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CONSTRUCTION EQUIPMENT MANAGEMENT (PRODUCTIVITY OF EQUIPMENT USED FOR VARIOUS PURPOSES)

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ABSTRACT

Construction Equipment is the important factor to run the project in a successful manner. Construction equipment is the foundation of each successful project, influencing the efficiency and efficacy of undertakings across the sector. The management of these critical assets has a significant impact on construction productivity, timeliness, and cost-effectiveness. This abstract navigates the complex environment of construction equipment management, revealing its critical role in maximizing resource usage, improving project results, and meeting the different objectives of construction undertakings. This abstract provides insights into the dynamic interaction between technology, human skill, and operational excellence in the construction industry by delving into the complexities of equipment selection, maintenance, and usage strategies.

Keywords - Construction Equipment, Asset Management, Productivity Enhancement, Equipment Utilization, Project Efficiency, Maintenance Strategies, Construction Industry.

1. INTRODUCTION

Good project management in construction must vigorously pursue the efficient utilization of labour, material and equipment. Improvement of labour productivity should be a major and continual concern of those who are responsible for cost control of constructed facilities. Material handling, which includes procurement, inventory, shop fabrication and field servicing, requires special attention for cost reduction. The use of new equipment and innovative methods has made possible wholesale changes in construction technologies in recent decades. Organizations which do not recognize the impact of various innovations and have not adapted to changing environments have justifiably been forced out of the mainstream of construction activities. The basic operations involved in the construction of any project are excavation, digging of small or large quantities of earth and moving them to fairly long distances, placement, compacting, leveling, dozing, grading, hauling, etc. All the machines that are usually used to carry out these construction operations are referred to as construction equipment. In most cases, they are called heavy equipment especially in road construction.

Construction only grows more complex each passing year, if not each quarter. As these complexities increase and timelines grow tighter, the management of resources becomes increasingly important. Equipment makes up some of the most valuable assets in this category. These items are not only expensive to purchase but also to maintain. Studies show that the maintenance of construction equipment plays a role in about 40% of total project overrun costs. Broken equipment has a domino effect on projects, leading to downtime, additional expenses, and frustrated owners. Putting more effort into planning the management of your equipment and its maintenance can improve project and financial outcomes. Fortunately, prioritizing construction equipment management has proven to pay off. Today, we'll take a look at what successful equipment management looks like and the innovations to make the management process much more efficient. Managing construction equipment is pivotal for optimizing productivity across diverse project requirements. The efficient utilization of equipment is a cornerstone of successful construction endeavors, impacting timelines, costs, and overall project outcomes. From heavy machinery to specialized tools, understanding the nuances of equipment management is key to achieving superior performance and maximizing the potential of each asset. In this exploration, we delve into the intricacies of construction equipment management, spotlighting its critical role in enhancing productivity across multifaceted project demands.

1.1 Evolution of Construction Equipment

The evolution of construction equipment encompasses significant milestones in the development of machinery crucial to the construction industry's advancement. In the late eighteenth century, during the Industrial Revolution, the invention of the steam engine marked a breakthrough in powering machinery for various applications, including earthmoving. William S. Otis created the first practical steam-powered shovel in 1838, which earned a patent in 1839 but initially operated on rails, limiting its flexibility. However, advancements in the early twentieth century led to crawler-mounted steam shovels with enhanced mobility. Benjamin Holt's transformation of a steam traction engine into a track-type

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tractor in 1904 marked a critical moment, and by 1910, the "Caterpillar" trademark emerged. World War I propelled Holt to supply crawlers globally, leading to industry dominance. The 1925 merger between Holt and Best formed Caterpillar Tractor Company, further solidifying their position. Innovators like R. G. LeTourneau revolutionized equipment with the tractor-mounted cable control, significantly impacting earthmoving efficiency. The introduction of the integral motor grader, diesel power, and yellow paint in the 1930s established industry standards, contributing to Caterpillar's leadership. LeTourneau's articulated wheel tractor-scraper, known as the Super C Tournapull, proved revolutionary, significantly increasing off-road productivity. The post-World War II era witnessed the emergence of the wheel loader, hydraulic excavator, and significant advancements in scraper development. General Motors' entry and subsequent legal challenges altered the competitive landscape, while Deere and Case's introduction of light construction equipment in 1957 ushered in a new era of machinery tailored for construction use. These pivotal moments in construction equipment history established fundamental machine types that remain prevalent in the industry today.

