

Construction Equipment Management in Project Site

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Abstract: Good project management in construction must vigorously pursue the efficient utilization of labour, material and equipment. The use of new equipment and innovative methods has made possible wholesale changes in construction technologies in recent decades. 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. It is therefore important for site managers and construction planners to be familiar with the characteristics of the major types of equipment most commonly used in construction. This thesis is to study the management of equipments practices in Construction Industry and to present the most popular practices of the contractors and to compare the equipment management policies with a Case study of a construction industry. The needed data were collected via a structured questionnaire. The collected data were analysed using SPSS Software. Finally, the findings of this study were compared with findings of questionnaire conducted for finding significant commonalities and differences in equipment management practices.

Keywords: Statistical package for the social sciences (SPSS)

1. Introduction

Construction firms are often faced with problems related to high rate of equipment failure or breakdown and accident resulting from unskilled operator's abuse. Poor training of equipment operators is often claimed as a major cause of equipment related accidents (John and Herman, 2009; Schenayder et al., 2002). In 1983, Agbo stated that the cost of equipment repair, fixed and variable operating cost wasted during the equipment downtime and a myriad of consequential costs that reverberate and surge through the construction business are enormous. The only way to avoid this huge amount of loss that usually lead to accompanies equipment breakdown or failure is to adopt proper equipment maintenance management strategy. This will keep construction equipment fit at all times and allow timely completion of construction project, thereby increasing construction project profitability. Thus, to understand effective construction equipment management, one must also understand effective construction equipment maintenance. There is need to let construction managers realize that maintenance of construction equipment if properly carryout is a profit Centre and not an unavoidable evil as some assumed.

The cost of construction is an important factor in all projects whether the construction project is to be linear (i.e., concept, design, procurement, construction) or fast-

track (i.e., design/build); whether a construction contract is unit price, lump sum, or cost-plus. The labour, materials, overhead, equipment and profit are important factors that impact construction costs. Shalomo Selinger (1983) established that to determine the economic service life of earthmoving and transportation equipment, the mathematical models are available. Michael C. Vorster (1990) has presents the capability to quantify, the significant costs of downtime and lack of availability by a model. A little thought and innovation applying in the model should make it possible to understand the philosophy, as well as the methodology used for quantification. Zane W. Mitchell (1998) has concentrated on the management of heavy construction equipment, which is a tough task. It was revealed how a second-order polynomial expression was selected as the optimum and it can be used to identify best economic decisions of the cumulative cost model developed by Vorster. Athanase I. Tsimberdonis (1994) examined the importance and magnitude of costs caused by equipment failure. Rickey A. Cook (1999) has developed a maintenance plan for improving safety and efficiency of cranes and heavy equipment's. Harkan Yman (2009) has stated future of management which likely to be happens. The information output can be used by both managers and no managers in the firm to make decision and to solve the problem. Accordingly, Cynthia S. Collyard (2012) mentioned that as the contractor's with large investments in equipment have a great impact on the profitability of the firm with equipment policy and equipment management system. Govindan Kannan (2011) studies with professional experts in the equipment management field. The purpose of this article is twofold: (a) to record observations and knowledge, and (b) to evaluate the performance of the tools. Many construction firms seek to gain competitive advantages by increasing controlling and service losses by reducing raw material and labour costs. By effective equipment maintenance, companies have found effective way to increase profit margins (Craig A. Clutts, 2010). Most construction firms are tends to concentrate on maintenance efforts of unscheduled breakdowns and emergency repairs; this eventually tends to concentrate on maintenance department overtime, the production losses and in expediting parts for repairs. Thus, the equipment's are largest assets of construction companies (C. William, 1984). The purpose of this study is to find out how construction equipment affects the effectiveness of construction operations and to analysis the traffic

flow. However, till date, limited work has been published related to these especially in planning for equipment utilization.

To function any project in smooth manner it is essential that an engineer should have a detailed knowledge about the equipment available and to direct it on a particular task. The overall progress of the project depends upon how fast the work is carried out. Hence it becomes a necessity to select the equipment by considering all aspects of working conditions of site. So it is necessary to make the proper planning & management of equipments available to use it in an effective manner at minimum possible cost and with maximum output productivity.

