Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 02, February-2017

A Critical Review of Identification of Critical Factors Affecting the Productivity of Construction Equipment

Sachin Pindoria[1]
Final year M. Tech. Student,
Construction Engineering and Management,
B.V.M. Engineering college,
Vallabh Vidyanagar, Gujarat, India

Dr. Jayeshkumar Pitroda[2]
Assistant Professor,
Civil Engineering Department,
B.V.M. Engineering college,
Vallabh Vidyanagar, Gujarat, India

Dr. H.V. Patel[3]
Associate Professor,
Civil Engineering Department,
B.V.M. Engineering college,
Vallabh Vidyanagar, Gujarat, India

***Abstract*—Output of the any equipment per minute, hour or day is called the productivity of the equipment. Study the Productivity relating to the construction equipment is very useful to decide the fair or rent of the equipment. A study made to find the efficiency and factors affecting the output of the construction equipment. The study involved the general information about the productivity of construction equipment. The paper hear presents the identification of various factors affect the productivity of construction equipment.**

Keyword— Construction Equipment, Productivity, Major Factors

I. INTRODUCTION

Construction industry is second largest industry in India after agriculture. Construction industry can great influence on the economy of the any country. Lots of cost and investment done every year in construction industry. Especially for developing country like, India due to heavy investment overall GDP (Gross Domestic Product) is affected. In construction sector Various costs are being involved in construction sector like, labor, material, equipment, (resources) land, etc. Equipment cost is major cost in construction sector. Equipment management is the part of project management. Effective management of resources in construction projects can produce significant savings in time and cost. So effective resource management lead to effective project management. For effective equipment management it is necessary to study productivity or output of equipment. For find out the productivity of equipment, study of factors affecting behind them is necessary.

In construction project equipment cost is high which affect the overall cost of the construction project. Proper equipment management can increase the equipment productivity which lead to reduce the overall cost of the project.

II. CRITICAL LITERATURE REVIEW

The following are the previous research review based on the identification of factors affecting the productivity of construction equipment.

Tavakoli et al. (1990) found the fleet module. FLEET, was presented four modules: (1) time, production, and cost records module; (2) Inventory (register) management module (3) report generating module; and (4) maintenance and repair management module; This four module help to manage the equipment effectively. [27]

Kannan et al (1999) introduced the use of on-board equipment as a technique to collect field data separately which leads to improve the productivity. This innovative method for independent data also provided the statistically required distributions for simulation of site management. [13]

Jonasson et al. (2002) studied that application of modern advanced location identifying methods and technologies for machine guidance is bring in the integrated construction for earthwork projects. Author suggested the 3D guidance system would be advantageously for the operations of earthmoving, and in the long run for the owner, since it helps to rise the overall productivity and lowers unit costs. Author also conclude that in the future more of machines are equipped with GPS (global positioning system. This decrease in idle situation leads to increase productivity of the equipment. [11]

Bhurisith et al. (2002) observed that the output is increased by 1.58% of an earthmoving equipment per year. The unit cost of the same family of the equipment, without altering for cost acceleration over the time period of 5 years, has increased by 1.77% every year. [3]

Schexnayder et al. (2002) planned the advancement of construction equipment used for earthmoving operations, into mobile counterbalances facility which serves as an efficient work platform for a selection of machine tools. New developments in on board positioning system GPS

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 02, February-2017

(Global Positioning System) and some another off-board communications indicate best possibilities which helps to improve the productivity by integrating the equipment with the design of the construction project and with other equipment to develop overall site operational time. [25]

Hildreth et al. (2002) innovate the application of GPS (global positioning system) for recognizing activities and events which happens on a construction project and collected data independently. [9]

Shapira et al. (2007) studied on selection criteria of equipment for large construction projects of buildings to raise awareness to their variety, nature, richness to their important role and possible effect on the result of decision making. [26]

Fan et al. (2007) studied on management of equipment and developed a system with the combination of data mining techniques. As an increment to the current rule-based equipment management decision support system, data mining empowers its decision support capability by joining previously tacit and dynamic knowledge to the knowledge base. So many different data mining models, such as regression tree, appear as transparent "white box" models that are easy to visualize and interpret. [7]

Goldenberg et al. (2007) investigated on a cast study of the evaluation of construction equipment alternatives. Author considered the three alternative for major construction equipment. In this study they focused on construction of high-rise tower to ensure both possibility and correspondence of three alternatives to meeting the project schedules and limitation, crane employment time were calculated for tower. After considering these alternatives analyze two modules, cost evaluation and benefits evaluation with the core concept of the AHP (Analytical Hierarchical Process) based selection process. [8]

Cheng et al. (2010) suggested a general and extensible Petri net for optimizing configuration of earthmoving equipment. The developed model has the ability to show the dynamic restraint relations among different equipment during the process of construction. The model supports for: (1) visualization of dynamic management and optimization of equipment assignment, (2) Quantitative and dynamic description of workflow and equipment resources in earthmoving operation (3) equipment configuration for planners and managers. The use and the capabilities of the developed model were analyzed through a construction project. [5]

