistics on -Environmental related factors

Environmental -related factors	N	Mean	Std. Deviation
The site conditions are conducive to the effective operation of construction equipment.	65	2.05	1.052
Weather conditions (e.g., rain, wind) do not significantly disrupt equipment operations.	65	3.46	1.448

Environmental regulations are adhered to, ensuring safe equipment operation.	65	2.45	1.186
The construction site is easily accessible for transporting equipment and materials.	65	2.05	1.124
Workers receive training on environmental considerations related to equipment usage.	65	3.05	1.243
Valid N (listwise)	65		

Source:(Survey Result, 2025)

4.4.2.5 Response-on equipment management performance

The descriptive statistics result on table 4.12 shows that a generally positive perception of project outcomes, with some areas for improvement. The mean score for "The construction project is completed within the scheduled timeline" is 2.42, which suggests a moderate agreement that projects are generally completed on time. A slightly less positive view is seen in the mean score of 2.58 for "The construction project is completed within the allocated budget," which falls into the neutral or moderately agreeable range, indicating that budget overruns may be a common issue. A very strong positive finding is the mean score of 1.91 for "The construction project meets the quality standards set by the client." This suggests a high level of agreement that projects successfully meet client quality expectations. Similarly, the mean score for "The construction project achieves the desired return on investment (ROI)" is 2.18, indicating a general agreement that projects are financially successful. The statement "The construction project is completed with minimal equipment-related issues" has a mean score of 2.51, which falls at the very beginning of the neutral or moderately agreeable range. This suggests that equipment-related issues, while not a major problem, are still present and could be minimized further. In summary, the data suggests that construction projects are generally successful in meeting quality standards and achieving a good return on investment. However, there is room for improvement in adhering to timelines and, more notably, in staying within the allocated budget. Additionally, the prevalence of equipment-related issues is a moderate concern that could be addressed to improve project efficiency.

Table 4. 11 Descriptive Statistics on -Equipment management performance

Equipment management performance	N	Mean	Std. Deviation
The construction project is completed within the scheduled timeline.	65	2.42	1.184
The construction project is completed within the allocated budget.	65	2.58	1.171
The construction project meets the quality standards set by the client.	65	1.91	0.914
The construction project is completed with minimal equipment-related issues.	65	2.51	1.017
The construction project achieves the desired return on investment (ROI).	65	2.18	1.088
Valid N (listwise)	65		

Source:(Survey Result, 2025)

4.4.3 Response-on construction equipment management time efficiency

The descriptive statistics result on table 4.13 indicates a generally positive perception of time efficiency in construction equipment management, with some areas for potential enhancement. The mean score of 2.02 for "Is there a measure to minimize idle time has implemented successfully" suggests a general agreement that successful measures are in place. This is further supported by the mean score of 1.98 for "There is metrics to evaluate the efficiency of time management practices for all construction equipment," which indicates a strong agreement that such metrics are in use. The mean score for "There is assessment on the impact of rented equipment on project timeline" is 2.22, suggesting a general agreement that these assessments are conducted. The mean score of 2.48 for "Operators are adequately trained to optimize the use of construction equipment within tight timeline" falls at the border of general agreement and neutrality. This suggests that while some training is provided, there may be a need for more robust or frequent training to ensure operators are fully equipped to handle tight deadlines. Finally, the mean score of 2.34 for "There is a practice to ensure rented equipment returned on time to avoid additional costs is implemented successfully" suggests a general agreement on this practice, but with less consensus than the first two statements. This indicates that while there are efforts to return rented equipment on time, these efforts may not be consistently successful, leading to a moderate risk of additional costs. In summary, the data suggests that while there are successful measures and metrics in place for time management, and assessments are conducted on the impact of rented equipment, there is a clear opportunity for improvement in the training provided to operators and in the consistent management of rented equipment return to avoid additional costs.

Table 4. 12 Descriptive Statistics on -Time efficiency

Construction equipment efficiency in terms of time management in CCCC	N	Mean	Std. Deviation
Is there a measure to minimize idle time has implemented successfully	65	2.02	1.023
There is assessment on the impact of rented equipment on project timeline.	65	2.22	0.927
There is metrics to evaluate the efficiency of time management practices for all construction equipment.	65	1.98	0.927
Operators are adequately trained to optimize the use of construction equipment within tight timeline.	65	2.48	1.002
There is a practice to ensure rented equipment returned on time to avoid additional costs is implemented successfully.	65	2.34	1.004
Valid N (listwise)	65		

Source:(Survey Result, 2025)

4.5 Interview Response

This study involved on semi-structured interviews with one project manager, three site engineers and two formans a total six respondents. The first question asked to respondents was what is the measured productivity rate per key construction activity on the project? The measured productivity rates for key construction activity includes earthworks machinery performs its tasks, typically measured by the amount of output produced per unit of time. the measured productivity rates for key construction activities includes; earthworks such as for excavation activities approximately 120 cubic meter per hour per excavator, for concrete pouring about 80 cubic meter per day, steel erection 30 tons per day, dozer production 50 cubic meter per hour for rock production, 80 cubic meter per hour for material production, 100 cubic meter per hour for soil (fine material) production and also for loader 120 cubic meter per hour for loading. Generally, CCCC have maintained an equipment utilization rate of approximately 75% by benchmarking against industry standards also setting performance goals and identifying inefficiencies. The second question was what are the most frequent causes of equipment related time delays in CCCC since there is preventive maintenance schedules and ensured timely fuel supply for real-time monitoring. the most frequent causes of equipment related time delays includes; adverse weather condition such as heavy rain halt operation, the other is unforeseen site conditions such as soil instability, also there is some amount of equipment breakdown due to unexpected mechanical failures still occur even with preventive maintenances in place.

The third question is what is the average duration of equipment downtime the average duration can vary according to the equipment used for example if the equipment used the average duration of equipment downtime is typically around approximately 1 day for scheduled preventive maintenances and usually ranging from 1-2 days depending on the nature of equipment failure issue

The other question asked was how often is each type of equipment in operation during typical working day in CCCC on a typical working day machineries might be in operation includes; excavators typically used throughout the day for earthworks operating around 8-16 hours per day depending on the phase of construction, bulldozers often continuous operation for site preparation and grading, usually around 8-16 hours daily, concrete mixers, generally operated as needed, often for 8-16 hours a day, depending on concrete pouring schedule, cranes also operating 8-10 hours daily based on tasks at hand particularly during steel erection and heavy lifting tasks, in addition there are dump trucks frequently in use for transporting materials, typically operating 8-16 hours per day and also there are compactors usually operated for about 8-12 hours daily during specific phases of site preparation this machinery hours including day and night depending on the phase of construction.

The other is what percentage of working hours is equipment actively used versus idle most of the time equipment can work the whole day without any idle? In CCCC active use versus idle time estimated if the equipments can work the whole day without idling the active use percentage is around 90% of total working hours and also the idle time percentage is 10% Includes factors like waiting for materials and brief maintenance checks.

To what extent are key project team members involved in planning equipment needs on a construction site all members including project managers, site engineers, and formans involving the entire project team including site managers, equipment operators, maintenance staff, and procurement personnel in the planning process. Their collective input helps identify potential risks, avoid scheduling conflicts, and improve decision-making. For example, operators can provide insights into machine limitations, while maintenance teams can advise on equipment readiness and required downtime.