2. Literature review

A. Nileshayane, mangeshgudadhe [2015]

In construction operations on a large scale require the standard Equipments for Effective operations especially in the area of infrastructural development. This is the true picture of large construction companies whose physical successful activities depends on men, materials and sophisticated machineries that will produce output of operations during a particular period use. Thus, the effectiveness of construction machineries is a major factor that differentiates construction companies in terms of heavy construction and light construction. In the today's era of intense global competition, construction industries are determined to improve and optimize their productivity in order to remain competitive. Overall Equipment Effectiveness (OEE) of a machine plays an important role where performance and quality of the product are of key importance to the company. The OEE intended at minimizing the breakdowns, increasing performance and quality rate and thus improving the effectiveness of the machine. 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. 3. TPM is a structured equipment-centric continuous improvement process that strives to optimize production effectiveness by identifying and eliminating losses associated with equipment and production efficiency throughout the production system life cycle through active team-based involvement of employees across all levels of the operational hierarchy.

B. D. B. Phadatare, s. B. Charhate [2016]

The equipment management system and equipment policy always has a huge impact on the profitability of the contractors with more investment in equipment. In civil engineering construction projects, the cost of equipment can vary from 25-40% of the total project cost. The objective of this project was to study that how

the planned and proper maintenance is important for construction equipment for better production. The overall equipment efficiency was improved with less idling, low machine breakdown and minimized accident in plants which maximized the productivity.

C. Bantamlakabebe [2013]

The survey and interview was conducted through purposive sampling technique. For the sake of achieving the objectives of this study, questionnaires were analyzed in descriptive form and findings were displayed in a table with assistance of a statistical package for the social science (spss) program and data from interview and document reviews were interpreted qualitatively. The results show that construction equipment management practice from various perspectives of equipment management aspects in a total number of sixty-five (65) well-structured questionnaires were administered to eight different construction companies with identity of A, B, C, D, E, F, G and H to collect quantitative and qualitative data on how equipment maintenance has been handled in some randomly selected construction companies located in Abuja, Minna and their environs. The case study areas were selected because of their hub-heavy construction projects activities. Fifty-seven (57) which represents 87.7% of the total questionnaires were retrieved and analyzed. It is recommended that construction practitioners afford the opportunity of equipment maintenance strategy as part of construction project management. This will help reduce expenses, probability of unexpected failure, optimize utilization and minimize equipment downtime, which will in return increase the overall construction projects profitability.

3. Sources of construction equipment

The equipments can be available with companies or also can be outsourced. So for outsourcing the equipment we need to scrutinize the vendor for each and every information provided by him. As if we are hiring an equipment from a vendor and if it breakdowns at a site then vendor must have provisions for other backup equipments. So as to avoid any lags for an activity. Equipment is also available at a company but when the situation comes where we require the same machine for more than one place then we are in need of an outsourcing agencies. A firm should have good database of such vendors. Depending upon the factors like Time period of equipment to be hired, Hiring cost, original cost, Name of manufacturer, Capacity of an equipment, Space constraints, Productivity of equipment, Maintenance cost, Working cost of equipments, the company/contractor can decide whether to purchase the equipment or to lease it or to hire it.

1. Purchase the equipment
2. Rent the equipment
3. Rent the equipment with an option to purchase it later.

4. Equipment classification

1. Horizontal moving equipment
2. Hand held equipment
3. Personal protective equipment
4. Concreting equipment
5. Inspection equipment
6. Surveying equipment

5. Factors behind the selection of equipments

Construction Equipment CE can improve the quality of production and increase project efficiency, cost savings, profitability and safety at any jobsite. Hence, selection of right CE is a very important step. Since, there are different options to choose from, the selection of appropriate CE becomes all the more difficult.

Here is a list of factors that affect the selection of CE and should always be kept in mind...

