Evaluation of Productivity of Earthmoving Construction Equipment by Using Fleet Management Technology

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Abstract: Optimum use of construction equipment saves the economy for heavy construction projects, minimises the completion time, increases the quality of work and improves the speed of a project. Equipment is used for highway projects, irrigation, houses, power projects, etc. Equipment and machinery account for 15-30 percent of the overall project cost. Heavy machinery such as excavators, tippers, bulldozers, scrapers etc. are needed to conduct the earthmoving operations, which have a high ownership and operating expense. Construction facilities occupy a large portion of project funding, but excessive usage of such services leads to efficiency losses, eventually affecting profit. This research aims to demonstrate how this equipment can be accomplished in terms of efficiency and benefit enhancement. The purpose of the research is to predict the production rate of the fleet and optimise the number and size of the equipment in the fleet to adopt the equipment to the project situations

Keywords: Construction Equipment, Productivity, Fleet, Optimization.

1. Introduction

Today, various styles, sizes, and groupings of equipment are needed for a different form of construction operation such as earthmoving, excavating, and raising, so there is a piece of equipment for virtually any work activity, large or small. The manufacturer's construction equipment is designed to perform such mechanical operations that contribute to the completion of a work activity. The efficiency of a job is a function of the machine size and the strength of the engine. To perform the high-power equipment needed for heavy work, which involved elevated operating and ownership costs.

The main support is the equipment for the bulk of general construction works operations. The operations are becoming enormous. In addition, BOT style contract, which is vast and commonly aggressive markets, forces contractors to complete the project as early as possible to start recovering the investments. Different types of equipment production types are used in enormous numbers to reach the completion deadline of certain project contractors. These supplies go under different sizes and from a variety of various suppliers. There are various types of equipment being used on sites today, such as excavating equipment such as excavators, piling equipment types such as front loaders, pulling equipment types such as dumpers, spreading equipment types such as dozers, leveling equipment types such as engine graders, compacting equipment types such as soil compactors, lifting equipment types such as cranes, and so on.

1.2 Productivity of Machinery

However, a construction contract is in any form and the construction project is an important element in all projects at any point (i.e. concept, design, procurement, construction) or fast-track (i.e. design / build), the cost of construction. Materials, labour, supplies, overhead, and benefit are the main factors that affect construction costs. The cost of construction equipment contributes almost 30 percent to 40 percent of the overall cost of the project, which is why it is critical that all things about construction equipment are known to designers and construction engineers. Construction equipment is an integral part of the construction process. The cost of construction is a function of the design of the construction operation.

Productivity defines different measurements of output efficiency. Productivity is expressed as the relation of output to inputs, i.e. output per unit of input, given in a production process. Productivity is a key factor in the efficiency of construction machinery in production. After choosing the equipment needed to perform the operation, the next job is to determine a efficiency analysis of the equipment to choose the optimum size. The goal is to decide the number of units and the size of equipment that will allow the builder to conduct the operation with a period that results in the lowest cost. The projects are divided into sub-activities, so the lowest cost of each activity that gives the maximum rate of output is crucial to decide.

1.3 Purpose of a Report

In the present analysis, the efficiency of earthmoving construction equipment is measured.

2. Review for Literature

The study of literature helps to accurately and efficiently interpret and determine the course of work. Previous work done on similar topics is studied in this literature review, the framework of equipment selection, equipment management system, efficiency analysis from different methods is studied.

2.1 Selection Method for Equipment Selection System

The selection of equipment is intended to increase the output rate and minimize downtime. When attempting to complete a project within budget and on time, equipment selection is a crucial factor. Productivity decreases, delays increase, potential accidents occur, and excessive costs are incurred without the correct working equipment (Allwood, 1989).

It is very critical that the project starts with the most suitable collection of the equipment required to conduct the work for all parties involved in an earth-moving process. Proper equipment selection leads to the productivity of projects and to improved income (Phasukyud, 1988).