For the question what intervention strategies should develop to enhance efficient construction equipment management? There is scheduled preventive maintenance, which reduces unexpected breakdowns and extends equipment life. Another key strategy is fleet standardization, which simplifies training, spare parts inventory, and repair processes. Managers also need to implement utilization tracking through digital tools like telematics, which provide real-time data on run-time, idle hours, fuel use, and location. Furthermore, operator training programs improve machine handling, safety, and fuel efficiency, while reducing wear and tear. Inventory control systems help manage spare parts, consumables, and repair tools to avoid delays due to shortages. Managers should also regularly analyze performance data to identify underperforming equipment and make informed decisions about repair, replacement, or reallocation. Finally, strong communication and coordination across procurement department, operations, and maintenance ensures that equipment strategies are aligned with project goals. Altogether, a proactive and data-driven management approach leads to lower costs, fewer delays, and higher equipment productivity.

Also for the question What best practices do you believe essential for effective construction equipment management responded as first making the right decisions when buying or renting an equipment second half shift operators and assistants and never skip equipment maintenances transforming how construction equipment is managed, monitored, and optimized. Since, modern construction projects increasingly rely on digital tools and smart technologies to improve equipment productivity, reduce downtime, and streamline operations. For example, telematics systems installed on machinery can track real-time data such as fuel consumption, engine health, idle time, and location, allowing managers to make informed decisions quickly. GPS and RFID tracking help monitor equipment movement and prevent unauthorized use or theft. Building Information Modeling (BIM) and 3D modeling tools assist in planning equipment workflows, minimizing clashes and improving logistics. Furthermore, automation and semi-autonomous equipment, like robotic bulldozers or self-driving haul trucks, reduce dependency on manual labor and increase precision and safety. Predictive maintenance systems, powered by Artificial Intelligence (AI) and Machine Learning (ML), analyze usage patterns to forecast failures before they occur, minimizing unplanned downtime. Innovations such as electric and hybrid machinery also contribute to environmental sustainability by reducing emissions and fuel costs. These technologies not only enhance efficiency but also support safer, greener, and more transparent construction operations. Embracing innovation has become a competitive advantage for construction firms aiming to deliver faster, more reliable, and cost-effective projects.

The response to the question related to technologies or innovations the most significant impact on construction equipment management tracking devices to check equipment daily activities transforming how construction equipment is managed, monitored, and optimized. Modern construction projects increasingly rely on digital tools and smart technologies to improve equipment productivity, reduce downtime, and streamline operations. For example, telematics systems installed on machinery can track real-time data such as fuel consumption, engine health, idle time, and location, allowing managers to make informed decisions quickly. GPS and RFID tracking help monitor equipment movement and prevent unauthorized use or theft. Building Information Modeling (BIM) and 3D modeling tools assist in planning equipment workflows, minimizing clashes and improving logistics. Furthermore, automation and semi-autonomous equipment, like robotic bulldozers or self-driving haul trucks, reduce dependency on manual labor and increase precision and safety. Predictive maintenance systems, powered by Artificial Intelligence (AI) and Machine Learning (ML), analyze usage patterns to forecast failures before they occur, minimizing unplanned downtime. Innovations such as electric and hybrid machinery also contribute to environmental sustainability by reducing emissions and fuel costs. These technologies not only enhance efficiency but also support safer, greener, and more transparent construction operations. Embracing innovation has become a competitive advantage for construction firms aiming to deliver faster, more reliable, and cost-effective projects.

4.6 Case study

4.6.1 Introduction

This case study section developed to have deep understanding regarding the construction equipment management practices in Ethiopian airlines the case of expansion projects in Addis Ababa to assess current construction Equipment Management Practice, Factors Affecting Equipment Management Practice, Construction Equipment Time Efficiency, and Best Practices for Construction Equipment Management in CCCC Hangar project.

4.6.2 Project Background

The Ethiopian Airlines Expansion Project, undertaken by CCCC, aims to enhance the operational capacity and infrastructure of Ethiopian Airlines. The key aspects of the project includes; the primary goals of the project is to expand the existing airport facilities in Addis Ababa, improving passenger handling capacity and enhancing operational efficiency to accommodate the growing demand for air travel in the region. The scope of the work such as terminal expansion construction of new terminal, runway upgrades to improve aircraft movement and reduce congestion, and support facilities development of new cargo facilities and maintenance hangars to support operational needs.

4.6.3 Current Construction Equipment Management Practice

The objective of selected hangar project within EAEP aims to enhance operational efficiency and service capacity through improved construction equipment management considering key objectives such as;

- Implementing advanced equipment management systems to track usage and maintenance schedules.
- Reduce idle time and ensure that construction deploy machinery effectively.
- Utilize data analytics for real-time monitoring of equipment performances.
- Support strategic planning and decision making with comprehensive reporting.
- Invest training programs for staff to enhance their skills in equipment management and operation.
- Foster culture of continuous improvement and professional development.
- effective ideas for construction equipment management in the context of the Ethiopian Airlines expansion project, focusing on regular inspections, minimizing downtime, and utilizing technology:

In EAEP, there are regular inspections and maintenance scheduling such as preventive maintenance plans by developing a schedule for regular inspections and maintenance of all construction equipment. Use a checklist tailored to each type of machinery to ensure all critical components checked and using digital inspection logs by implementing excel for recording inspection results, which accessed in real-time by relevant stakeholders. In addition, minimizing downtime on-site maintenance teams established to address issues as they arise, reducing the time equipment is out of service. And also, there is spare parts inventory to keep an inventory of critical spare parts on-site to minimize delays in repairs. Use a just-in-time inventory system to balance cost and availability. In addition, there are regular team meetings to discuss equipment status, upcoming needs, and maintenance issues, ensuring all stakeholders are informed.

When considering factors affecting construction equipment management in EAEP Since the project is complex, the construction process requires more specialized equipments and the scale of hangar project the types and quantities of equipment needed. There are different factors such as; Labor related factors significantly influence equipment management practices in EAEP. Thus, there is available skilled operators and technicians directly affects how efficiently equipment used and maintained and there is no shortages in qualified personnel can lead to less downtime and equipment proper handling. Also, there is ongoing training programs essential for ensuring that workers are familiar with the latest equipment and safety protocols lead to accidents and inefficient use of machinery and there high morale among workers leads to better performance in equipment management and maintenance. In addition, there is effective communication between management and labor facilitating smoother operation, minimizing accidents, and ensuring that equipment is used resolution of issues related to equipment by retaining experienced workers essentials for effective equipment handling and maintenance. There is also effective shift management to ensure adequate equipment operation.

