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Enhanced Construction Productivity by Effective Equipment Management through Fleet Operations

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Abstract: In construction equipment management, achieving optimum utilization is essential for cost reduction and ensuring efficient completion of tasks. Equipment fleets, which comprise various machines working together, are central to this goal. For instance, tasks like loading, hauling, and compaction often require coordination between an excavator, multiple haul units, and auxiliary machines. These interconnected systems form the backbone of construction projects, with each component contributing to overall productivity. Take, for example, an excavator and a fleet of trucks; they operate as a linked system where the performance of one directly impacts the efficiency of the others. Therefore, effective management involves not only maximizing the efficiency of individual machines but also coordinating their operations to minimize downtime and optimize production. By understanding the interdependence of equipment and implementing strategies to enhance their performance collectively, construction projects can achieve greater efficiency and cost-effectiveness.
Keywords: Equipment Management, Excavators, Fleet production, Auxiliary Machines, Cost Reduction.

I. INTRODUCTION

A. Equipment Management

Good construction equipment management in construction must vigorously pursue the efficient utilization of equipment. Improvement of equipment productivity should be a major and continual concern of those who are responsible for cost control of constructed facilities. Equipment management, which includes proper utilization of equipment without any downtime, optimum utilizationof equipment requires special attention forcost reduction. The use of new equipment and innovative methods has made possiblewholesale changes in constructiontechnologies 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. Equipment management is required and this will focus and enhance a companywide approach to improving equipment productivity. A phased equipment management approach is the process of focusing efforts to improve the elements of equipment utilization,equipment performance, and equipmentavailability. These phases are key to movinga company through the installation of total productive management.

II. LITERATURE REVIEW

Dushyant A. Deshmukh and Parag S. Mahatme (2016) focused on factors which affects construction equipment performance. By monitoring excavators in terms of its planning, selection and performance; Some of the common factors that can affect the performance of excavating equipment has been identified and discussed in this work such as Proper equipmentselection may affect to increase its productivity

Kunal Ghadge and Ashish Ugale (2015) focused on study of proper planning and management of equipments on dam site analysed.On time completion of project can be possible by only three factors as economy, time, quality and this contributes to many factors of resources but much affected by equipments.

Saurabh Kadam and Prof. Dhananjay Patil (2013) described equipment optimization and benefit analysis at the site through equipment production analysis with the help of studying the highway construction site for current practices of equipment management. To optimize the current composition of the earth material moving fleet they have focused on performance of equipment also they have studied comparison of the current composition at site by productivity analysis and benefit analysis.

Amir Tavakoli, Member, ASCE, Emmanuel D. Taye and Mehmet these authors has mentioned a result of a questionnaire survey that reports the construction equipment policy in the Engineering News Recorded top 400 construction companies. They are presented what kind of special attention is paid to equipment financing, replacement analysis, equipment standardization, safety and maintenance management.

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Fadi A. Kara[1]and Anas Y. Nasr[2], *Resource management in construction Journal of Construction Engineering* These authors mainly described the allocation of resources of different types to a construction project is a difficult managerial problem, particularly when construction equipment has to be shared among a number of project sites.

Govindan Kannan "*Field studies in construction equipment economics and productivity*" This paper marked difference between companies that handle equipment from a central function versus using equipment as a consumable for a project. The equipment policy department is involved with capital and budget-related decision making (eg. asset management), analysis of fleet performance (eg. age, cost, reliability), ownership period and economic decision (eg. repair, replace, rebuild, retire) The job site optimization department is basically responsible for the operational strategy at a particular job site.

Kjell B. Zandin: "*Maynard's Industrial Engineering Handbook* In this book Kjell Zandin discusses about the Japanese productive management on equipment management. This study mainly emphasis on the production equipment which is normally the largest asset. A phased equipment management approach is the process of focusing efforts to improve the elements of equipment utilization, equipment performance, and equipment availability. These phases are key to moving a company through the installation of TPM.

III. OBJECTIVES

In this dissertation it is proposed to do the following work,

1) To study the equipment optimization and benefit analysis at the site through equipment production analysis
2) To do survey of various construction companies for their equipment management strategies on the basis of economy.
3) To study the different costs affecting the economy in construction.
4) To identify how to improve a economy of Construction equipment.

IV. METHODOLOGY

For carrying the proposed work, following methods are used for analyze the data,Determination of production capacity of the total system with the help of lesser of the production capacities of individual systems.
(Fleet management-equipment fleet/spread of work)

A. Productivity analysis of Equipment

To accomplish a task, machines usually work together and are supported by auxiliary machines.To accomplish a loading, hauling and compaction task would involve an excavator, several haul units, and auxiliary machines to distribute the material on the embankment and achieve compaction. Such groups of equipment are referred to as equipment fleet/spread. An excavator and a fleet of trucks can be thought of a linked system, one link of which will control the fleet production.