The framework provides 930 rules for the soil condition of the project, performance of the operator and necessary earthmoving operations. Various input parameters such as soil type, swell value, project length, etc. have to be provided to the device. For each type of equipment being chosen, the device provides the consumer with a printed spreadsheet. (In 1992, SerjiAmirkhanian and Nancy J. Baker).

2.2 Device Control of Equipment

For the interpretation of facts and figures, by conducting a survey of top construction companies. The fleet management system is a user-friendly and practice-oriented system designed to show that database management systems are available. Creation, adoption and continued use of such systems can contribute to contractors' effectiveness and profitability. (In 1990, Amir Tavakoli)

The 3D equipment management system concept is concerned with careful preparation, selection and optimal usage of construction equipment. They also identified the use of existing technologies in information technology for equipment management. (Y.R. Anbhule, 2013, by Prof. M.B. Kumthekar)

The so-developed SEM model offers a structure for monitoring the causes and effects of downtime and recommends maintenance of equipment as an acceptable practise for equipment management. (PrasertunganianThanapun and Hadikusumo B.H.W., 2009

The GPS devices continuously record the location of the equipment that can assist in tracking on-site construction equipment operations. This data is processed using a virtual 2010 user interface (NipeshPradhanga and JochenTeizer, 2013) (NipeshPradhanga and JochenTeizer, 2013)

2.3 Study of Efficiency

To decide the optimum size of the hauling unit in the material moving system, the model relies on the derivation of the cost index number (CIN). This model also offers a way for a wide variety of material moving issues to design the construction equipment fleet. (1996 by Douglas D Gransberg)

The model's simulation outcome is more precise than using beta distribution and considers the transit state instead of the steady state, then increases the output of fleet experience and unites the cost reduction. (In 1994, FoadFarid and Thomas L. Koning)

By investigates the findings collected from over 140 separate earthmoving operations taken from four different highway construction projects. This paper provided separate regression studies with very good results on real earthmoving efficiency, and on earthmoving bunch factor, with correct results. (1999 by Simon D. Smith)

To support its management functions, the model utilises genetic algorithms, linear programming, and geographic information systems. They also specify the amounts of the earth to be transferred from various borrowing pits and those to be placed at separate landfill sites to achieve the user's optimization goal and to meet project constraints. (In 2009, Osama Moselhi and Adel Alshibani).

3. Details of the web

Sangli was taken for this paper analysis on the construction of roads including drains and sewers in kavathemahankal. The entire evolution of various industries. Each process is divided into several phases that are built by various subcontracts.

Name of Authority: Infra-Raj Road, Maharashtra

Project cost: 260cr

Completion Date: 11 July 2021.

4. Methodologics

A methodological flow map outlined in Fig1. Describe the steps that are taken to accomplish a project's goals. Site selection means finalising the site for further research to do the project work in the very first stage. This involves an examination of the essence of the project going on, the configuration of the site, the environmental conditions of the site. The research of different types of equipment employed on site and policy management, on-site usage of equipment. Once the equipment is identified on site, the actual composition of a fleet is analysed and statistical analysis measures the current working efficiency of the fleet.

If the productivity of the current fleet is measured, the next step is to identify the scope of optimization for the current fleet and to optimise the fleet and measure the productivity of the optimised fleet after optimization. In both cases, then compare the productivity.