When considering technical factors play a crucial role in shaping equipment management practices in the EAEP. Equipment quality and specifications, the choice of high quality, suitable equipment that meets project requirements which is essential for efficiency and safety. Since, outdated or inappropriate machinery can lead to increased downtime and maintenance issues. In addition, in CCCC there is data management systems through effective data collection and analysis systems enable better tracking of equipment usage, performance, and maintenance needs by utilizing software for equipment management can streamline operations and improve decision-making and also there is reliable supply chains for spare parts and maintenances project timelines. Equipment management performance in CCCC during the Ethiopian Airlines hangar expansion project can be evaluated through several key aspects includes there is high utilization rates indicate effective scheduling and planning which maximizes productivity and reduces idle time. Also, there is implementation of preventive and predictive maintenance strategies to minimize equipment downtime to ensures reliability and extends the lifespan of equipment, leading to smoother operations. In addition, there is downtime management tracking and analyzing downtime due to equipment failures or maintenance to enhance project timelines and overall productivity.

The construction equipment time efficiency in CCCC for Ethiopian Airlines Expansion Project shows effective equipment utilization during construction activities, affecting overall project timelines and productivity. There was effective scheduling to implementing a detailed project schedule that aligns equipment availability with project phases. To reduces waiting times for equipment and ensures that all tasks are completed on time. In addition, there is preventive maintenance to keep equipment in optimal working condition reduces the likelihood of unexpected breakdowns, ensuring that equipment is available when needed. Also, there is optimized equipment selection by choosing the right type and size of equipment for specific tasks to enhance efficiency to reduces the time taken for tasks by using equipment that is best suited for each job. Also, there is skilled operators' involvement complete tasks more efficiently and safely, reducing the time required for each operation. Improves coordination, ensuring that equipment is used effectively across different project areas to enhancing communication among teams regarding equipment availability and project timelines.

The best practices for construction equipment management that CCCC implemented during the Ethiopian Airlines expansion project includes; comprehensive planning and scheduling by developing a detailed project schedule that includes equipment needs for each phase of construction to ensures that the right equipment is available when needed, minimizing idle time and delays. Also, there was regular maintenance and inspections by establishing a preventive maintenance program with scheduled inspections and servicing to reduce the likelihood of equipment failures and extends the lifespan of machine. There is also training and skill development providing ongoing training for operators on equipment handling, safety protocols, and maintenance practices ensures skilled operation, reduces accidents, and improves efficiency.

In addition, there is organized inventory of spare parts and tools to support quick repairs and maintenance minimizes downtime by ensuring quick access to necessary parts. Also, there is established key performance indicators (KPIs) to track equipment efficiency, utilization rates, and maintenance costs provides insights for continuous improvement and informed decision-making and a robust safety program that includes regular safety audits and training sessions to reduces accidents and promotes a safety-first culture among workers. Whereas there was open communication between project managers, operators, and maintenance teams regarding equipment status and needs enhances coordination and ensures that everyone is informed about equipment availability and requirements. Data Analysis and Reporting Use data analytics to assess equipment performance and identify trends or issues enables proactive management and strategic planning for future projects.

4.7 Discussion of Main Findings and Implications

The study on construction equipment management in the Ethiopian Airlines Expansion Projects provides a comprehensive understanding of current practices, strengths, and challenges by drawing evidence from questionnaires, interviews, and a case study. Integrating these sources highlights both common themes and contextual differences, offering broad insights into how equipment management influences project outcomes in terms of efficiency, costs, timeliness, and quality. The discussion emphasizes key aspects such as current management practices, material and labor factors, technical and environmental conditions, performance outcomes, and time efficiency. Across all areas, the findings reveal encouraging practices but also underscore areas that require strategic improvement.

4.7.1 Current Equipment Management Practices

One of the most consistent findings across all three data sources was that CCCC clearly defined and communicated project objectives. Questionnaire results emphasized that objectives were well understood by both managers and operators, while interview responses confirmed that planning involved project managers, site engineers, and foremen working collaboratively. This implies that clear objectives align stakeholders, minimize misunderstandings, and ensure efficient resource allocation. Previous studies by Alzahrani and Emsley (2013) and Tadesse (2019) similarly argue that well-communicated goals are fundamental in reducing disputes and delays. The implication is that such clarity creates a culture of accountability and focus, which is particularly important in Ethiopia’s expanding construction sector where miscommunication has often been a cause of project inefficiency.

Another strong practice identified was routine equipment inspections and preventive maintenance. Respondents to the questionnaires highlighted those inspections were common and structured, and the case study demonstrated how systematic maintenance reduced downtime and extended equipment lifespan. Interviews reinforced this finding by confirming the presence of preventive maintenance schedules, though they also noted that weather conditions and unforeseen site challenges sometimes undermined these efforts. This combination of evidence implies that preventive maintenance is highly effective but not sufficient on its own to address unexpected risks. The implication is that predictive maintenance technologies and better contingency planning are necessary to achieve greater resilience, as suggested by Zhang et al. (2018) and Abebe (2018).

The study also found strong agreement on the adequacy of financial resources for maintenance and operations. Questionnaire respondents emphasized that budgets were allocated for spare parts and servicing, ensuring timely repairs. The case study confirmed that stable access to spare parts and fuel positively influenced equipment utilization rates. However, interview responses highlighted that international sourcing sometimes caused delays, showing that financial resources alone do not guarantee timely availability. This finding implies that strengthening local supplier networks and implementing predictive inventory management could improve reliability. Supporting this, Kiviniemi et al. (2015) argue that budgeting is critical, but Mekonnen (2020) found that projects with strong local supply arrangements were more resilient to delays.

Decision-making and communication also emerged as notable strengths. Questionnaire responses highlighted that manager made timely procurement decisions, while interviews noted collaborative planning across teams. This implies that quick decision-making reduces waiting times and idle labor, supporting findings from Oyedele (2013) and Bekele (2018). Effective communication between managers and operators was also emphasized, with both surveys and interviews noting regular briefings. This implies stronger coordination, enhanced workflow, and better compliance with safety standards, echoing findings by Perera et al. (2020) and Dinku (2019).

Finally, the study highlighted the role of skilled operators. Both questionnaires and interviews found that operator competence enhanced productivity and reduced accidents. The case study reinforced that operator skills directly influenced utilization rates. This implies that human capital remains central to equipment management. Studies by Abbasianjahromi et al. (2016) and Worku (2019) similarly show that certified operators improve safety and efficiency. However, the implication is that without continuous training and motivation strategies, the benefits of operator skills may diminish over time.

4.7.2 Material-Related Factors

Across questionnaires, interviews, and the case study, regular equipment maintenance and spare parts availability were identified as critical material-related factors. Respondents confirmed that maintenance was widely practiced, implying reduced breakdowns and increased machine lifespan. This is consistent with Abebe (2018) and Caterpillar Inc. (2017), who noted that planned maintenance reduces unplanned downtime by up to 50%. The case study further showed that preventive maintenance schedules and predictive checks were essential for keeping utilization rates high. However, interviews revealed that international sourcing of parts created delays. This finding implies that while systems are effective, reliance on imports increases vulnerability. Strengthening local production and supplier networks could address this gap. Minimal delays in material supply were also reported, suggesting efficient procurement and logistics at CCCC. However, other Ethiopian studies, such as Mekonnen (2019), show that delays are common locally. The implication is that while this project benefited from proactive supplier management, broader sector-wide improvements are still needed. High-quality materials were also emphasized, implying that strong quality control reduces rework and equipment strain. Tesfaye (2021) and Xia et al. (2018) confirm that poor-quality materials increase operating costs and reduce safety. Effective inventory management systems were also noted, implying that digital tools and forecasting reduce shortages. Overall, these findings imply that advanced predictive systems, combined with stronger supplier networks, are necessary to maintain consistency and reduce risks.