1. Economic factors: Economic considerations such as the cost of owning the equipment and operation and fuel costs are some of the most important factors that play a deciding role in selecting the equipment. Besides, consideration over resale value is also very important.
2. Factors specific to companies: The selection of Construction Equipment also depend on the need of the company. If the company has a lot of projects in hand for the coming few months or even years, then it definitely makes sense for it to invest in the heavy CE. However, if there is a one-off job or a short term job that needs to be completed, then the company might opt for renting the equipment. Further, if the company is doing really well and is ready to expand, then this also has a considerable impact on CE selection decision. Also, the amount of outsourcing the company does to execute its projects has an impact on CE selection decision. If the projects are given on a contract-basis to the third party, then the investment on equipment is kept low. Further, storage issues also come into play. If the company has its own industrial garage where it can store the equipment, then it may prefer to buy the CE.
3. Factors specific to the jobsite: Both ground as well as climatic conditions at the site also affect the selection decision. For example, the soil and overall terrain at the jobsite and nearby surroundings define which CE should be used. At the same time, climatic conditions such as the presence of strong winds, visibility level etc., also affect the decision process.
4. Factors specific to the equipment: CE are always very costly. So, standard equipment which are manufactured in large numbers by various manufacturers and whose spare parts are easily available are preferred by the companies. The size of the equipment is also an important factor. The bigger the equipment, the more the investment and other considerations. In addition, versatility of the equipment whether it can perform more than one function, the adaptability for future use and the interaction with other equipment also affect the selection of CE. Further, if the company is in a position to bear the repair and maintenance cost, then it can select any equipment type but if the case is otherwise, then a lot of thought needs to be put in before finalising on any equipment.
5. Project timeline considerations: Project deadlines also affect the selection of the equipment. If there is limited time available to complete a project, then companies may prefer highly advanced CE that can reduce a project's completion time significantly.
6. Labour considerations: This also highly affects the selection decision. If there is a shortage of manpower at the jobsite, then the companies may opt for highly automated machines. Further, the selection of CE may also be highly governed by the availability or non-availability of trained manpower as then the company may or may not opt for highly sophisticated equipment.
7. Safety considerations: Any construction site is the locus of multiple high-risk activities. There are obvious safety concerns associated with workers operating on the ground, particularly within confined spaces when heavy materials are being moved around. Hence, in such cases, companies may have to select equipment which ensures safety of the workers. Thus, safety considerations also affect the selection of the equipment.

6. Methodology

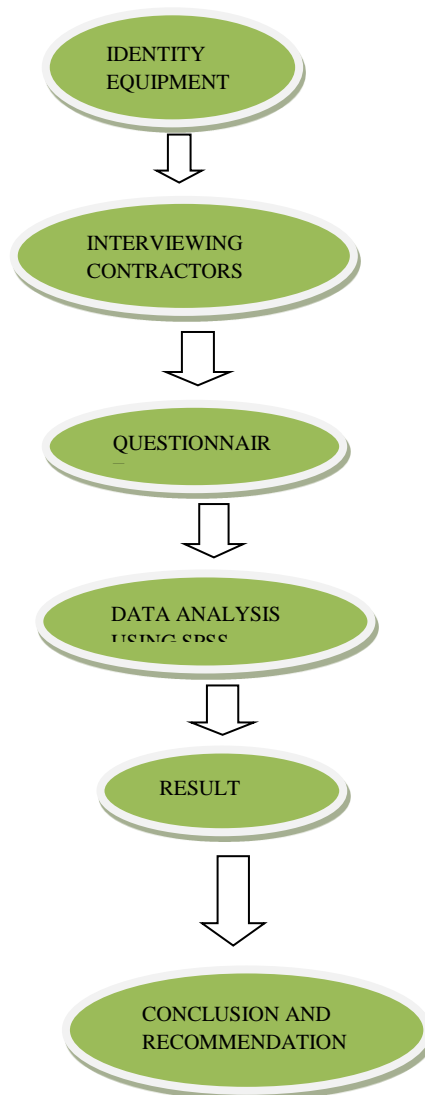


Fig.1. Methodology

7. SPSS Software

SPSS is a widely used program for statistical analysis in social science. It is also used by market researchers, health researchers, survey companies, government, education researchers, marketing organizations, data miners, and others. The original SPSS manual (Nie, Bent & Hull, 1970) has been described as one of "sociology's most influential books" for allowing ordinary researchers to do their own statistical analysis. In addition to statistical analysis, data management (case selection, file reshaping, creating derived data) and data documentation (a metadata dictionary is stored in the datafile) are features of the base software.

