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Comparative study of factors affecting productivity and cycle time of different excavators and their bucket size

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***Abstract*—** Earthmoving and constructing equipments have evolved significantly during the past century. In every construction project some type of excavation must be performed. Excavators are primary earthmoving machines and equipment used to excavate earth and related materials. Contractors generally depend on their experience for selecting the right excavator for a job. Hence there is a need to build an understanding of how machine usage affects performance, extending across productivity. This study focuses on study of actual productivity against the theoretical productivity to demonstrate the loss of productivity. This real time monitoring of the heavy equipment can help practitioners improve machine intensive and cyclic earthmoving operations.

Keywords- *excavator, productivit, cycle time, construction equipment*

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I. INTRODUCTION

Every construction project includes some type of excavation work. The construction of dams, highways, airports, commercial, industrial and residential buildings all utilize some type of earth moving operations. Hence our ability to study and understand equipment productivity has also gained significant ground. Equipment selection is a critical factor when trying to complete a project within budget and on schedule. Without the proper working equipment, productivity decreases, delays increase, possible injuries occur, and unnecessary costs are incurred. It is important for all parties involved in an earth moving operation that the project begins with most appropriate selection of equipment needed to perform the work. Proper selection of equipment contributes to project efficiency and to increased profits. For each type of equipment selected, there are unique qualities that must be considered. (E.g. size, productivity etc.) The preparation for selecting a fleet of equipment and estimates for earth moving operations depend heavily on skilled judgment and taking into account all likely variables. (E.g. job specifications, soil conditions, etc.)

Earthmoving operations include excavating, hauling, placing and compacting earth. Excavators are primary earthmoving machines and equipment used to excavate earth and related materials and to lift items frequently used in constructions operations. They are called by different names to different uses, depending upon the implements and attachments required. They are made of various sizes and capacities to suit the need for light, medium or heavy duty applications whereas backhoe and shovels may be either hydraulic or mechanical.

Many contractors depend on their years of experience for selecting the right piece of equipment for a job. Much of the information needed is available to assist the selector; it usually exists in the form of historical data, manufactures performance specifications, guidelines on methods of calculating production output, labor resources, and equipment requirements. However, even the most accurate of these sources still leave the user deciding the job conditions and categories of equipment for particular situations. All the earthmoving operations depend on heavy equipment and have repetitive character, slight reductions in cycle durations may result in considerable improvements in productivity and cost savings. For this reasons, timely and reliable data are critical.

Hence there is need build an understanding of how machine usage affects performance, extending across productivity. Real time monitoring of the heavy equipment can help practitioners improve machine intensive and cyclic earthmoving operations. It also can provide reliable data for future planning. Also the Production Performance Ratio can be found out to compare actual productivity against the estimated productivity to demonstrate the amount of loss of productivity and, thus, to judge level of productivity.

II. OBJECTIVES

The broad objective of the work is to provide an analytical approach for identifying causes of productivity loss, evaluating their effects, evaluating their performance and to understand how the machine is used and how different modes

of use relate to its productivity and reliability. The production performance ratio compares the actual productivity against the estimated productivity to demonstrate the amount of loss of productivity and, thus, judge the level of productivity.

Cycle times can be one of the more puzzling aspects of open -pit excavation. Depending on one's perspective' the term has several connotations. A hoe operator might view a cycle time as the point from which the bucket dumps to the point where it dumps again, while a truck driver might view it as the time it takes to complete a circuit from the face to the dump point and back.

Measurement of a cycle time is to determine equipment performance and operator efficiency. Those statistics also serve as a measure of efficiency of the entire operation. Unusually high reading in certain segments can highlight problems. By measuring cycle times, benchmarks can be established, allowing the quick check that all is well.

Hydraulic hoe productivity as it relates to cycle times. At the end of the session, it was clear that minutes saved per cycle meant nothing if the machine did not have properly trained operator.

III. METHODOLOGY

The total experimental approach involved in this work has been divided into four different phases. The details of the work in phase are narrated below.

Phase-I:-

1) Study of available literature excavator productivity.
2) Studying basic operations and parts of hoe.

Phase-II:-

3) Studying estimated hourly production chart of excavator.
4) Identifying different factors affecting cycle time and productivity of excavator.
5) Selection of a site for studying real time monitoring of an excavator.

Phase-III:-

6) Collecting data by time motion study of hydraulic hoe.

Phase-IV:-

7) Analysis of actual and theoretical production of hydraulic hoe.
8) Generating Production Performance Ratio and conclusion.

IV. CALCULATION AND DATA OBSREVED

Calculation for site 1:
For calculating the productivity we have to know the capacity of Excavator.

Bucket Capacity of the available komatsu excavator was = 0.5 Cum.

Consider the efficiency as 75% (This may be changing based on the type of material to be excavated)

Therefore, net capacity = 0.5*75%= 0.375 Cum.

Time per swing (unload, swing, fill, swing) = 17.20seconds

17.20/60 = 0.28minutes

Consider 5 minutes rest taken by the operator per hour.

Therefore, no of cycles per hour = 55/0.28 = 196

capacity per hour = 196*0.375 = 73.5 cum/Hour

Factors	Site 1	Site 2
Class of Material	Earth and Gravel	Earth Dry
Angle of Swing	90 degree	110 degree
Operator skill	Average	Poor
Bucket Capacity (Cum)	0.5	0.7
Cycle Time Recorded (Recorded)	17.20	18.12
Cycle Time Recorded (Theoretical)	14	14
Actual Site Production/hr (cum)	62.5	65.62
Theoretical Production/Hr (cum)	73.5	96.25
Production Performance Ratio	0.85	0.68

V. CONCLUSION

Hoe productivity as it relates to cycle times, it is possible to gain a second here and a few milliseconds there, but if the excavator does not have the operator trained properly then all the efforts are wasted.

Putting the truck in the right position also saves time for operator If the backhoe is set up correctly with the truck on the lower level with a low swing angle say 30^{o} to 40^{o} the cycle time could as little as 10 to 13 seconds . With the truck on the upper level, it's not nearly as efficient.

The production performance ratio observed was relatively low which indicates poor production per hour. It is recommended that high production rates can be obtained by giving proper training to the operator.

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