4.7.3 Labor-Related Factors

Labor factors emerged as both strengths and weaknesses. Skilled operators were available, implying efficient equipment use and reduced misuse. Questionnaire responses, interviews, and the case study all confirmed that operator competence directly influenced performance. However, the lack of continuous training was consistently highlighted. This finding implies that operators may not adapt to evolving technologies or safety standards. Studies by Perera et al. (2020) and Worku (2019) support the importance of refresher training in reducing accidents and improving efficiency. Breakdowns were reported to negatively affect labor productivity by causing idle time and rescheduling. This implies that even small equipment failures have a significant ripple effect on labor costs and project schedules. Sweis et al. (2019) and Amare (2021) confirm that breakdowns are a major source of idle labor in construction. Communication gaps among workers were another weakness, implying that unclear protocols undermine safety and productivity. Al-Bayati et al. (2017) and Tadesse (2020) highlight poor communication as a barrier to performance. Moderate motivation levels were also reported, implying that incentive schemes could improve responsibility and efficiency. Jarkas & Bitar (2016) and Mekonnen (2018) similarly show that recognition reduces maintenance costs and enhances operator engagement.

4.7.4 Technical and Environmental Factors

Technical factors showed strong scheduling systems, procedure adherence, and equipment compatibility. These imply efficient use of resources and improved project outcomes, supported by Han et al. (2016) and Lemma (2018). However, limited adoption of new technologies was noted across all methods. Interviews highlighted some use of telematics, GPS, and BIM, while the case study emphasized the potential of predictive analytics. This implies that CCCC is on a positive path but not yet fully leveraging modern tools. Abdel-Wahab & Al-Jundi (2017) and the Ethiopian Ministry of Urban Development (2019) argue that technology adoption remains a challenge due to cost and training barriers. Performance monitoring was also moderately rated, implying that while systems exist, they are not fully optimized. O’Brien et al. (2018) and Abebe (2021) show that inadequate monitoring leads to unexpected breakdowns.

Environmental factors presented mixed results. Site conditions were favorable, implying reduced hazards and efficient operations. However, weather disruptions were a recurring issue across interviews and case study data. This implies that contingency planning for adverse weather remains weak. O’Brien et al. (2018) and the Ethiopian Ministry (2019) confirm that rainfall and site instability cause significant delays in Ethiopia. Compliance with environmental regulations was moderately rated, implying potential risks of penalties or unsafe practices. Limited environmental training further suggests that workers are not fully aware of sustainability responsibilities. These findings imply that robust training and stricter enforcement are needed to align practices with sustainability goals.

4.7.5 Equipment Management Performance

Performance in construction equipment management (CEM) is fundamentally evaluated by its contribution to strategic project outcomes like quality, return on investment (ROI), and client satisfaction. High performance is characterized by systematic, data-driven practices, including meticulous utilization tracking and benchmarking against industry standards, which demonstrate an organization's capacity to deliver value (Lalonde et al., 2018). However, this performance is often compromised by chronic operational failures. Equipment breakdowns and poor planning frequently lead to significant cost and time overruns, revealing a fragility in the operational framework that undermines financial sustainability and project success (Lemma, 2018).

4.7.6 Efficiency in Construction equipment management

Efficiency, as a distinct yet interconnected concept, focuses on the optimal use of resources within strict time and cost parameters. It is achieved through minimizing idle time and maintaining high utilization rates, ensuring assets are actively generating value. Data-driven management is crucial for this, allowing for proactive adjustments and productivity gains. Nevertheless, this operational efficiency is highly vulnerable to deficiencies in supporting processes. As noted in studies on productivity, insufficient operator training, particularly for tight deadlines, and inconsistent protocols for managing rented equipment create significant bottlenecks (Zhong et al., 2020). These gaps introduce inefficiencies that result in extra costs and delays, effectively negating the gains from high equipment utilization (Abdel-Wahab & Al-Jundi, 2017). Therefore, true CEM excellence requires a dual focus: robust systems for monitoring overall performance must be seamlessly integrated with meticulous attention to daily operational efficiency. This ensures that the strategic value delivered by equipment is not eroded by preventable execution flaws, securing both project-specific and long-term organizational objectives.

Overall Implications

Taken together, the findings across questionnaires, interviews, and case study data provide a nuanced picture. Strengths include clear objectives, preventive maintenance, adequate budgeting, skilled operators, strong scheduling, favorable site conditions, high-quality outcomes, and positive ROI. These practices imply that CCCC has established an effective foundation for equipment management in the Ethiopian context.

However, the recurring challenges limited adoption of technology, dependence on international spare parts, inconsistent training, moderate motivation, weather-related delays, weak environmental compliance, budget overruns, and occasional equipment-related issues imply that there is still a gap between current practices and global best practices. Addressing these issues requires investment in predictive maintenance and analytics, stronger supplier networks, structured training, incentive systems, robust contingency planning, and comprehensive monitoring tools. Doing so would not only reduce costs and delays but also enhance sustainability, safety, and competitiveness in the Ethiopian construction sector.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter presents the conclusion and recommendation of this research. The main objective of this study was to assess practices, factors, time efficiency, and best practices for construction equipment management practices in Ethiopian airlines expansion projects (CCCC). The following conclusions and recommendations presented in line with the specific objectives.

5.2 Conclusion

Based on the results obtained from analysis and findings with respect to the research questions, interview and case study the results concluded as follows;

The study's findings indicate that construction equipment management at CCCC for the Ethiopian Airlines expansion projects is perceived as effective in several key areas. The results show a high level of agreement among respondents that the company has clear and well-defined project objectives, which serves as a foundation for all management activities. Furthermore, the survey data highlights a positive perception of current equipment scheduling practices, suggesting that the company is generally successful in aligning equipment use with project timelines and demands.

A significant finding is the company's proactive approach to equipment maintenance. The results demonstrate a strong agreement that regular equipment inspections are conducted, which is a crucial practice for preventing unexpected breakdowns and extending the operational life of the machinery. This emphasis on preventive maintenance is a core strength identified by the study, contributing to a stable and reliable equipment fleet.

The study also delved into the human factor, revealing that the company has a sufficient supply of skilled operators. This is a critical finding, as the competence of the personnel operating the equipment directly impacts its efficiency and safety. The presence of a skilled workforce is therefore a major asset for the company.

However, the findings also identify a notable gap in the company’s adoption of modern technology. The results show a low level of agreement regarding the implementation of specialized software for equipment management. This indicates that the company relies more on traditional, manual methods, which may hinder its ability to achieve real-time tracking, optimize maintenance schedules, and improve overall operational efficiency. Related to the technology gap, the study's results point to a need for more frequent and comprehensive training. The findings suggest that the training programs provided to operators, particularly for handling new technologies and addressing operational challenges, are not as frequent or robust as they could be. This limits the potential for performance improvement and the full utilization of modern equipment.

