

# Equipment planning and management in road construction project

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**Abstract** - Equipment management is defined as a management system that is required in planning and controlling the quality and quantity of the equipment, punctual equipment placement, good price and the right quantity as required. Construction is a business sector that relies primarily on high utilization of construction equipment. This thesis presents the identification of problems of construction equipment planning and management for road projects. The past researchers focused on construction equipment selection, acquisition, operation, maintenance and disposal or replacement. The data collection method is integrated questionnaire, interview and case studies; a descriptive and inferential statistical data analysis has also been used. Interpretations and discussions were made on the basis of the results from the analysis of past research work and questionnaire survey. Most respondents believed that their companies have no documented construction equipment planning and management policy; also the result indicated that idle time, down time, poor equipment maintenance practices are some of major problems that affect construction equipment planning and management. Cost overrun is the first ranked among the negative effects of construction equipment planning and management problem. By enhancing the effectiveness of utilizing equipment; extensive volume of work can be completed within a shorter period of time and, more importantly, within the project schedule. Equipment is thus one of the key factors for improving contractor's capabilities in performing their work more effectively and efficiently.

**Key Words:** Equipment Planning and Management, Road Construction, Optimization

## 1. INTRODUCTION

Construction is a business sector that relies primarily on high utilization of construction equipment. Equipment is thus one of the key factors for improving capabilities in performing work more effectively and efficiently. 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 equipment's available to use it in an effective manner at minimum possible cost and with maximum output productivity.

Currently in Nashik city the Road construction sector plays an important role in short term trends, with more frequent development, not only for the sector itself but also for other economic activities as well. As a result, it is firmly believed that the road construction industry needs an effective resource management practice to retain profitability and continue its dynamic contribution to the growth of the country. The cost of equipment in a project varies from 10% to 30% of the total cost of the project, depending upon the extent of mechanization. In modern fully mechanized projects the cost of equipment goes up to 30%. Proper planning, selection, procurement, installation, operation, maintenance and equipment replacement policy plays an important role in equipment management for the successful completion of the project. With the growing use of machinery it has become necessary for construction engineers to be thoroughly familiar with the Construction application and upkeep of the wide range of the modern equipment.

### 1.1 Equipment's management

Equipment's management is defined as a management system that is required in planning and controlling the quality and quantity of the equipment, punctual equipment placement, good price and the right quantity as required (Bailey and Cole, 1995).

The management of equipment's by construction firms is an enterprise that involves many people with diverse interest, talents and background. The building team indirectly constitutes the management team on building sites. This is due to the role played by each member of the team in relation to the successful erection of the building (Skyoles, 1974).

### 1.2 Key factors which governs construction equipment management

- Selection of equipment
- Acquisition of Equipment
- Operation
- Productivity
- Maintenance
- Disposal

## 2. LITERATURE REVIEW

M. Manikandan, et al., (2018) analyzed and studied construction equipment management with respect to improve productivity He suggested improving productivity it is essential to improve the performance of construction systems, productivity will be achieved through high equipment availability which is influenced by equipment reliability and maintainability [1]. Mekdim Mathewos (2017) studied the construction equipment planning and management problems in road construction projects in Addis Ababa city roads in Ethiopia. He carried out survey where most of the respondents agreed that maintenance is very important part of equipment management which directly affects the cost of operation of any equipment.[2]. Ilias Naskoudakis and Kleopatra Petroutsatou (2016) have done thematic review on construction equipment in which he covers operator's competence as an important parameter for equipment management.[3]. Samson Mekbib Atnew, et al., (2016) studied a case study on road construction equipment management in Malaysia in which they they concluded use of solutions methods based on minimization of cost and maximization of profit modules implementations will help in optimum decision making [4]. Kartik Shard Thete and Dhiraj Rajendra Baviskar (2016) studied the Construction Equipment management in which they gave more importance to selection of equipment and discussed selection of equipment depends upon site conditions, duration of work and its overall cost of operation.[5]. Prasannasangeetha and A, Alan. S (2015) from Coimbatore India gives great significance over acquisition of [6]. Mr. Nilesh D. Chinchore and Prof. Pranay R. khare (Dec.2014) from Pune University have given importance regarding selection of equipment for highway construction project in which experience in operation and maintenance is essential. [7]. Tsado, Theophilus Yies and Theophilus Yisa Tsado (2014) from Nigeria studied Equipment maintenance as an aspect of construction project profitability.[8]. Major Virender Singh Phogat and Ajit Pratap Singh (2013) from BITS Pillani-India studied the multi criteria approach for selection for equipment at hilly road region.[9]. Sri. Nuwan Randunupura and Chandanie Hadiwattege (2013) studied plant and equipment management to minimize delays in road construction in which they have reviewed plant and equipment selection practices [10]. David J. Edward and Gary D. Holt (2009) studied the construction plant and management in UK and gives special importance towards the operator and its competence[11]. Douglas D. Gransberg, Calin M. Popescu and Richard C. Ryan (2006) in their book construction equipment management for engineers estimators and owners gives very detailed attention towards acquisition of heavy equipment listing financial methods of acquiring[12].