The evolution of modern construction equipment encapsulates a fascinating journey through historical milestones and technological leaps. Beginning with the age of muscle power, where human and animal strength formed the cornerstone of construction, advancements in simple tools like levers and pulleys laid the groundwork for future innovations. Ancient pioneers, as documented by Roman engineer Vitruvius, introduced wooden cranes and treadwheel-powered heavy equipment, setting the stage for the sophisticated cranes and piledrivers used today. The advent of portable steam engines in the late 1600s marked a significant turning point, revolutionizing construction equipment and ushering in traction-engined tractors and steamrollers. Later, the internal combustion engine emerged as another game-changer, supplanting steam engines and leading to mass-produced ICE machines, including tractors. Hydraulic systems, rooted in Blaise Pascal's principles, began appearing in the late 1800s and eventually evolved into modern hydraulic construction equipment by the mid-20th century. The concept of continuous tracks over wheels, initially conceived by Józef Maria Hoene-Wroński in the 1830s, gained commercial success in the early 1900s and found military adaptation during World War I, paving the way for tracked vehicles' widespread use. Colossal bucket-wheel excavators, developed in the 1920s for surface mining and continually growing in size, stand as marvels of construction machinery. Bulldozers, traced back to the 1920s and first derived from farm tractors, emerged as powerful workhorses in construction. Dump trucks, with origins dating to the late 19th century, evolved from steam-powered carts to motorized versions with innovative features like hydraulic systems. Overall, this evolutionary trajectory showcases human ingenuity, driving the transformation of construction equipment from humble origins to today's sophisticated machinery, while hinting at a promising future with advancing technology.

Construction Equipment Management

Selecting the right equipment for a construction project is crucial when it comes to budget, timelines, and execution. When a construction equipment manager has the information and tools they need to do their job properly, the entire project runs smoothly and equipment is better managed, scheduled, and maintained. Without proper equipment management, construction companies experience more equipment breakdowns and failures, projects running over budget, stalls of productivity, and decreased profitability.

Construction equipment management is the process of directing and controlling construction equipment. Construction equipment managers are in charge of the equipment used by a construction company. They are responsible for purchasing, maintaining, and repairing the equipment, as well as storing, cleaning, and transporting them. They are also responsible for keeping inventory and assigning the right equipment for the job. Construction equipment managers use a process called equipment asset management to help them monitor and manage their equipment properly.

1.2 Objective of the study

- To evaluate and enhance construction equipment efficiency.
- To optimize equipment usage aligned with project needs.
- To establish proactive maintenance protocols.
- To identify construction equipment and tools management practices that have the potential to improve productivity in multistory building projects

2. LITERATURE REVIEW

2.1 General

The emphasis is spread over numerous essential components of construction equipment management. It starts by tracing the historical development of building tools, emphasizing significant breakthroughs that led to the contemporary technology used in the construction industry today. This part next investigates the effect of equipment usage on project results, looking at how optimum deployment affects project deadlines and overall success. It also discusses maintenance

techniques for decreasing equipment downtime, stressing the need of preventative and predictive maintenance. The part also looks at how cutting-edge technologies are being integrated into construction equipment, offering light on how innovations like IoT and automation are affecting the future of equipment management techniques in the construction industry. This review lays the framework for succeeding subsections' in-depth investigation and analysis of relevant material.

2.2 Literature review

Sathvik Sharath Chandra et.al. 2023,

Author sought to improve the construction industry's performance by examining the elements influencing equipment productivity. They evaluated six critical characteristics connected to construction equipment using a hypothetical framework to determine their impact on project productivity. The researchers examined the data acquired from a survey of 110 respondents in the construction sector using exploratory factor analysis (EFA) and structural equation modeling (SEM). The SEM model that resulted included 31 qualities drawn from six essential aspects: management (MG), materials (MT), human (HM), technical (TN), environmental (EM), and other factors (OT). Notably, the research found that MT and OT had a significant impact on construction equipment productivity, owing to variables such as operational life, equipment age, and accidents during construction operations. The research highlighted current gaps in equipment productivity and presented solutions targeted at reducing major limiting factors within MT and OT using insights gained from construction experts. This study provides significant insights for industry specialists by measuring the interdependencies among numerous restrictions in construction equipment productivity, assisting in the formulation of ways to alleviate delays caused by idle time and improve total equipment productivity.