Environmental management presents a significant challenge, primarily due to inadequate contingency planning for disruptive weather and insufficient training on sustainability protocols. While generally favorable site conditions provide a foundation for efficiency, the recurring issue of weather-related delays and moderate compliance with regulations implies a reactive rather than proactive approach. Therefore, achieving alignment with sustainability goals and ensuring operational resilience requires the implementation of robust training programs and stricter enforcement of environmental standards.

Equipment management performance is ultimately a measure of strategic value delivery. It demonstrates an organization's success in leveraging its assets to achieve overarching project goals like quality, profitability, and client satisfaction. Strong performance is indicative of effective high-level systems and planning, but it remains vulnerable to being undermined by fundamental operational breakdowns, which can erase financial gains and damage reputation.

Construction equipment management efficiency is a measure of operational excellence in resource utilization. It reflects the day-to-day effectiveness of processes that minimize waste, maximize productivity, and control costs. While high utilization rates signal potential efficiency, its sustainability is entirely dependent on robust supporting activities like training and maintenance. Without this foundation, apparent efficiency is fragile and often leads to the delays and overruns that hinder project success.

5.3 Recommendations

Based on the findings of the study, the following recommendations put forwarded for improvement of the current practices in CCCC construction equipment management participate and to future construction equipment management participants

To CCCC

Implement a Dedicated Equipment Management Software: The most critical recommendation is for CCCC to adopt and integrate specialized software for construction equipment management. This would enable real-time tracking of equipment location and usage, automate maintenance scheduling, and provide data-driven insights to improve overall efficiency. Moving away from manual methods would enhance productivity and reduce operational costs.

Enhance and Regularize Training Programs: The company should establish more frequent and structured training programs for its equipment operators and managers. These programs should not only cover the technical aspects of operating new machinery but also focus on utilizing the new management software effectively. Training should also address best practices for time management, particularly for handling tight deadlines and the timely return of rented equipment.

Improve Data-Driven Decision Making: CCCC is advised to leverage the data collected from equipment usage and performance to make more informed decisions. By analyzing metrics on idle time, maintenance costs, and productivity, the company can optimize its fleet, improve scheduling, and adopt more proactive maintenance strategies.

Foster a Culture of Continuous Improvement: The company should encourage a culture that embraces technological change and continuous improvement in its management practices. This involves regular reviews of current processes, soliciting feedback from on-site personnel, and staying abreast of new trends and technologies in construction equipment management.

To Other Construction Companies

Embrace Technology from the Outset: other construction companies should prioritize the adoption of modern technology, such as equipment management software, from the initial stages of their projects. This proactive approach will help in establishing efficient and transparent management systems from the beginning, avoiding the challenges of transitioning from traditional to digital methods later on.

Invest in Human Capital: It is essential to invest in the continuous training and professional development of equipment operators and management staff. A skilled and well-trained workforce is a foundational element of effective equipment management, capable of maximizing productivity and properly utilizing advanced equipment and software.

Establish Robust Maintenance Protocols: other construction companies should design and strictly follow robust preventive maintenance schedules. This is crucial for minimizing downtime, extending the life of equipment, and ensuring project continuity.

Focus on Cost and Time Efficiency: other construction companies should develop clear strategies for minimizing both operational costs and project timelines. This includes careful planning for equipment acquisition and rental, strict adherence to schedules, and the use of metrics to continuously monitor and improve time efficiency.

Maintain Clear Communication Channels: Effective communication between project managers, site supervisors, and equipment operators is vital. Clear communication helps in coordinating equipment usage, addressing maintenance issues promptly, and ensuring that all team members are aligned with the project's equipment management goals.

The main recommendations of the thesis are to adopt modern technology, specifically dedicated equipment management software, and to enhance training programs for operators and managers. These steps would allow for better data-driven decision-making, improve time efficiency, and transition the company from traditional to more proactive management practices. For other construction companies, the thesis advises a similar proactive approach by embracing technology and investing in human capital from the outset.

REFERENCES

Abebe, (2016). An Assessment of Construction Equipment Management Practice at Defence Construction Enterprise. SSRN Electronic Journal, 1(2), شماره 8; ص 99-117.

Abebe, (2022). Construction equipments & classification content.

Abebaw, (2014). Assessment of factors affecting construction equipment productivity: Case study of highway projects in Addis Ababa. Master's Thesis, Addis Ababa University.

Abiy, (2015). Construction equipment management practice in Ethiopian construction industry: A case of selected contractors.

Adoption level and challenges of implementing agile project management methodology at the private banking industry in Ethiopia. (2019, August).

Ahren, C. H. T. J. (2011). Transportation construction equipment. Environmental Protection.

Alahyaril. (2014). Determinants of relationship marketing: The case of Ethiopian Airlines. Global Journal of Management and Business Research, 14(E3), 45–51.

Alkass, S., & Harris, F. (2017). Expert system for earthmoving equipment. Journal of Construction Engineering and Management, 3, 426–440.

Alzahrani, J., & Emsley, M. (2013). The impact of project goals on project success: An empirical study. International Journal of Project Management, 31(8), 1053–1065.

Assefa, E. (2018). The impact of project management practices on project performance: The case of Ethio Telecom.

Ayalew, W., & Worku, B. (2017). An assessment of construction equipment management practices in road and building projects in Ethiopia.

Azmi, A., & Danish, M. (2017). Selection criteria of equipment in construction project. International Research Journal of Engineering and Technology, 4(7), 2328–2335.

Bogahawatta, J., & Amarathunge, B. (2019). Construction equipment management through selection, maintenance and replacement practice.

B.M. Desta and H.L. Woubishet, (2018) which emphasizes that a holistic approach involving preventive maintenance and performance tracking is essential for optimizing equipment lifecycle and reducing operational costs.

Bock, T., &Linner, T.,(2015) Utilizing telematics systems to gather real time data on equipment usage, location, fuel consumption, and maintenance needs.

Creswell, J. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). Sage Publications.

Damtew, T. (2017). Comparative study of actual productivity and theoretical productivity of construction equipments: A case study of Ethiopian road construction projects.

Desta, B. M., & Woubishet, H. L. (2018). The role of construction equipment management on project performance in the Ethiopian construction industry.

Edwards, D. J., & Holt, G. D. (2019). Construction plant and equipment management research: Thematic review. Journal of Engineering, Design and Technology, 7(2), 186–206.

Equipments, E., & Equipments, M. H. (n.d.). Advanced building construction equipment.

Ethiopian Economic Association. (2008). Report on the Ethiopian economy: The current status of the construction industry. Addis Ababa, Ethiopia.

Field, A. (2006). Discovering statistics using SPSS (2nd ed.). London: Sage Publications Ltd.

Getaneh, A. (2012). Assessment of the impact of equipment productivity loss on running cost: Case study of heavy-duty construction equipment on selected road projects.

Ghule, G. (2020). Delay & cost overrun in construction projects: Implementation of lean techniques for minimizing the risks on time & cost. Theseus.

Gransberg, D. D., Popescu, C. M., & Ryan, R. C. (2016). Construction equipment management for engineers, estimators, and owners.

Han, S. H., et al. (2016). An empirical study of the relationship between construction equipment issues and project performance. Journal of Civil Engineering and Management, 22(8), 1030–1040.