## 3. PROBLEM STATEMENT

Management of equipment's have over the years was a great problem to most firms in the construction industry. In construction project operations, there is always a tendency of mismanagement of equipment's by construction firms. As the size of the contract increases, however so do the scale of activities concerning equipment's management. During the occurrence of high number of projects, most construction firms focus on getting work done while neglecting the management of equipment's. The negligence of proper equipment's management contributes to several negative consequences such as, breakages of equipment's, dissatisfaction by client, and reduction in the productivity of workers, equipment's wastage, high project cost and delay in the progress of work at hand, which affects the maximization of limited resources. Most construction firms have given little priorities to the setting up of a department which oversees the management of their equipment's resulting in improper equipment's management if there is any at all. Mismanagement of equipment's can be classified as loss since it has adverse effects on construction projects. On the small sites, equipment's are managed by individuals with little or no knowledge about the management of equipment's. It is therefore prudent for construction firms to have a critical look on equipment's management, since it has a rippling effect on construction projects.

## 4. METHODOLOGY

The focus of this research is identifying major problems in construction equipment planning and management, and their effect on construction equipment productivity on Nashik city road projects. Investigating causes and effects of construction equipment planning and management problems within domestic grade one contractors and equipment rental companies participating in Nashik city road projects. Therefore, the choice of the mixed research method is justified as an appropriate research strategy. The determination of the study sample and the techniques of data collection are also described.

### 4.1 Survey study

the questionnaire survey was used to obtain information about the identification of major construction equipment planning and management problems, its causes and effects among parties which were participating in Nashik City Road projects. This included domestic Grade One contractors. The questions had a number of choices of possible answers and the respondents selected whatever they feel was most appropriate. In this research, the response of the questionnaire data was prepared based on the scale of percentage rating scale measurement of the agreement towards each statement. The reason to adopting this simple scale is as to provide simplicity for the respondent to answer and to make evaluation of collected data easier to evaluate; and to rank major integration problems as the

objective of this research

PR – Performance rate and  
QR – Quality Rate

#### 4.2 Case study 1- Shevgedarna-donwade road asphalt road project

This road section is about 5km long and it is at early construction stage. Only excavation work of side trench and supplying of excavated material to side shoulder work has been considered to examine OEE (overall equipment effectiveness) of Tata Hitachi 120x excavator. The project is in active stage and is handled by researcher itself. Data collection and record keeping of site is done by researcher personally. With respect to equipment utilization and its management OEE of excavator is carried out. All the records and data will be maintained in different register format from which comparative analysis will be done to conclude most effective and efficient equipment management policy to adopt with respect to equipment selection, its operation

#### 4.3 Case study 2- Sarul stone quarry

This stone quarry is located near Nashik-Mumbai highway near sarul village. 50m x 40x hill section is used for blasting purpose to obtain stone metal from it. Operation of loading of blasted dubber (large size blasted stone) is analyzed to obtain OEE of Tata Hitachi 200x excavator.