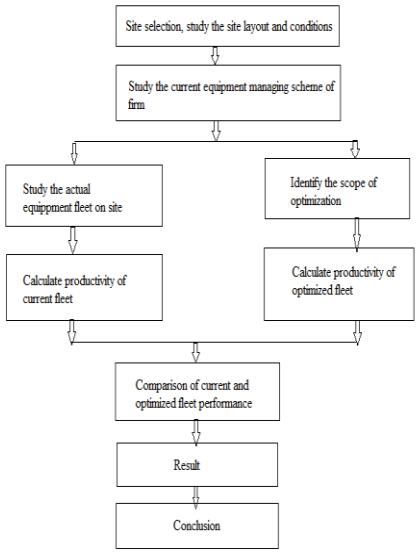

Fig1. Methodological flowchart

5. Study of Efficiency

The manufacturing capacity of each and every unit in the fleet is important because it will provide an indication of the capacity of the fleet as a whole. Using different mathematical formulas, the output of each equipment involved in the fleet is manipulated as real and theoretical using performance charts and other parameters such as distance, speed, number of journeys, power, cycle time, etc. The quantity of material excavated or moved on an hourly basis , i.e. m3 / hr, is often the unit of measurement for production.

5.1 Excavator productivity:

Excavator output = **(3600 * Q*F*E*V.C.)/T**

Where,

Q = capacity bucket in m3 loose

F = fill factor

E = operator efficiency

V.C. = soil conversion factors

T = excavator cycle time (sec)

5.2 Tipper productivity:

Tipper output = **(V*60)/T**

Where,

v = tipper body volume (m3)

T = tipper cycle time (min)

Important parameters required for productivity calculations:

5.1 Capacities

That is the volume power of the equipment that works with. In the case of the tipper, bucket capacity denotes excavator capacity or body capacity. Express capacity in terms of cubic metres. This is determined by the standard measurements provided by the manufacturing company of each unit.

5.2 Results

It reveals how often in one working day the operator actually operates. It is the skill of the user of the machinery to do the job. Operational performance of construction equipment, referring to the ratio of the equipment's efficient working time to its total working time.

5.3 Fill Factor

It is often referred to as the performance factor for buckets. There will be less voids in the different material fills differently in bucket loose material, so volume will be more when rock etc will fill at less volume, which is less quality. How specific material is filled will be provided by this fill factor.

5.4 Reasons for Soil Conversion

In one of the three states, soil volume is measured:

1. Bank volume: As it lies in the natural state, it is the indicator of material.

2. Loose volume: It is the indicator of material after a loading phase has disrupted it.

3. Compacted volume: In the compacted state, it is the measure of material.

5.5 Cycle Time

The sum of the time needed for one production cycle to be completed is the cycle time for the equipment. The cycle time for different equipment consists of various components. For various equipment, typical cycle time elements are as follows:

Excavator:

1. Excavate/load bucket

2. Swing with load

3. Dump load

4. Return swing

Dumper:

1. Load

2. Haul

3. Dump

4. Return

The mean value of actual observations taken is considered as the cycle time of equipment.

6. Fleet Optimization

As per the output values, a decision is taken about which equipment needs to be optimised in the fleet. If a 1.Executor 2.Tipper fleet is generated by two equipment, then the decision to take optimization is focused on which equipment controls the fleet. In general cases, if such conditions arise, the fleet is mostly operated by the excavator, then the tipper operation must be optimised. Tipper optimization can be defined as employing close to an exact number of tippers at work in order to monitor the unnecessary loss of productivity. By determining the optimal number of units, this is done. You will find out by using the following formula. No. of Units.

Tipper (n) optimum number = tipper cycle time / tipper loading time

7. Values of Efficiency

7.1 Curve of Load Growth

The unit of hauler capacity is plotted against the loading time to create a load growth curve. First, a specified loading facility equal to the loading period must be divided into its various components. These components are then classified into groups that are productive and nonproductive. It is called efficient the physical act of putting material into a hauling machine. Other elements in this application are considered nonproductive, such as filling the bucket, manoeuvring, and movement. As sloping vertical deflections, productive elements are plotted, and nonproductive elements are plotted as horizontal displacements.