Bhoye, E. R. (2018). Fleet management of construction equipment: A case study of road. IRJESTs, 1(9), 89–94.

Jaijith, A. (2020). Construction equipment management in project site. International Research Journal of Engineering and Technology, 9(May), 7603–7610.

Khot, A., & Patil, S. (2020). Construction equipment management: An analysis of factors affecting its performance.

Kiviniemi, A., et al. (2015). The role of sufficient maintenance budgeting in ensuring high equipment availability.

Kothari, C. R. (2004). Research methodology: Methods and techniques (2nd ed.). New Age International Publishers.

Kumar, R., & Sarmah, S. P. (2020). A study on construction equipment downtime and its causes.

Lauria, P. T. (2021). NCHRP Project 20-7/Task 309: Challenges and Opportunities: A Strategic Plan for Equipment Management Research. Transportation Research Board of the National Academies, September.

Mohammed, A. & Kebede, M. (2017). The Role of Hands-on Training for Equipment Operators on Ethiopian Construction Sites.

Mekdim, M. (2017). Construction Equipment Planning and Management Problems in Road Construction Projects. Master's Thesis, Addis Ababa University.

Madan, P., & Kaur Bajwa, J. (2016). 14 X INDIAN JOURNAL OF APPLIED RESEARCH Factors Affecting Employee Job Performance: With Special Reference To Banking Sector. April, 114–117.

Mellese, T., & Ababa, A. A. (2020). Challenges and Opportunities of Air Transportation in Ethiopia and Airline Success Factors: A Case Study of Ethiopian Airlines.

Mekonnen, T. (2020). The Impact of Maintenance Budgeting on Equipment Uptime in Ethiopian Infrastructure Projects.

sportation in Ethiopia and Airline Success Factors: A Case Study of Ethiopian Airlines.

Narang, R. (2020). AN ASSESSMENT OF CONSTRUCTION EQUIPMENT MANAGEMENT PRACTICE AT DEFENSE CONSTRUCTION ENTERPRISE. 16(22), 119–128.

Ohkawa, S. (2018). Construction equipment. Toraibarojisuto/Journal of Japanese Society of Tribologists, 45(12), 944–947. https://doi.org/10.2307/j.ctvvh85zm.29

Oloke, D. A., Edwards, D. J., & Li, B. (2021). Intelligent Construction Plant Information Management. Association of Researchers in Construction Management, 1(September), 5–7. http://www.arcom.ac.uk/-docs/proceedings/ar2001-169-177_Oloke_Edwards_and_Li.pdf

Parveen, S., & Khan, Z. R. (2018). A Review Paper on Cost Evaluation of Heavy Construction Machinery Used in Real Estate Sector Based in Lucknow Using Depreciation Method. International Journal of Advanced Scientific Research and Management, 3(6). www.ijasrm.com

Prajeesh, V. P., & Sakthivel, N. (2016). Management of Equipment & Machinery in Construction. IInternational Journal of Innovative Science, Engineering & Technology (Ijiset), 3(5), 113–118. www.ijiset.com

Rafsanjani, H. N., Gholipour, Y., & Ranjbar, H. H. (2019). An Assessment of Nominal and Actual Hourly Production of the Construction Equipment Based on Several Earth-Fill Dam Projects in Iran. The Open Civil Engineering Journal, 3(1), 74–82.

Razali, M. N., Manaf, Z., Binti, Z., Muhammad, M. &, & Razali, N. (2017). the Management of Plant and Machinery At Construction Site. October. https://www.researchgate.net/publication/259978493

Shaaban, I. G., Zaher, A. H., Said, M., Montaser, W., Ramadan, M., & Abd Elhameed, G. N. (2020). Effect of partial replacement of coarse aggregate by polystyrene balls on the shear behaviour of deep beams with web openings. Case Studies in Construction Materials, 12(January 2020), e00328. https://doi.org/10.1016/j.cscm.2019.e00328

Shen, X., Awolusi, I., & Marks, E. (2017). Construction Equipment Operator Physiological Data Assessment and Tracking. Practice Periodical on Structural Design and Construction, 22(4). https://doi.org/10.1061/(asce)sc.1943-5576.0000329

Sjodin, E., Granskog, A., & Guttman, B. (2016). Reengineering construction equipment: from operations focused to customer centric. Advanced Industries, April, 1–62.

Sokolovskyy, A. (2012). Analyzing Factors Impacting Students ’ Choice between Low-Cost and Full-Fare Airlines.

Sriworrarat, M. (2016). Key Factors Affecting Thai Passengers to Select Low Cost Airline. July, 133.

Thomas, R. (2023). Equipment Management In Construction. International Journal For Multidisciplinary Research, 5(5), 1–21. https://doi.org/10.36948/ijfmr.2023.v05i05.7867

Yeo, K. T., & Ning, J. H. (2016). Managing uncertainty in major equipment procurement in engineering projects. European Journal of Operational Research, 171(1), 123–134.

Appendix 1: Survey Questionnaire

ADDIS COLLEGE

DEPARTMENT OF CONSTRUCTION TECHNOLOGY AND MANAGEMENT

CONSTRUCTION EQUIPMENT MANAGEMENT PRACTICE IN ETHIOPIAN AIRLINES EXPANSION PROJECS (THE CASE OF CCCC IN ADDIS ABABA)

Questionnaire

Dear Sir/Madam, my name is Yeshi Tedla, MSc. student at Addis College school of Graduate Studies Department of Construction Technology & Management. I am currently working on a research entitled "**Construction Equipment Management Practice in Ethiopian Airlines Expansion projects (The Case of CCCC in Addis Ababa)**". I believe your experience and educational background will greatly contribute to the success of my research. So, it is with great respect that I ask you for a little of your time to fill this questionnaire. Your response is highly valuable and contributory to the outcome of the research. All of your responses to any of the questions will be kept strictly confidential and used for this academic research only. No report of the study will ever expose your identity. You kindly requested to answer accurately and with truth.

Part One-Demographic information

1. What is your age?
   - 18-24
   - 25-34
   - 35-44
   - 45-54
   - 55 and above
2. What is your gender?
   - Male
   - Female
3. What is the highest level of education you have completed?
   - Diploma
   - BSC/BA
   - MSC/MBA
   - PHD
4. What is your current role in the construction industry?
   - Forman
   - Sit engineer
   - Office engineer
   - Team leaders
   - Document control
   - Other (please specify) ____________
   - Construction manager
   - project coordinator
   - Resident engineer
   - Material engineer
   - Safety engineer
5. How many years of experience do you have in the construction industry?
   a. Less than 5 years
   b. 5-10 years
   c. 11-15 years
   d. More than 15 years

Part Two – Research Question

Please, choose appropriate answer according to their degree of rank on significant influence on your organization (1= strongly agree, 2=agree, 3= neutral, 4= disagree, and 5=strongly disagree)

1. Current construction Equipment Practice

No.	Current construction equipment management practices	1	2	3	4	5
1	The project objectives are clearly defined and communicated to all team members.					
2	Regular inspections of construction equipment are conducted to ensure optimal performance.					
3	The project has adequate financial resources allocated for equipment maintenance and operation.					
4	Management makes timely decisions regarding equipment procurement and utilization.					
5	There is effective communication between management and equipment operators regarding equipment needs.					
6	How do you rate that regular maintenance of construction equipment in your organization?					
7	To what extent do you agree that the availability of skilled operators significantly affects the productivity of construction equipment?					
8	How do you rate the efficiency of the current equipment management practices in minimizing downtime during construction projects?					
9	How do you rate the utilization of technology in your organization (e.g., tracking systems, maintenance software) for managing construction equipment?					
10	How do you rate the experience of delays in project timelines due to equipment-related issues?					