By using the performance charts and other parameters such as distance, speed, number of trips, capacity, cycle time etc. production of each equipment involved in the fleet is manipulated as actual and theoretical using various mathematical formulae. The unit of measure for the production is always quantity of material excavated or moved on hourly basis i.e. m^3/hr. various mathematical standard formulas are used for the direct production calculations for the respective equipment as follows:

a) Excavator output = $\dfrac{3600\ X Q\ X\ F X\ E X\ V.C.}{T}$

Q = capacity of bucket in m^3 looseF = fill factor
E = operator efficiency
V.C. = soil conversion factors T = excavator cycle time (sec)

b) Tipper output = $\dfrac{V\ X\ 60}{T}$

v = tipper body volume (m^3)T = tipper cycle time (min)

c) Dozer output = $\dfrac{60XL}{T}$ XFXE

L = blade load (m^3)
T = dozing cycle time (min)
f = material type correction factor E=Efficiency

The ultimate goal of optimizing a haulingsystem is to maximize productivity while minimizing total cost. Therefore, it is conceivable that an optimum equipment mix which is based on physical factors alone maynot minimize the cost in every location. Thus, cost factors must be considered equally important to engineering fundamentals.

Tipper cycle time = (loading time + hauling time + dumping time + return time)

Optimum number of haul units (N) can becalculated from the following,

$$N = \frac{C}{L}$$

Where, N = optimum number of haul units.
C = Tipper cycle time
L = Tipper loading time

1) Project Name

Construction ofSwimming Tank Dhonewadi- Karadgal.

1.1Excavation by Crawler type excavator-(HYU 220 LC-7)

1.2 Excavation by Crawler type excavator-(HYU 220 LC-7)

2) Equipment Specifications

Crawler type excavator-(HYU 220 LC-7)	Heaped bucket capacity	1.4 cum
	Max. digging depth	6.010 m
	Swing angle	Varies from 75 to 180 degrees
	Average depthof cut	3 m
	Working efficiency	40 min. per hour
	Cycle time	20 sec.

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Cycle time 20 sec:

Load Bucket- 6 Sec Swing with load- 6 SecDump load- 4 Sec Return swing- 4 Sec

a) Bucket Load = $\frac{14.17}{14}$ =10.12 $\simeq$ 10 Nos.

b) Loading Time =20 x 10 =200sec.=3.33 minutes

c) Haul time (Lead time) =15 minutes

d) Return time =10 minutes

e) Dump time =01 min. (In averagespotted dump condition)

f) Truck cycle time =3.33+15+10+01
= 29.33 minutes

g) No. of Trucks (No. of haul units)

= $\frac{29.33}{5.33}$ =8.80 $\simeq$ 09Nos.

h) Production

(Truck)= $\frac{55}{29.33} \times 14.17 \times 9$ =239.15 cum/hr

	Actual Individual Values			
Work Case No.	Tipper Volume (m3)	Loading Time (min.)	Cycle Time (min.)	Nos.
1	14.95	11	32.93	2.99
2	18.52	13.75	29.85	2.17
3	14.95	16.85	40	2.37
4	18.52	13.75	33.24	2.42

Table 1.1 Practiced Fleet Equivalent Value

Case	1	2	3	4
Quantity m3	2675	2675	2675	2675
Tipper Cycle Time (min.)	32.93	29.85	40	33.24
Operating Tipper Cost (Rs./hr)	812.33	812.33	812.33	812.33
Operating Excavator Cost (Rs./hr)	1800	1800	1800	1800
No. of tippers	3	2	2	3
Size of Tippers (m3)	14.95	18.52	14.95	18.52
Total Cost	85513	93859	155808	69679

Table 1.2: Project cost using practiced fleet

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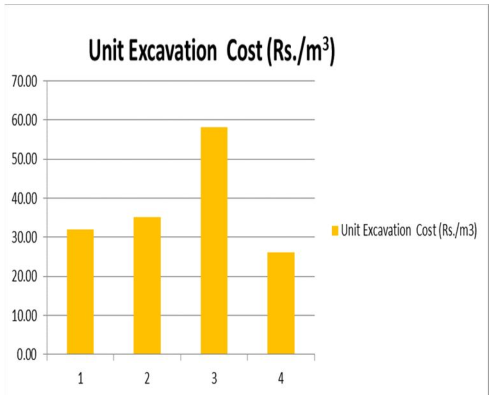

B. Project Name

Construction contract of NH-4package 3 six laning of Pune-Satara

1.3 Excavator (L& T- Komatsu PC-200)

1.4 Loading in Tipper (Ashok Leyland)

Observed Site Location:Pune-Satara Road,Near Khed-Shivapur Toll plaza

crawler type excavator (L& T- Komatsu PC-200)	Heaped bucket capacity	1.2 cum
	Max. digging depth	5.535 m
	Swing angle	Varies 75 to from180 degrees
	Average depth of cut	3.17 m
	Working efficiency	40 min. per hour
	Cycle time	20 sec.