Sajoudi et al. (2011), studied about the various factors for aquisitation of construction equipment. financial and non-financial, factors are studied based on market condition and company policy based on the acquiring expected outcome had been carried out. [23]

Kannan et al. (2011) determined that the cost per unit hour is the most important characteristics for performance indicator (KPI). The reliability of the equipment and overall productivity are not often becoming the major concerns of the end users. [15]

Deshmuk et al. (2013) conclude that excavation in major case is easier and simple for the soft earth material as compared to hard strata. During the excavation process better angle of swing results in larger cycle time which decreases the overall productivity of the equipment. [6]

Klanfar et al. (2014) measured that the actual productivity of bulldozer's cycle amounts to 535 m^3/h. By the calculation obtained the bulldozer's productivity ranges from 477 m^3/h to 642 m^3/h with determining the volume of blade load according to the equation and transport speed according to the equation along with the specified parameter spans and speed of return (0,9 to 1,43 m/s). This theoretical measured value for the output of bulldozer is deviate from -10% to +14%. [13]

Jariwala et. al. (2015) found the various features that affect the selection of equipment do the analysis by RII (Relative Important Index) method. As per the survey author conclude that most important factors affecting in Selection of Construction Equipment's are Maintenance, Fuel, Purchase price, Performance/Productivity, Freight charges, Storage, Instalment payment, Overhead, Initial unloading and assembly and Repair. [10]

Kadam et al. (2015) studied the output of the various construction equipment like, excavator, tripper, dozer and vibratory roller. Author conclude that the overall time required to complete an project related to earthmoving operations is simply the total quantity of earth to be towed and the production rate of the hauling system. Once the total hourly based cost of the project are known, then it can be multiplied by the total time required to find the total cost required to complete the project. [13]

Sarode et al. (2015) analyzed the output data of the crawler mounted hydraulic backhoe excavator reveals that on an average these equipment are giving an productivity efficiency factor between 50 % to 72 % of output. And author output data of different batching plants of concrete also conclude which discloses that these output efficiency factor is 34% to 48% for plants as compared with the specific characteristics given by the manufactures. [24]

Patil et al. (2015) used the concept of continuous cycle time which will help in estimating to compensate for the unseen interruptions that may arise in a typical equipment production cycle. Author used the stochastic methods for differentiate the sustained and instantaneous cycle for estimating productivity. [22]

Ok et. al. (2015) found the output of the various construction equipment by neural network model (NNM) and compare the productivity by neural network model with actual productivity. Author also conclude that the nonlinear artificial neural network (NN) improves the productivity of estimation model.[19]

Parikh et. al (2015) studied that Efficient TPM (Total Productive Maintenance) implementation initiative highlights maintenance related problems, with a view to improve performance of equipment. The significance can be understood by the most fact that even as 1% improvement in OEE (Overall Equipment Effectiveness) index can increase and improve profits and productivity drastically. [20]

Nimbalkar et al. (2016) proposed the model to automatically gather and analyze the monitoring data which provides the construction manager with real-time control information. The model was designed for road

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 02, February-2017

Construction. GPS (Global Positioning System) technology is used for automating data collection, showing the location of all the earth moving and excavating equipment while working on the project. [18]

Kadivar et al. (2016) studied the output capacity of motor grader equipment which is used in road construction and find the various features that affect the productivity and performance of motor grader. From the case studies of road project author conclude that the Output of motor grading equipment depends on various job conditions factor and management factor. Length of job line, working space, soil condition and soil types are key factors which affect the productivity of grading equipment. [12]

Sheikh et al. (2016) obtained the problems concerned with equipment usage and their output and how they harmfully affect the cost is realized. Major problems relating to equipment usage are found to be difficulty in management, scheduling and maintenance of the machines, the laying of unwanted cost due to unseen factors, failure and wrong choice of technology (machines and their combinations). To prevent such problem applying queuing theory for equipment selection in order to minimize the degree of delays by reducing cycle time and idle time and thus reducing the total cost. [27]

Bhoye et al. (2016) conclude that the systematic application of Equipment fleet management (Fleet Module) helps to increase the productivity of overall construction project and increases the profit by adopting a proper selection of equipment & production monitoring and controlling, tracking of equipment, maintaining a maintenance schedule, optimization etc. Application of different tools & methods can be used for the similar operations such as GPS navigation and information transmission systems. The system offered a practice-oriented and user-friendly system and is developed to prove the accessibility of the management systems of database. Profitability and efficiency of contractor as well as project can be contributed by the continued use of such system. [2]