2. Factors that affect equipment management practices

No.	1. Material-Related Factors	1	2	3	4	5
1	The construction equipment maintained regularly to prevent breakdowns.					
2	Spare parts for construction equipment are readily available when needed.					
3	There are minimal delays in the supply of construction materials required for operations.					
4	The quality of materials used in construction positively impacts equipment performance.					
5	The inventory management system effectively tracks the availability of construction materials.					

No.	2. Labor-Related Factors	1	2	3	4	5
1	Skilled operators are available to handle construction equipment efficiently.					
2	Regular training programs are conducted for equipment operators to enhance their skills.					
3	Equipment-related issues do not hinder labor productivity.					
4	There is effective communication among workers regarding equipment usage and safety.					
5	Operators are motivated and engaged in their work, leading to better equipment management.					

No.	3. Technical-Related Factors	1	2	3	4	5
1	Equipment is scheduled effectively to maximize productivity on the construction site.					
2	Established construction procedures are followed to ensure the proper use of equipment.					

3	New technologies are implemented to improve equipment management practices.					
4	The equipment used is compatible with the specific requirements of the project.					
5	There are systems in place to monitor the performance of construction equipment regularly.					

No.	4. Environmental-Related Factors	1	2	3	4	5
1	The site conditions are conducive to the effective operation of construction equipment.					
2	Weather conditions (e.g., rain, wind) do not significantly disrupt equipment operations.					
3	Environmental regulations are adhered to, ensuring safe equipment operation.					
4	The construction site is easily accessible for transporting equipment and materials.					
5	Workers receive training on environmental considerations related to equipment usage.					
No.	5. Equipment Management Performance	1	2	3	4	5
1	The construction project is completed within the scheduled timeline.					
2	The construction project is completed within the allocated budget.					
3	The construction project meets the quality standards set by the client.					
4	The construction project is completed with minimal equipment-related issues.					
5	The construction project achieves the desired return on investment (ROI).					

3. Time Efficiency

No	Time efficiency for construction equipment management	1	2	3	4	5
1	Is there a measure to minimize idle time has implemented successfully					
2	There is assessment on the impact of rented equipment on project timeline.					
3	There is metrics to evaluate the efficiency of time management practices for all construction equipment.					
4	Operators are adequately trained to optimize the use of construction equipment within tight timeline.					
5	There is a practice to ensure rented equipment returned on time to avoid additional costs is implemented successfully.					

Appendix 2: Interview Question

1.What is the measured productivity rate per key construction activity on the project?

2.What are the most frequent causes of equipment related time delays?

- Fuel shortage
- Operator absence
- Breakdown
- Weather

3.What is the average duration of equipment downtime?

4. How often is each type of equipment in operation during a typical workday?

5.What percentage of working hours is equipment actively used vs idle?

6.To what extent are key project team members involved in planning equipment needs on a construction site?

7.What intervention strategies should develop to enhance efficient construction equipment management?

8.What technologies or innovations do you think will have the most significant impact on construction equipment management?

Appendix 3: Equipment non-performance and performance time sheet

CHINA COMMUNICATION CONSTRUCTION COMPANY(CCCC) IN EAEP

Project Weekly Physical and Productivity Summary

Summary of Weekly Reason for Non - Performance

APRIL -15 -2024

No.	Equipment		Unit	Hrly/ Mtr/Daily Rental Rate(Birr)	Work (Hr) (M)	Idle (Hr)	Total Hr	Remark
	Type	Plate No.						
	Direct Own Machineries							
1	Ex- Hitach	Ex-1550		2,200.00	430:00:00	10:00	440:00:00	Weather
2	Ex- Hitach	Ex-1820		2,200.00	220:00:00	13:00	233:00:00	Maintenance
3	Ex- Hitach	Ex-1250		2,200.00	198:30:00	12:00	210:00:00	Maintenance
4	Ex- Hitach	Ex-1850		2,200.00	315:30:00	9:30	325:00:00	Weather
5	Ex- Hitach	Ex-1108		2,200.00	235:00:00	14:00	239:00:00	Weather
6	Exc-Doosan	Ex-1430		2,200.00	265:00:00	10:00	275:00:00	Maintainance
7	Exc-Doosan	Ex-1643		2,200.00	320:00:00	13:00	333:00:00	Maintainance
8	Exc-Doosan	Ex-2010		2200	225:00:00	9:00	234:00:00	Weather
9	Grader	G-0599		3.200.0	160:00:00	3:00	163:00:00	Weather
10	Grader	G-0429		3.200.0	245:00:00	-	245:00:00	
11	Grader	G-0322		3.200.0	120:00:00	-	120:00:00	
l2	Loader	G-0139		3.200.0	65:00:00	-	65:00:00	
13	Loader	G-0087		3.200.0	125:00:00	-	125:00:00	
14	Loader	G-0236		3.200.0	130:00:00	-	130:00:00	
15	Dozer	D-0344		3,500.00	121:00:00	11:00	132:00:00	Maintainance
16	Dozer	D-0114		3,500.00	213:00:00	22:00	215:00:00	Weather

	Direct Rental Machineries		Unit	Hrly/ Mtr/Daily Rental Rate(Birr)	Work (Hr) (M)	Idle (Hr)	Total Hr	Remark
	Type	Plate No.						
1	Loader	Lo-2241		1200	124:00:00	0	124:00:00	
2	Dozer	Dozer-1449		3100	132:00:00	0	132:00:00	
3	Ex-Komtsu	Ex-0884		2200	143:00:00	0.00	143:00:00	
4	D- Truck	3-53006		700	122:00:00	0.00	122:00:00	
5	D-Truck	3-54527		700	329:00:00	0.00	329:00:00	
6	D-Truck	3-58361		700	345:00:00	0.00	345:00:00	
7	D-Truck	3-69182		700	322:00:00	0.00	322:00:00	
8	D-Truck	3-77645		700	354:00:00	0.00	354:00:00	
9	D-Truck	3-78655		700	289:00:00	0.00	289:00:00	
10	D-Truck	3-83032		700	378:00:00	0.00	378:00:00	
11	D-Truck	3-84790		700	346:00:00	0.00	346:00:00	
12	D-Truck	3-85915		700	337:00:00	0.00	337:00:00	
13	D-Truck	3-87018		700	375:00:00	0.00	375:00:00	
14	D-Truck	3-87568		700	386:00:00	0.00	386:00:00	
15	D-Truck	3-89958		700	365:00:00	0.00	365:00:00	
16	D-Truck	3-90129		700	354:00:00	0.00	354:00:00	
17	D-Truck	3-91933		700	331:00:00	0.00	331:00:00	
18	D-Truck	3-93101		700	379:00:00	0.00	379:00:00	
19	D-Truck	3-06206		700	371:00:00	0.00	371:00:00	
20	D-Truck	3-33478		700	342:00:00	0.00	342:00:00	