The many features of SPSS Statistics are accessible via pull-down menus or can be programmed with a proprietary 4GL command syntax language. Command

syntax programming has the benefits of reproducible output, simplifying repetitive tasks, and handling complex data manipulations and analyses. Additionally, some complex applications can only be programmed in syntax and are not accessible through the menu structure. The pull-down menu interface also generates command syntax: this can be displayed in the output, although the default settings have to be changed to make the syntax visible to the user. They can also be pasted into a syntax file using the "paste" button present in each menu. Programs can be run interactively or unattended, using the supplied Production Job Facility.

Additionally a "macro" language can be used to write command language subroutines. A Python programmability extension can access the information in the data dictionary and data and dynamically build command syntax programs. The Python

programmability extension, introduced in SPSS 14, replaced the less functional SAX Basic "scripts" for most purposes, although SaxBasic remains available. In addition, the Python extension allows SPSS to run any of the statistics in the free software package R. From version 14 onwards, SPSS can be driven externally by a Python or a VB.NET program using supplied "plug-ins". (From Version 20 onwards, these two scripting facilities, as well as many scripts, are included on the installation media and are normally installed by default.)

SPSS Statistics places constraints on internal file structure, data types, data processing, and matching files, which together considerably simplify programming. SPSS datasets have a two-dimensional table structure, where the rows typically represent cases (such as individuals or households) and the columns represent measurements (such as age, sex, or household income). Only two data types are defined: numeric and text (or "string"). All data processing occurs sequentially case-by-case through the file (dataset). Files can be matched one-to-one and one-to-many, but not many-to-many. In addition to that cases-by-variables structure and processing, there is a separate Matrix session where one can process data as matrices using matrix and linear algebra operations.

The graphical user interface has two views which can be toggled by clicking on one of the two tabs in the bottom left of the SPSS Statistics window. The 'Data View' shows a spreadsheet view of the cases (rows) and variables (columns). Unlike spreadsheets, the data cells can only contain numbers or text, and formulas cannot be stored in these cells. The 'Variable View' displays the metadata dictionary where each row represents a variable and shows the variable name, variable label, value label(s), print width, measurement type, and a variety of other characteristics. Cells in both views can be manually edited, defining the file structure and allowing data entry without using command syntax. This may be sufficient for small datasets. Larger datasets such as statistical surveys are more often created in data entry software, or entered during computer-assisted personal interviewing, by scanning and using optical character recognition and optical mark recognition software, or by direct capture from online questionnaires. These datasets are then read into SPSS.

SPSS Statistics can read and write data from ASCII text files (including hierarchical files), other statistics packages, spreadsheets and databases. SPSS Statistics can read and write to external relational database tables via ODBC and SQL.

Statistical output is to a proprietary file format (*.spv file, supporting pivot tables) for which, in addition to the in-

package viewer, a stand-alone reader can be downloaded. The proprietary output can be exported to text or Microsoft Word, PDF, Excel, and other formats. Alternatively, output can be captured as data (using the OMS command), as text, tab-delimited text, PDF, XLS, HTML, XML, SPSS dataset or a variety of graphic image formats (JPEG, PNG, BMP and EMF).

Several variants of SPSS Statistics exist. SPSS Statistics Gradpacks are highly discounted versions sold only to students. SPSS Statistics Server is a version of SPSS Statistics with a client/server architecture. Add-on packages can enhance the base software with additional features (examples include complex samples which can adjust for clustered and stratified samples, and custom tables which can create publication-ready tables). SPSS Statistics is available under either an annual or a monthly subscription license.