Alshibani et al. (2016) proposed the new system for estimating onsite productivity and forecasting project cost and time of earthmoving operations. The new system uses limited GPS (Global Positioning System) data, collected from construction site using GPS (Global Positioning System) receivers mounted on hauling units. The new system utilizes only samples of GPS data which is received from satellite as substitute approach to current systems that require collecting a large volume of data. The system is can be used during construction or execution of project by reconfiguring fleet dynamically while operations are in progress to support needed corrective actions. [1]

Patel et al. (2016) studied that Overall equipment effectiveness(OEE) is finest method for measure the effectiveness and efficiency of the machine and equipment. OEE (Overall Equipment Effectiveness) method can be also use for calculation of overall plant efficiency in many industries. [21]

W. A. Dhwale at el. (2016) conclude that the maintaining and cleaning of concrete pump and pipe with most care is necessary for reducing the chances of choking of pipeline and pump. Straight concrete pipes with lesser lengths. i.e. distance and minimum bends has to be accepted. Proper correlation between the concreting team has to be maintained. [30]

In the proposed model, the identification of various factors affect the productivity of construction equipment criterion has been developed on the basis of literature review and a series of discussions with the academicians and teaching guide. The details of the criteria are given as follows (Table 1):

TABLE 1: FACTORS AFFECTING THE PRODUCTIVITY OF CONSTRUCTION EQUIPMENT

Factors Affecting productivity of construction equipment	(A) Soft factors	A1) Company policy
		A2) Site ground condition
		A3) Company project forecast
		A4) Commercial consideration
		A5) Procurement method
		A6) Work night shift
		A7) Site congestion
		A8) Obstacle on site
		A9) Project specialization
		A10) Dependent of out sourcing
		A11) Shifting responsibility to external party
		A12) Progress plan
		A13) dependent on other equipment
		A14) Labor availability
		A15) Heavy traffic
		A16) Strong winds
		A17) Previous experience
	(B) Hard factors	B1) Technical specification
		B2) Physical classification
		B3) Construction facilities
		B4) Equipment specification

Factors Affecting productivity of construction equipment	(C) Controllable factors	C1) Equipment repair and facilities of maintenance
		C2) Level of motivation & Planning
		C3) Working facilities
		C4) Efficiency factor of different tasks
		C5) Overall control and life of equipment
		C6) Maneuverability of equipment
		C7) Operators kill

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 02, February-2017

	(D) Uncontrollable factors	D1) Type of soils
		D2) Temperature effects
		D3) Snow, Rain and wind effect
		D4) Altitude Effect on the performance of the engine
		D5) Working space availability
		D6) Condition of haul road
		D7) Specifications requirement

III. MAJOR FINDINGS OF THIS LITERATURE REVIEW

From the detailed literature review 35 factors have been identified and classified them in 4 different groups. The different contributed factors are as follows:

1. For the soft consideration 17 factors were identified from the literature survey are: company policy, site ground condition, company project forecast, commercial consideration, procurement method, work night shift, site congestion, obstacle on site, project specialization, dependence on out sourcing, shifting responsibility to external party, progress plan, dependent on other equipment, previous experience, labor availability, heavy traffic, strong winds.
2. For the hard consideration 4 factors were studied from literature work as: Physical Classification, Technical Specification, Equipment specification and Construction facilities.
3. For the controllable condition 7 factors were identified from the previous study as: Operators Skill, Equipment repairs and maintenance facilities, Planning and level of motivation, Working facilities, Task efficiency factor life of equipment and control of equipment, Maneuverability of equipment
4. For uncontrollable condition 7 factors were obtained from the literature survey as: property of soil, snow and wind effect, Effect of temperature, Rain, Effect of altitude on the performance of the engine, Condition of haul Roads, Specifications requirements and availability of working Space.

IV. CONCLUSION

we have studied various sources of literatures in this paper which is related to productivity of construction equipment. We have derived various critical factors from various papers from different point of view. An integrated framework of such critical factors affecting productivity, which contained main 4 groups containing different 35 factors which provides an extensive background to enhance knowledge regarding equipment productivity. In construction sector proper handling of these factor can improve the productivity of equipment as well as construction. By increasing the productivity minimize the total cost of the project.

ACKNOWLEDGEMENT

This research paper has made possible through help of professors, HOD and Principal. I would like to express sincerely thanks to Dr. Indrajit. N. Patel, Principal, B.V.M engineering College, Vallabh Vidyanagar, Dr. L. B. Zala, Professor and Head of Department, Civil Engineering Department, Prof. J. J. Bhavsar, Associate Professor, Civil Engineering Department, Dr. H. V. Patel, Associate Professor, Civil Engineering Department. I am also very much thankful to Dr. Jayeshkumar Pitroda, Assistant Professor, Civil Engineering Department, Birla Vishvakarma Mahavidyalaya Engineering College, Vallabh Vidyanagar for giving me an opportunity to explore different technology of construction and thus to undertake this research subject for study, and to continuously helping me to increase the level of enthusiasm and moral support.

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International Journal of Engineering Research & Technology (IJERT)
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