Nazi Soltanmohammadlou et.al (2019)

This study aims to conduct a systematic literature review to investigate predominant research streams, achievements, and limitations to the all existing applications of RTLS technology in construction safety management, and suggest potential areas for future research on the integration of RTLS applications into wider scopes of onsite safety management. The main contribution of this review lies on providing a more comprehensive knowledge of the current utilization and further development of RTLS applications on improving construction safety management. RTLSs have aided safety management process in eight major research streams including safety monitoring, accident prevention, behavior-based safety, safety alerts and warnings, ergonomics analysis and physiological status monitoring, communication-based safety, performance evaluation of the developed RTLS-related technologies and on-site safety training. However, there are limitations and gaps in applying each particular application which are highlighted to clarify the future research avenues.

Sanat A. Talmaki et.al (2022)

This paper develops a scalable technical approach and presents a prototype application framework for transmitting real world sensor data to update 3D equipment models inside a graphical digital twin for concurrent visualization of a monitored construction operation. The developed framework and workflow can be extended to visualize any construction operation, as it occurs, inside a dynamic 3D world simply by outfitting the real equipment with appropriate sensors and connecting them to their virtual counterparts.

The implemented proof-of-concept interface is described in the context of a real-time 3D digital twin for assisting excavator operators prevent unintended strikes with underground utilities. Experiments to validate the proposed technical approach by simulating the real-time motion of a backhoe loader’s articulated arm using orientation sensors installed on its boom, stick, and bucket are described. The experimental results characterize the scope and potential reasons for spatio-temporal discrepancies that can occur between a monitored real operation and its replicated digital twin.

3. RESEARCH METHODOLOGY

3.1 General

The methodology section is the research's backbone, including the tactics and procedures utilized to discover, gather, and evaluate data. It usually includes the study design, data gathering techniques, participant selection, and statistical processes. The methodology describes how the study was carried out, and it provides a clear roadmap for reproducing or comprehending the research process.

It acts as a guide to validate the results' dependability and validity by describing the logic behind the techniques used, whether qualitative, quantitative, or mixed approaches. This section explains how the research questions or hypotheses were addressed, the techniques or instruments that were utilized, and the processes for analyzing and deriving conclusions from the data collected.

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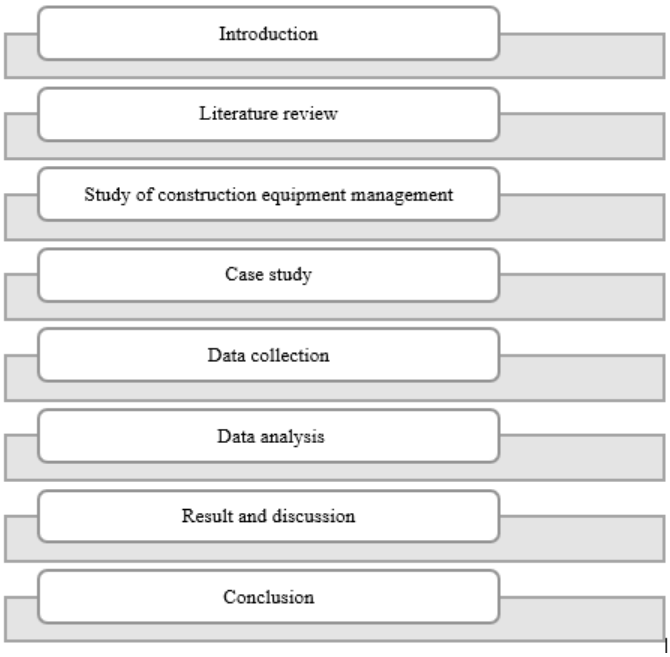

Fig no 1: Steps in Methodology

3.2 Methodology

The methodology for this study on construction equipment management in Pune centers on involving engineers and laborers in local construction projects. Data will be gathered using a structured questionnaire to investigate their viewpoints on the use of equipment, maintenance procedures, difficulties encountered, and possible enhancements. The questionnaire will be distributed to the target groups as part of the primary data analysis, and answers about equipment handling, maintenance, and their effect on project efficiency will be gathered. Both quantitative and qualitative analysis will be performed on the gathered data, with statistical tools being used to extract numeric insights and qualitative subtleties from open-ended questionnaire parts. The results will be discussed, highlighting the differences and similarities between the views of engineers and laborers and providing suggestions for improving equipment management procedures in Pune building projects.