Table 2.1 Equipment specifications

	Actual Individual Values			
Work Case No.	Tipper Volume	Loading Time	Cycle Time	Nos.
	(m3)	(min.)	(min.)	
1	14.17	5.00	46.00	9.00

Table 2.2 Practiced Fleet Equivalent Value

Case	**1**
Quantity m3	152.48
Tipper Cycle Time (min.)	46
Operating Tipper Cost (Rs./hr)	812.33
Operating Excavator Cost (Rs./hr)	1850
No. of tippers	9
Size of Tippers (m3)	14.17
Total Cost	2440.45

Table 2.3: Project cost using practiced fleet

V. METHODOLOGY

1) Only one third of the construction industries were found to have documented policies, it was found that there is a uniform practice of management among industries, which indicates that there is a policy for management although it is not properly documented.
2) Incorrect equipment selection may directly affect to its productivity for that work. Excavation is generally faster for soft soil as compared to hard strata.
3) Greater angle of swing results in greater cycletime which may lead the work to delay.
4) Time saved per cycle is nothing if the operator's skill is poor.
5) The choice for equipment will vary case by case depending upon terrain, task, time of completion of project and construction cost.

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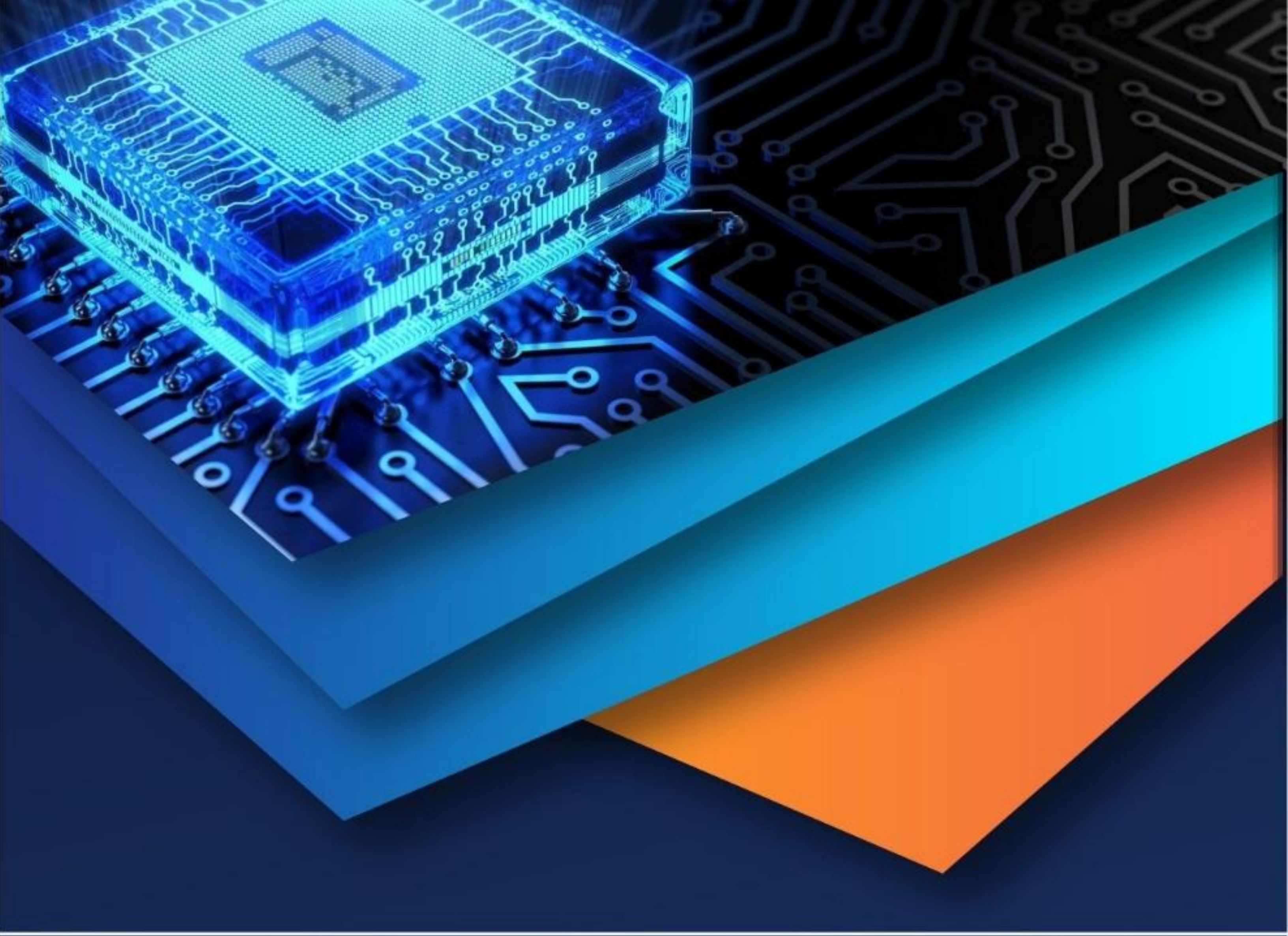

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