SPSS Statistics launched version 25 on Aug 08, 2017. SPSS v25 adds new and advanced statistics, such as random effects solution results (GENLINMIXED), robust standard errors (GLM/UNIANOVA), and profile plots with error bars within the Advanced Statistics and Custom Tables add-on. V25 also includes new Bayesian Statistics capabilities, a method of statistical inference and publication ready charts, such as powerful new charting capabilities, including new default templates and the ability to share with Microsoft Office applications.

8. Questionnaire

Table 1

Questionnaire

Sl.NO.	FACTOR	1	2	3	4	5
1	Does the regular inspection avoid cost overrun?					
2	Will the equipment maintenance affect by improper cash flow?					
3	Have the past experience increase equipment workability?					
4	Have they facing accidents by improper equipment training?					
5	Do you reduce completion time of project by construction equipment?					
6	Have the quality improve by					

	construction equipment?					
7	Have you choose earthwork equipment based on soil condition?					
8	If equipment management create any impact on construction?					
9	Does the equipment usage cost increase construction cost?					
10	If the usage of modern equipment enhance projects?					
11	Do you test the equipments before buying?					
12	Are equipment proposal alternatives searched?					
13	Budget prepared for capital budgeting?					
14	Is standard forms used?					

15	Frequency of undertaking routine maintenance?					
16	Type of routine maintenance?					
17	Maintenance personnel?					
18	Is equipment utilization record maintained?					
19	Does operator fill operator's daily report?					
20	Frequency of making equipment reports?					
21	Checking replacement time					
22	Frequency of replacement?					
23	Influence of obtainable salvage value?					

9. Result

Table 2

Descriptive statistics

Descriptive Statistics						
	N	Minimum	Maximum	Mean	Std. Deviation	
COSTOVERRUN	60	4.00	5.00	4.5833	.49717	
CASHFLOW	60	4.00	5.00	4.5833	.49717	
WORKABILITY	60	1.00	5.00	1.8000	.98806	
ACCIDENTS	60	3.00	5.00	3.3333	.65527	
TIME	60	2.00	5.00	2.7167	1.07501	
QUALITY	60	2.00	5.00	3.8333	.61525	
SOILCONDITION	60	1.00	4.00	1.2167	.58488	
MANAGEMENT	60	3.00	5.00	3.3333	.65527	
USAGE	60	4.00	5.00	4.5833	.49717	
ENHANCEMENT	60	1.00	5.00	1.8000	.98806	
TESTING	60	2.00	5.00	3.8333	.61525	
ALTERNATIVES	60	1.00	4.00	1.2167	.58488	
BUDGET	60	4.00	5.00	4.5833	.49717	
STANDARDFORM	60	1.00	4.00	1.2167	.58488	
MAINTENANCE	60	1.00	5.00	1.8000	.98806	
TYPE	60	1.00	5.00	1.8000	.98806	
WORKER	60	3.00	5.00	3.3333	.65527	
RECORDS	60	1.00	5.00	1.8000	.98806	
REPORT	60	3.00	5.00	3.3333	.65527	
FREQUENCYREPORT	60	1.00	4.00	1.2167	.58488	
REPLACEMENTTIME	60	2.00	5.00	2.7167	1.07501	
REPLACEMENTFREQUENCY	60	2.00	5.00	3.8333	.61525	
SALVAGEVALUE	60	4.00	5.00	4.5833	.49717	
Valid N (listwise)	60					

Table 3: Total percentage

SI. NO.	Factor	Strongly agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly disagree (%)
1	Cost	58.3	41.7	-	-	-
2	Quality	10	65	23.3	1.7	-
3	Training	10	13.3	76.7	-	-
4	Time	11.7	11.7	13.3	63.3	-
5	Efficiency	1.7	6.7	10	33.3	48.3
6	Other		1.7	3.3	10	85