3.3 Construction Equipment Types and Construction Equipment

Construction machinery, also known as construction equipment, consists of a variety of heavy machines used in the construction industry. These machines are used to perform work such as loading and unloading materials, driving material and tools into and out of the site, moving materials from one location to another, feeding material into a machine for processing, retrieving materials from a machine for processing or handling of raw materials by transporting them to another location for processing, cutting down trees or other vegetation and the like. Kindly check below the types of heavy construction equipment used in the construction industry.

Construction Equipment Types

Kindly check the classification of construction equipment and construction equipment names and pictures. Various types of construction equipment are generally categorized into;

1. Earth Moving Equipment
2. Construction Vehicles
3. Material Handling Equipment
4. Other Construction Equipment

3.4 Design of Questionnaire

Developing the structured questionnaire, this was divided into three sections.

- General information about the company such as, its size and the value of its equipment fleet etc.
- Information related to the contractor’s practices in equipment acquisition, equipment economics, replacement, operation and maintenance, record keeping and standardization.
- Miscellaneous questions on safety policy, classification methods and the utilization of computers for the management of equipment.

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3.5 Company Identification

Companies for questionnaire survey are mainly classified three levels I, II, III on the basis of them

- ✓ Characteristics of the company
- ✓ Experience
- ✓ Types of work performed
- ✓ Owned value

3.6 Questionnaire Analysis

Collected data to be analyzed using statistical tools analysis method, SPSS (Statistical Package for Social Science) is a statistical analysis and data management software package. SPSS can take data from almost any type of file and use them to generate tabulated reports, charts, and plots of distribution and trends, descriptive statistics, and conduct complex statistical analyses.

3.7 Survey Result and Inference

A total of 18 responses were received for our questionnaires. Therefore, a total of 8, 5 and 5 completed questionnaires were received from the level I, level II and Level III companies respectively. The received data were analyzed using SPSS software.

4. CASE STUDY

4.1 Case Study Information

CASE STUDY 1: Ready Mix Concrete Plant and Stone Crusher Plant

NAME OF THE PROJECT: Improvements and extension of NH-150 highway construction from sinnor (Karnataka) to akkalkot (Maharashtra).

Basic info about plant:

Nature

Total purchase cost of m/c:

1) Ready mix concrete plant: Rs.3.4cr

2) Stone crushing plant: 1.2cr

The construction industry is a dynamic and demanding sector where efficient management of construction equipment plays a pivotal role in project success. In this case study, we delve into the details of a project involving the improvement and extension of NH-150 highway in the region stretching from Sinnor in Karnataka to Akkalkot in Maharashtra. Two key components of this project are the Ready Mix Concrete Plant and Stone Crusher Plant.

Associated Plants	STONE CRUSHING PLANT
Nature /mode of plant	Mobile portable pozzalona crusher-200TPH
Total purchase cost of m/c	RS.1.2CR
Life of equipment in years	12
Expected daily production	140TPH
Operation hours per day	15
Average duration of downtime	60 HOURS
Operating days per month	25
Operating hours per month	375
Monthly downtime for minor repair-	2-4%
Monthly downtime for major repair	1-2%
Yearly planned hours of operation	4000

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Figure No.1 Case Study Stone Crusher

5. RESULTS AND DISCUSSION

5.1 Introduction

Construction Equipment Management plays a pivotal role in the efficient execution of construction projects, directly influencing productivity and project timelines. A comprehensive survey was conducted to assess the productivity of equipment utilized for various purposes within the construction industry. The survey targeted a diverse range of construction projects, encompassing residential, commercial, and infrastructure developments. The results of the survey provide valuable insights into the utilization patterns, maintenance practices, and overall efficiency of construction equipment. Through a systematic analysis of the data, key trends and patterns emerge, shedding light on the factors that contribute to or hinder equipment productivity. The survey also delves into the preferences of construction professionals regarding specific types of equipment for different tasks, offering a nuanced understanding of industry preferences. In this introduction section, we outline the purpose and scope of the survey, emphasizing its significance in optimizing construction processes. The subsequent sections will delve into specific survey results, drawing inferences that can guide industry stakeholders in enhancing construction equipment management practices for improved productivity.