#### 4.4 Case study 3- Suprabha stone crusher and plant

Suprabha stone crusher and plant is a well-known stone crusher in Nashik city situated at villolhi village. The company owns stone crusher plant, ready mix concrete plant and bitumen plants where large quantity of loading and dumping operation is carried out with the help of CAT Hindustan loader. OEE of Loader is carried out from the day to day registered data keeping of the company

#### 4.5 OEE (Overall equipment effectiveness)

By definition, OEE is a measure of value added to the production by a certain machine in a production time. The demand for increasing productivity in the current competitive construction industry led to a need for performance measurement system for the production process. One of such a performance measurement tool which measures different production losses and which indicate area of process improvement is an Overall Equipment Effectiveness (OEE) index. It is a tool designed to distinguish factors contributing for productivity losses. Knowing the three fundamental performance rate Availability Rate (AR), the Performance Rate (PR) and the Quality Rate (QR) will help to compute overall equipment effectiveness index. These rates indicate the degree to which the required output those equipment production losses stated

$$OEE = AR \times PR \times QR$$

Where; AR – Availability Rate

### 5. OBSERVATIONS AND CALCULATIONS

#### 5.1 Case study 1: Shevgedarna-donwade road asphalt road project

Table no 1: collected data for Tata Hitachi EX 120 model.

Type of equipment	Excavator
Model	Tata Hitachi Model EX 120
heaped bucket capacity	0.8 cum
material type	medium hard murrum
Ideal excavation from manufacturer	11.6 cum/hr.
Work done (day 1)	excavation of side trench 37.5 cum
Hour reading start time: 4262.9 hrs.	Hour reading end:4270.6 (320minuits)
work done (day 2)	formation of side shoulder 875 meters
Hour reading start time: 4252 hrs.	Hour reading end:4258.6 (400minuits)
Work done (day 3)	excavation of side trench 32.5cum
Hour reading start time: 4258.6 hrs.	Hour reading end:4263 (260minuits)

#### 5.2 Case study 2: - Sarul stone quarry

Table no 2: Data for Tata Hitachi EX 200 model excavator

Type of equipment	Excavator
Model	Tata Hitachi Model EX 200
heaped bucket capacity	1.2 cum
material type	Blasted stone ( Dubber)
Ideal excavation from manufacturer	20 cum/hr.
Work done (day 1)	Loading operation 132m <sup>3</sup>
work done ( day 2)	Loading operation 77.53 m <sup>3</sup>
work done ( day 2)	Loading operation 122.38 m <sup>3</sup>

**5.3 Case study 3:** Suprabha stone crusher and plant

**Table no 3:** collected data for Hindustan wheel loader 2021

Type of equipment	Wheel loader
Model	Caterpillar-Hindustan 2021D
heaped bucket capacity	2.5 cum
material type	Crushed metal
Ideal loading by manufacturer	20 cum/hr.
Work done (day 1)	Loading operation 350m <sup>3</sup>
work done ( day 2)	Loading operation 290 m <sup>3</sup>
work done ( day 2)	Loading operation 410 m <sup>3</sup>

**6. RESULT AND DISCUSION**

**6.1 Questionnaire survey:**

Questionnaire survey carried out shows current status of road construction companies of Nashik city. There are variation in responses of contractors and different psychology seen behind the answers of contractors. From the result it is clearly seen that there is lack of construction management in most of the firms in Nashik city. Most of the construction firms do not have separate equipment of maintenance manager which result into poor equipment practices and faces breakdown of equipment twice a month. The analysis shows most of the firms are not getting expected output from their equipment which result them into less productivity. Most of the contractors prefer local garages and fitters to minimize the maintenance cost. Contractors mostly select equipment according to the spare part availability and general experience to minimize production and maintenance cost. From the result of questionnaire it seems that equipment management is very important and necessary to increase the productivity. Most of the construction companies in Nashik own the equipment instead of going for rental option, Tata products shows more reliability and favorite choice of contractors as the cost of maintenance is low and suitability to Nashik region. From the survey it has seem that most of the construction firms in Nashik city do not have specific equipment management policy. Overall result of questionnaire survey shows lack of equipment management results into low productivity and loss of time and money.

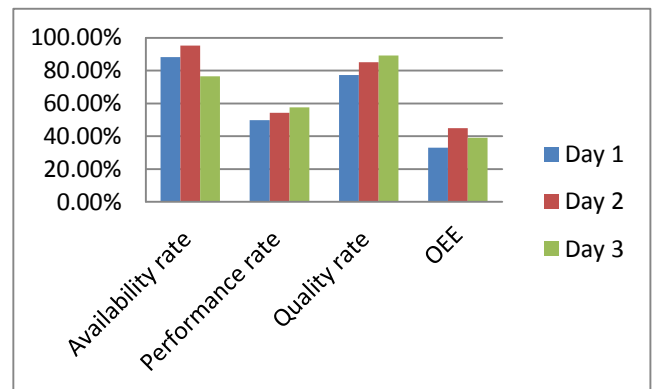
**6.2 Case study 1** Shevgedarna- Donwade road project:

Table 4 shows the result for three days analysis of Overall equipment effectiveness of excavator TATA EX 120 which was performing side trench excavation and shoulder laying work.