- R1:** Every owner are concerned with the profit of the company. Earning a profit is important to a small business because profitability impacts whether a company can secure financing from a bank, attract investors to fund its operations and grow its business. Companies cannot remain in business without turning a profit.
- R2:** Quality control and safety are a number one concern in the construction industry, defects or failures can be very costly to both businesses financially but also to people as they can result in personal injuries or fatalities. Therefore whatever the job may be, big or small; you must always ensure that the equipment and materials used is to the highest quality standard, preventing the likelihood of accidents and costly delays. Better quality products not only provide a higher safety level for both you and others around you but they can also enhance the quality of the finished project. One of the biggest mistakes in DIY or homebuilding is buying low quality equipment, to try and save money, however these products generally require frequent and annoying repairs, meaning that you end up spending far more that you would if you would have bought the higher quality equipment.
- R3:** Trained personnel will be able to make better and economical use of materials and equipments. Wastage will be low. In addition, the rate of accidents and damage to machinery and equipment will be kept to minimum by the well-trained employees. These will lead to less cost of production per unit.
- R4:** Construction equipment management requires real-time visibility and tracking of all of your equipment and tools—the very foundation for profitable construction jobs. Regardless of how you bid the job, you need to accurately track costs, mobilize assets, measure utilization and be able to charge back costs to that specific job site or task. Equipment rental companies know a thing or two about managing assets that construction equipment managers might find useful. Specifically, the software they use to track their rental assets could be successfully used to help you better manage your equipment and accurately track costs.

- R5:** To be efficient means being able to produce the desired results with a minimum of effort, resources, or waste. This is a concept that permeates our lives. A part of every occupation is the desire to improve the product or services by producing more for less or a better product for the same input. Engineers are constantly trying to improve the efficiency of operations by reducing the energy requirements and/or wastes from agricultural and manufacturing processes. When referring to machinery, efficiency is an evaluation of how well a machine does the tasks that it is designed to perform.
- R6:** Factors that are not affecting the company profit.

10. Conclusion and recommendations

Construction equipment are the most crucial and critical resource for a construction company. Construction equipment are a prerequisite for timely completion of all construction projects. As a matter of fact the equipment are one of the most capital intensive long terms investments that a construction company makes. Expenses related to construction equipment have a major impact on whether the company’s balance sheet shows profits or losses and in what quantity. Keeping the economic viability of the company in mind managing the construction equipment and the related expenses becomes top priority at construction equipment companies. Construction equipment management refers to continuous evaluation of the construction equipment fleet and its cost while at the same time considering the projects at hand. The process of balancing the expense and use of the construction equipment against the timelines and income from the projects can be called construction equipment management. A construction equipment manager needs to be able to take practical decisions with regards to management of the construction equipment to ensure maximum benefits with minimal expenses for the company.

Factors affecting productivity in construction can be divided into two categories: human-related factors and management-related factors. These factors affect the morale and motivation of individuals. Quality of supervision, material management, site planning, constructability, and change management are the most significant management related factors that influence

productivity directly. The cost of the project must include the cost of equipment needed to build the project. The constructor must be able to determine, as accurately as possible, the duration of each piece of equipment required for each activity of the project. In our project focused on leading construction equipment planning and management problems in construction projects. The result indicated that idle time, down time, poor equipment maintenance practices, improper determination of economic life and timing of replacement, poor training of equipment operators, equipment breakdown, over maintenance of equipment, huge capital investment during acquisition, balance of interdependent equipment, misunderstanding the scope of work carried out, unit cost of production and equipment suitability for job condition were found to be the major problems that affect construction equipment planning and management. The overall productivity of construction is affected by various reasons. 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.

The success of a small business depends on its ability to continually earn profits. Profit equals a company's revenues minus expenses. Earning a profit is important to a small business because profitability impacts whether a company can secure financing from a bank, attract investors to fund its operations and grow its business. Companies cannot remain in business without turning a profit. All factors related to money comes first.

A. RECOMMENDATIONS

1. Know what you have.
2. Track how it is used.
3. Right asset, right place, right time.
4. Don't spend more – spend smarter.
5. Fix things before they break.
6. Find underlying issues.
7. Buy the best.
8. Use the right equipment inventory system.

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