A total of 18 responses were received for our questionnaires. Therefore, a total of 8, 5 and 5 completed questionnaires were received from the level I, level II and Level III companies respectively. The received data were analyzed using SPSS software.

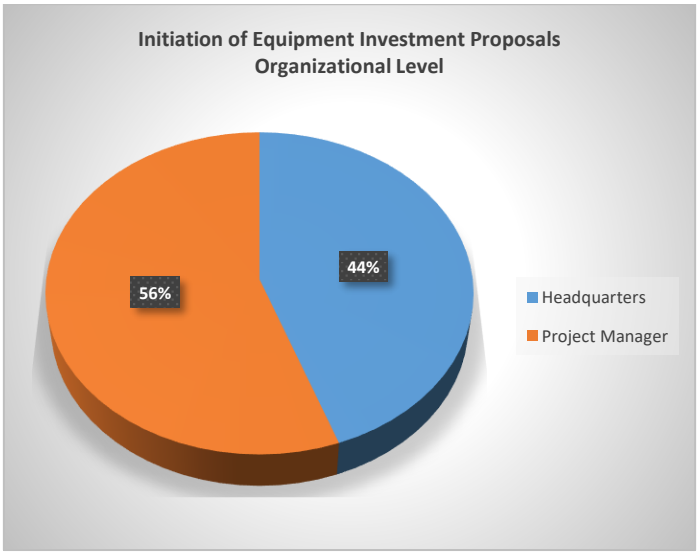

Fig no 2: Initiation of Equipment Investment Proposals Organizational Level

Many companies stated that project managers are usually charged with the responsibility of making requests for equipment investments on their respective projects.

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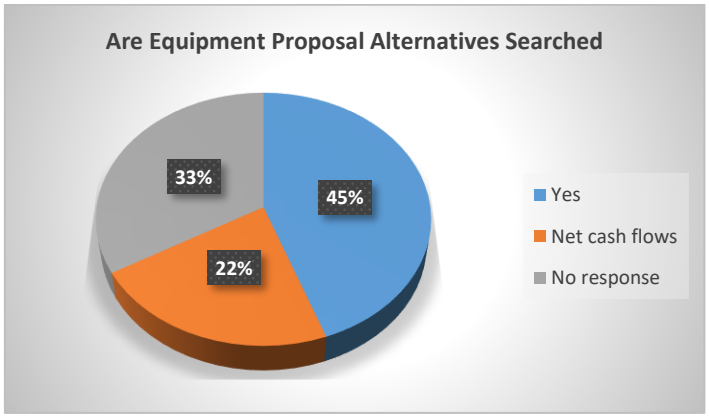

Fig no 3: Are Equipment Proposal Alternatives Searched?

Acquisition process is to identify alternatives to satisfy the identified need. The results indicate that almost all the companies consider alternatives to investment proposals that are evaluated quantitatively and qualitatively.

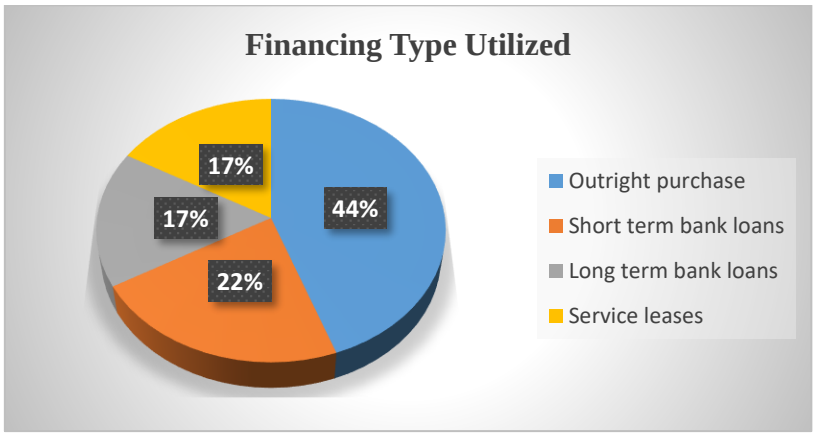

Fig no 4: Financing Type Utilized

Figure 5.3 illustrates the financing types employed for construction equipment management. Outright purchase is the most prevalent method, constituting 44% of cases, followed by short-term bank loans at 22%. Long-term bank loans and service leases each account for 17%, contributing to a comprehensive view of the various financial approaches. This data emphasizes the diverse strategies utilized to acquire construction equipment, showcasing a balanced distribution across outright purchase, short-term and long-term bank loans, and service leases in the construction industry.