**Table 4** OEE for excavator EX 120

Index	Day 1	Day 2	Day 3
Availability rate	88.23%	95.23%	76.47%
Performance rate	49.87%	54.25%	57.54%
Quality rate	77.33%	85.14%	89.23%
OEE	33%	45%	39%

The result analysis shows Availability rate 86.64%, performance rate is 53.88% Quality rate is 83.9% and OEE is 39%.



**Chart 2** OEE analyses for excavator Tata EX 120

**6.3 Case study 2:** - Sarul stone quarry

Table 5 how's the result for three days analysis of overall equipment effectiveness of excavator TATA EX 200 which was performing loading of blasted stone work.

**Table no 5:** OEE for excavator EX 200

Index	Day 1	Day 2	Day 3
Availability rate	90.47%	90.47%	90.47%
Performance rate	84.19%	49.34%	77.88%
Quality rate	100.00%	100.00%	100.00%
OEE	75%	44%	69%

The result shows Availability rate 90.47, performance rate 70.47%, quality rate 100% and OEE is 62.66%



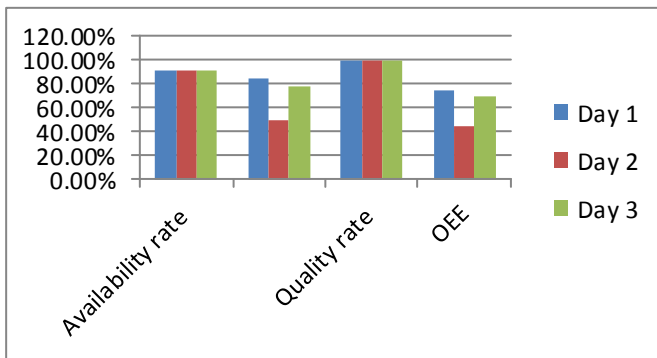


Chart 3 OEE analyses for excavator Tata EX 200

**6.4 Case study 3: Suprabha stone crusher and plant**

Table 6.3 shows the result for three days analysis of overall equipment effectiveness of CAT-Hindustan wheel loader 2021D which was performing loading of Crushed metal work.

**Table no 6: OEE for Hindustan wheel loader 2021D**

Index	Day 1	Day 2	Day 3
Availability rate	73.91%	91.30%	84.78%
Performance rate	42.27%	68.16%	40.87%
Quality rate	100.00%	100.00%	100.00%
OEE	30%	61%	57%

The result shows Availability rate 83.33%, performance rate 50.43%, Quality rate 100% and OEE is 49.33%

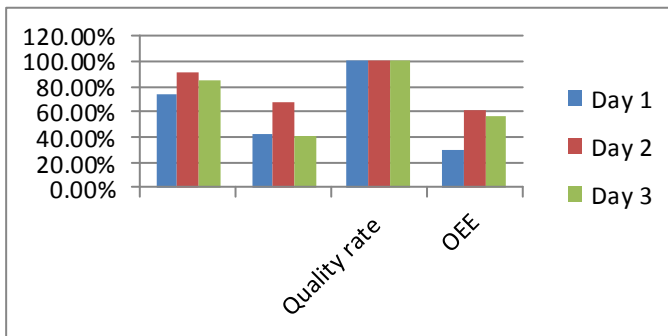


Chart 3 OEE analyses for Hindustan loader 2021D

**7. CONCLUSIONS**

The result indicated that insufficient knowledge of selection of equipment, equipment down time, poor equipment maintenance practices, improper determination of timing of replacement, poor training of equipment operators, equipment breakdown, ignorance towards maintenance of equipment, huge capital investment during acquisition, 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 on Nashik city projects during the planning and construction process.

At Nashik city knowledge about construction equipment planning and management policy is very little. Insufficient training of professional workforces on construction equipment planning and management is the major problem at Nashik city road construction projects. So, this study proved that most of sampled respondents majorly use only one or two types of equipment planning and management policy.