Ethiopian Airlines Expansion projects performance time-Sheet

Equipment Name & No: -Excavator -Hitachi (H) -2756										
Date	Morning		Afternoon		Night		Idel hrs/day	Working hrs/day	Total hrs/day	Remark
	Start	End	Start	End	Start	End				
6/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
7/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
8/9/2024	2:00	6:00	7:30	11:30				8:00	8:00	
9/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
10/9/2024	2:00	6:00	7:30	11:30				8:00	8:00	
11/9/2024	2:00	6:00	7:30	10:30			1:00	7:00	8:00	Weather
12/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		12:00	14:00	
13/9/2024	2:00	6:00	7:30	11:00			0:30	7:30	8:00	Weather
14/9/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
15/9/2024	2:00	6:00	7:30	10:30			1:00	7:00	8:00	Weather
16/9/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
17/9/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
18/9/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
19/9/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
20/9/2024	2:00	6:00	8:30	11:30			1:00	7:00	8:00	Weather
21/9/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
22/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
23/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
24/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
25/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
26/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
27/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
28/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
29/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
30/9/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
1/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
2/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
3/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
4/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
5/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
Total Working hours for the month							3:10hrs	549:50hrs	552:00hrs	

Ethiopian Airlines Expansion project performance time-Sheet

Equipment Name & No:- Dozer (1075)										
Date	Morning		Afternoon		Night		Idle hrs/day	Working hrs/day	Total hrs/day	Remark
	Start	End	Start	End	Start	End				
1/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
2/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
3/10/2024	4:00	6:00	7:30	11:30			2:00	6:00	8:00	Rain
4/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
5/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
6/10/2024	2:00	6:00	7:30	10:30				7:00	8:00	
7/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		12:00	14:00	
8/10/2024	2:00	6:00	7:30	11:00			0:30	7:30	8:00	Rain
9/10/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
10/10/2024	2:00	6:00	7:30	10:30			1:00	7:00	8:00	Rain
11/10/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
12/10/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
13/10/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
14/10/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
15/10/2024	2:00	6:00	8:30	11:30				7:00	8:00	
16/10/2024	2:00	6:00	7:30	9:00			2:30	5:30	8:00	Rain
17/10/2024	2:00	6:00	7:30	9:30			2:00	6:00	8:00	Rain
18/10/2024	2:00	6:00	8:30	11:30			1:00	7:00	8:00	Rain
19/10/2024	2:00	4:00	7:30	11:30			2:00	6:00	8:00	Rain
20/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
21/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
22/10/2024							8:00	0:00	8:00	Mechanical
23/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
24/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
25/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
26/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
27/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
28/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
29/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
30/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
Total Working hours for the month							20:00hrs	306:00hrs	326:00hrs	

Ethiopian Airlines Expansion project performance time-Sheet

Equipment Name & No:-LOADER (I)- 1974										
Date	Morning		Afternoon		Night		Idle hrs/day	Working hrs/day	Total hrs/day	Remark
	Start	End	Start	End	Start	End				
1/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
2/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
3/10/2024	4:00	6:00	7:30	11:30			2:00	6:00	8:00	Rain
4/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
5/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
6/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
7/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		12:00	14:00	
8/10/2024	2:00	6:00	7:30	11:00			0:30	7:30	8:00	Rain
9/10/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
10/10/2024	2:00	6:00	7:30	10:30			1:00	7:00	8:00	Rain
11/10/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
12/10/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
13/10/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
14/10/2024	2:00	6:00	7:30	11:30	12:00	4:00		12:00	12:00	
15/10/2024	2:00	6:00	8:30	11:30				7:00	8:00	
16/10/2024	2:00	6:00	7:30	9:00			2:30	5:30	8:00	Rain
17/10/2024	2:00	6:00	7:30	9:30			2:00	6:00	8:00	Rain
18/10/2024	2:00	6:00	8:30	11:30			1:00	7:00	8:00	Rain
19/10/2024	2:00	4:00	7:30	11:30			2:00	6:00	8:00	Rain
20/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
21/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
22/10/2024	2:00	4:00	7:30	11:30				8:00	8:00	
23/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
24/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
25/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
26/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
27/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
28/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
29/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
30/10/2024	2:00	6:00	7:30	11:30	12:00	6:00		14:00	14:00	
	Total Working hours for the month						12:00hrs	314:00hrs	326:00hrs	

Ethiopian Airlines Expansion project performance time-Sheet

Equipment Name & No:-Grader-0599										
										Remark
Date	Morning		Afternoon		Night		Idle hrs/day	Working hrs/day	Total hrs/day	
	Start	End	Start	End	Start	End				
1/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
2/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
3/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
4/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
5/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
6/10/2024	2:00	6:00	7:30	10:30				8:00	8:00	
7/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
8/10/2024	2:00	6:00	7:30	11:00				8:00	8:00	
9/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
10/10/2024	2:00	6:00	7:30	10:30				8:00	8:00	
11/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
12/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
13/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
14/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
15/10/2024	2:00	6:00	8:30	11:30				8:00	8:00	
16/10/2024	2:00	6:00	9:30	11:30			3:00	5:00	8:00	rain
17/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
18/10/2024	5:00	6:00	7:30	11:30			5:00	3:00	8:00	rain
19/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
20/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
21/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
22/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
23/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
24/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
25/10/2024	4:30	6:00	7:30	11:30			1:30	6:30	8:00	rain
26/10/2024	2:00	6:00	9:30	11:30			3:30	4:30	8:00	rain
27/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
28/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
29/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
30/10/2025	2:00	6:00	7:30	11:30				8:00	8:00	
Total Working hours for the month							13:00hrs	227:00hrs	240:00hrs	

Ethiopian Airlines Expansion project performance time-Sheet

Equipment Name & No:- Roller (1279)										
Date	Morning		Afternoon		Night		Idle hrs/day	Working hrs/day	Total hrs/day	Remark
	Start	End	Start	End	Start	End				
1/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
2/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
3/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
4/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
5/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
6/10/2024	2:00	6:00	7:30	10:30				8:00	8:00	
7/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
8/10/2024	2:00	6:00	7:30	11:00				8:00	8:00	
9/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
10/10/2024	2:00	6:00	7:30	10:30				8:00	8:00	
11/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
12/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
13/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
14/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
15/10/2024	2:00	6:00	8:30	11:30				8:00	8:00	
16/10/2024	2:00	6:00	9:30	11:30			3:00	5:00	8:00	Rain
17/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
18/10/2024	5:00	6:00	7:30	11:30			5:00	3:00	8:00	Rain
19/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
20/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
21/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
22/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
23/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
24/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
25/10/2024	4:30	6:00	7:30	11:30			1:30	6:30	8:00	Rain
26/10/2024	2:00	6:00	9:30	11:30			3:30	4:30	8:00	Rain
27/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
28/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
29/10/2024	2:00	6:00	7:30	11:30				8:00	8:00	
30/10/2025	2:00	6:00	7:30	11:30				8:00	8:00	
Total Working hours for the month							13:00hrs	227:00hrs	240:00hrs	