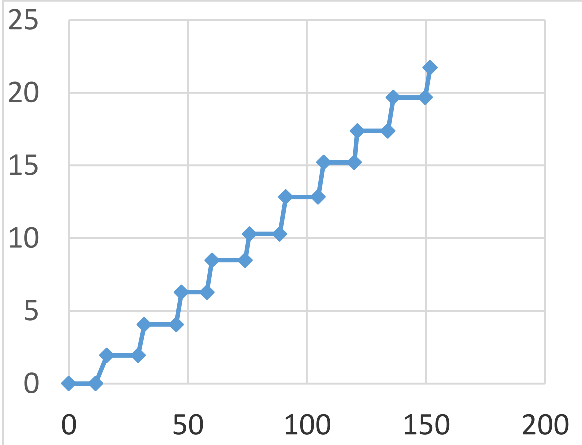

Fig 2. Load Growth Curve of case A. load time (sec) vs. load size (sec)

Fig 2. Load growth curve shows the progress of load time in sec vs. load size in sec. for case A of the study.

Table 1. Productivity values of current fleet (m3/hr)

CASE	EQUIPMENT	MORNING	AFTERNOON	AVERAGE
A	Excavator	116.96	105.53	111.245
	Tipper	30.14	24.12	27.155
B	Excavator	87.93	89.42	88.67
	Tipper	24.34	21.29	22.815
C	Excavator	68.68	66.63	67.65
	Tipper	30.79	26.50	28.645
	Bull dozer	41.82	41.60	41.71

For better performance and uniformity of cycle time observation, an average of these two readings are taken as cycle time of equipment in the morning session and afternoon session. The production rate values of the equipment in cubic metres per hour for all three cases are shown in Table 1

Table 2. Overall Productivity values of current fleet (m3/hr)

Current fleet				
CASE	Equipment	No. of equipment	Individual Productivity	Overall Productivity
A	Excavator	1	111.245	81.465
	Tipper	3	27.155	
B	Excavator	1	88.67	73.02
	Tipper	3	22.815	
C	Excavator	1	67.65	57.24
	Tipper	2	28.645	
	Bull Dozer	2	41.71	

The minimum value of a production rate of equipment is known as the average productivity of equipment when equipment operates in the fleet, since the fleet's production rate will not go above that value. Oh. Table 2. In all three situations, the values of the output rate of equipment in the current fleet are displayed in cubic metres per hour.

Table 3. Number of Tippers in current and Optimize fleet in different cases

Case	Current fleet	Optimize fleet
A	3	5
B	3	5
C	2	3

Results after optimization show that optimising the fleet required more tippers to increase the equipment fleet's output rate. Oh. Table 3. Displays the number of tippers required to optimise and upgrade the fleet

Table 4. Overall Productivity values of Optimize fleet

Optimize fleet				
CASE	Equipment	No. of equipment	Individual Productivity	Overall Productivity
A	Excavator	1	111.245	111.245
	Tipper	5	27.155	
B	Excavator	1	88.67	87.93
	Tipper	5	22.815	
C	Excavator	1	67.65	67.65
	Tipper	3	28.645	
	Bull Dozer	2	41.71	

If a number of devices are used in the equipment fleet to maximise, then the output rate of equipment is sure to increase. Oh. Table 4. Displays the output rate values for equipment in the optimization of the cubic metre fleet per hour in all three situations.

8. Capacity of Output

After the study of efficiency for both cases, Table 5. Shows the difference in both fleet output power , i.e. current and optimised.

Table 5. Difference in production capacity (percentage)

Case	Current fleet		Optimize fleet		% Increase in productivity
	Productivity (m3)	Type	Productivity (m3)	Type	
A	81.465	Tipper Control	112.45	Excavator control	38.03%
B	73.02	Tipper Control	87.73	Excavator control	20.41%
C	57.24	Tipper Control	67.65	Excavator control	18.18%

9. Conclusion

It can be inferred from the findings that,

1. The spectrum of optimization occurs in both circumstances.

2. After an analysis of efficiency and a comparison of all instances, it is shown that fleet optimization has optimum productivity values relative to the current fleet. After optimization, production rate is 38.03 %, 20.41 % and 18.18 % of cases A, B and C respectively.

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