Proper maintenance of construction equipment is vital to keep construction equipment in good and serviceable condition. As the study revealed, 40% of the respondents use planned preventive maintenance method while only 33% performs periodic maintenance, 27% contractor's still go for maintenance after breakdown of equipment shows negligence towards maintenance activity. All types of maintenances are critically needed to keep equipment in good and serviceable condition. By periodically maintaining equipment using planned preventive maintenance method, different major failures of equipment can be prevented because "prevention is better than cure". Also it is better to do corrective maintenance when necessary to increase the efficiency of equipment. In addition, unplanned or unscheduled maintenance is necessarily needed because, equipment can break down suddenly. Therefore, it is better to use all maintenance methods to make equipment more productive. 70% of the construction companies do not keep maintenance record of the equipment's by which it is difficult to keep an eye on maintenance cost expenditure result of this company's faces loss in profitability.

Study concluded only 20% of the respondent have separate maintenance staff at company office, which is necessary to minimize maintenance cost. Most of the firms appoint technical expert on site when needed which adds visiting charges resulting into extra maintenance cost. Survey concluded management, Technical staff and operator of the equipment are equally responsible for management problems in road construction sector. It shows equipment planning and management problems can be solved if these factors are organized.

The performance of equipment effectiveness is evaluated based on actual on site measurement. This actual onsite construction equipment effectiveness is evaluated by overall equipment effectiveness (OEE) indexes. OEE analysis concluded there is major flaw in performance factor of the equipment. All three equipment's do not delivering expected output. OEE for Excavator EX 120 is only 39% which shows lack of productivity and performance rate. OEE for EX 200 Excavator is 62.34% which is quite acceptable but it can be improved as machine shows rate drop in performance rate factor. OEE for loader is 49% which is very low as machine fails in giving expected performance. Overall conclusion of OEE Analysis shows all machines were available for more time but because of lack in performance factor machine showed low productivity. While quality factors depends

upon the operator of the equipment and management of the activity. As proved by the case study, actual on site performance of equipment is very poor due to different management problems. All the analyses show that, OEE of construction equipment is 50% and below 50%. This shows that, the equipment productivity rate is below half of its capacity. To avoid or reduce construction equipment planning and management problems it is necessary to identify the major causes of the problem. The results of analysis indicated that, huge capital investment at acquisition phase and poor maintenance practice with improper determination of economic life and timing for replacement are the major causes of construction equipment planning and management problems.

This causes of construction equipment planning and management problems reflected negative effects on project performance. loss in productivity of equipment, time overrun, cost overrun and equipment related accidents are some of the major effects of construction equipment planning and management problems. Most effects, like loss in productivity of equipment, time overrun, equipment related accidents are reflected on cost overrun. This is why cost overrun was ranked first with the highest negative effect on performance of road projects.

## 8. RECOMMENDATIONS:

After detail investigation on construction equipment planning and management problems its causes and effects, recommendations can be forwarded to contractors. The recommendation meant to diminish construction equipment planning and management problems on Nashik city road construction projects. The following recommendations are forwarded offices:

### 8.1 Recommendations at management level:

- [1] Develop construction equipment planning and management policy to be used as a guideline to use equipment efficiently.
- [2] Should give awareness training for site engineers about equipment planning and management policy and how to manage equipment at project level.
- [3] Collect data about the current status of construction equipment and efficiency of equipment at project level.
- [4] Develop planned preventive maintenance method to eliminate long down time of equipment.
- [5] Develop optimization methods to use available equipment resource effectively and efficiently; and Management has to establish a training center, to train unskilled and semi-skilled operators.
- [6] Management has to update the equipment management guideline to reconcile with the current working condition and work load.
- [7] Management has to implement the currently available technologies regarding equipment.

### Recommendations for maintenance of equipment:

- [1] Implement preventive maintenance, corrective maintenance and unscheduled maintenance program to leading construction equipment.
- [2] Provide maintenance by equipment operators, through in-house equipment department, equipment dealers and external dealers.
- [3] Consider poor maintenance and use of non-original parts as the main cause of machine failure during use.
- [4] Wait until the failed machine is completely repaired and ready for use.

### Recommendation's for operator's level:

- [1] Provide training for equipment operators through in-house equipment department, equipment dealer or external agencies.
- [2] Consider poor operating procedure as a main cause of equipment accidents.
- [3] Allow an equipment operator to work with more than one machine.
- [4] Collect daily based data to measure the overall equipment effectiveness.
- [5] Identify major factors that cause idle time of equipment.

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