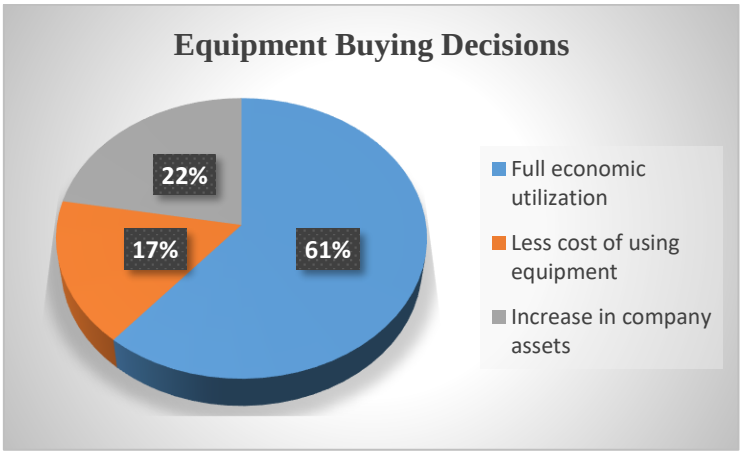

Fig no 5: Equipment Buying Decisions

Table 5.4 illustrates the Equipment Buying Decisions within the context of construction equipment management. Among the respondents, 61% prioritize Full Economic Utilization, emphasizing efficient and optimal use of equipment. Meanwhile, 17% consider the option of Less Cost of Using Equipment, highlighting a focus on minimizing operational expenses. Additionally, 22% prioritize an Increase in Company Assets, indicating a strategic approach to building and enhancing the company's overall resources through equipment acquisition. The table summarizes these perspectives, with a total of 18 responses analyzed.

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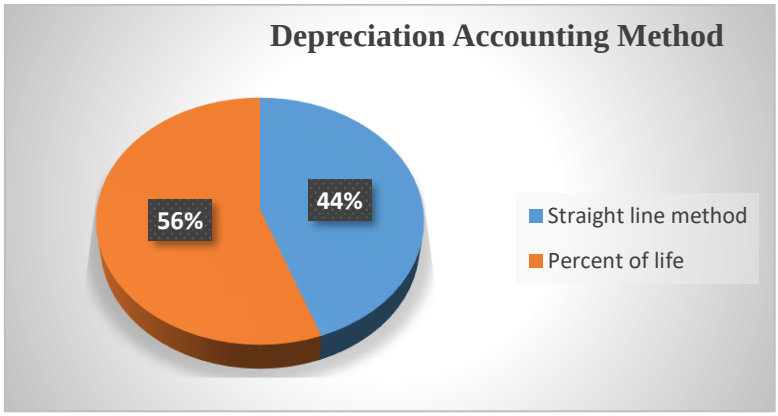

Fig no 6: Depreciation Accounting Method

The results indicated that the majority of the participants do depreciate their equipment for pricing and taxes on the equipment. The most popular methods for depreciating equipment are the straight-line method (level I) and the percentage of life method (level II and III).

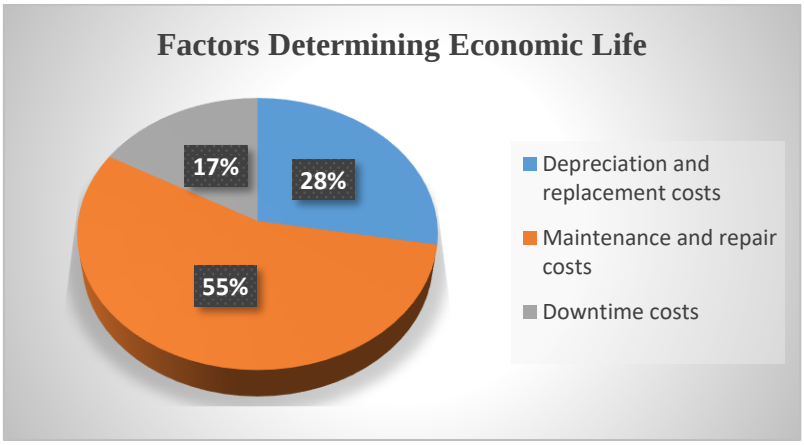

Fig no 7: Factors Determining Economic Life

It seems that the major decisive factor in determining the economic life of equipment is maintenance and direct and indirect repair costs. Determining the economic life of equipment is not only important for the equipment replacement decision process, it is also important for calculating annual equipment depreciation.

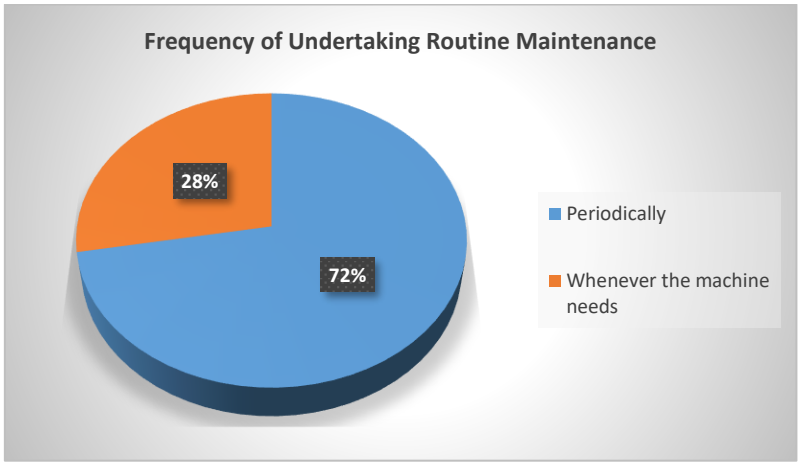

Fig no 8: Frequency of Undertaking Routine Maintenance

Figure 5.7 illustrates the frequency of undertaking routine maintenance for construction equipment management. The majority, comprising 72%, opt for periodic maintenance, indicating a proactive approach to equipment upkeep. Meanwhile, 28% prefer addressing maintenance needs as they arise. In total, 18 responses were analyzed, shedding light on the diverse strategies employed by professionals to ensure the productivity and longevity of construction equipment. This data underscores the significance of routine maintenance in optimizing the performance of various construction machinery.

6. CONCLUSION

The data analysis provides valuable insights into the construction equipment management practices across different organizational levels within the construction industry. The initiation of equipment investment proposals predominantly lies with project managers, as indicated by 56% of the respondents from Level I, Level II, and Level III companies. The survey also reveals that most companies actively search for alternatives when considering equipment proposals, with 45% confirming the exploration of alternatives. In terms of financing, outright purchase emerges as the leading method, preferred by 44% of the participants. The choice of equipment buying decisions is predominantly influenced by full economic utilization (61%), emphasizing the importance of maximizing the utility of equipment to achieve cost-effectiveness.

Depreciation accounting methods vary across levels, with the straight-line method being favored by Level I companies and the percentage of life method by Level II and III companies. The economic life of equipment is primarily determined by maintenance and repair costs, highlighting the significance of effective maintenance practices in prolonging equipment life. Routine maintenance is undertaken periodically by 72% of respondents, with preventive maintenance being the dominant type at 61%. The survey indicates that the replacement time for equipment is often triggered by inefficient performance (67%) or a need for major overhaul.

Factors such as downtime costs, obsolescence, and depreciation play a crucial role in replacement analysis, with downtime costs being the most influential factor. Interestingly, a majority of companies (67%) prefer standardization, primarily by brand or engine family, citing advantages such as savings in spare parts and lower maintenance costs. The findings underscore the importance of well-defined equipment management policies, with security and standardization being key focus areas for written policies. However, a notable observation is that a majority of contractors (28%) manage their equipment through unwritten policies, emphasizing the need for more formalized and comprehensive equipment management guidelines within the industry. Overall, the survey outcomes provide a roadmap for enhancing construction equipment management practices, optimizing productivity, and ensuring efficient project execution in the construction sector.

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