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Analysis of Equipment Maintenance Operation and Repair in a Construction Industry

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ABSTRACT

Machinery and equipment which have become an integral part of any construction activity and plants and machinery now constitute a substantial portion of the construction cost in a project(in tune of 10 to 30 percentage of total project cost depending up on the extent of mechanization), has to be maintained to turn the project in to a profit making centre for any organization And also because the cost of maintenance of any equipment is in tune of 200 to 250 percentage of cost of equipment it has become imperative for going in for maintaining the equipment during its expected life cycle. Equipment maintenance is a science because it involves scientific and technical know how of different machineries involved, and it is an art because for identical problem it may require different treatment or action or process. We need equipment for technical and speedy construction and at the same time for economical and timely completion of project. The objective of this thesis is to study the various maintenance management practices that are currently being employed by large construction sector and to identify the best practices for effective maintenance management. This study will help to understand the maintenance phenomenon and factors responsible for better efficiency and less operating cost of owning and operating by reducing the down time of equipment.

Keywords-- Profit, Machinery, Software

I. INTRODUCTION

With the advent of heavy construction equipment and the approach of large construction company of converting the construction sector to a more mechanized and in turn an organized sector has made it mandatory for maintaining the fleet of equipment to perform to its optimum.

Since machinery and equipment which have become an integral part of any construction activity and plants and machinery now constitute a substantial portion of the construction cost in a project (in tune of 10 to 30 percent of total project cost depending upon the extent of mechanization), has to be maintained to turn the project into a profit making center for any organization. And also because the cost of maintenance of any equipment is in tune of 200 to 250 percent of cost of equipment it has become imperative for going in for maintaining the equipment during its expected life cycle.

Equipment maintenance is a science because it involves scientific and technical knowhow of different machineries involved, and it is an art because for identical problem it may require different treatment or action or process. We need equipment's for technical and speedy construction and at the same time for economical.

Reactive maintenance

Reactive maintenance is basically the "run it till it breaks" maintenance mode. No actions or efforts are taken to maintain the equipment as the designer originally intended, either to prevent failure or to ensure that the designed life of the equipment is reached. Reactive maintenance is still predominant mode of maintenance in the Indian construction scenario.

The breakdown of the maintenance program as followed in India:

a) 67 percent Reactive
b) 31 percent Preventive
c) 2 percent Predictive

The advantages are

- Has lower initial costs
- Requires Fewer Staff

The disadvantages are

- Increases costs due to unplanned downtime of equipment
- Increases labor costs, especially if overtime is needed for untimely repairs or replacement
- May increase costs associated with repair or replacement of equipment

- May result in possible secondary equipment or process damage from equipment failures
- Is an inefficient use of staff resources?

Predictive Maintenance

A predictive maintenance approach strives to detect the onset of equipment degradation and to address the problems as they are identified. This allows casual stressors to be eliminated or controlled, prior to any significant deterioration in the physical state of the component or equipment. This leads to both current and future functional capabilities.

Predictive maintenance techniques provide data that define required servicing and inspection periods so that maintenance departments can determine in advance when equipment must be shut down for overhaul. Statistics are proving that these programs, when properly implemented, can minimize equipment and system breakdowns, resulting in a major reduction in total maintenance and operating costs.

Six major diagnostic tools in predictive-maintenance program on a regularly scheduled basis.

- Oil and Wear Particle Analysis
- Vibration Analysis
- Infrared Thermograph
- Electrical Testing
- Ultrasonic/Acoustic
- Process Variables/Inspection/Non-Destructive

The advantages are

- Provides increased component operational life and availability
- Allows for preemptive corrective actions
- Results in decrease in equipment and/or process downtime
- Lowers costs for parts and labor
- Provides better product quality
- Improves worker and environmental safety
- Raises worker morale
- Increases energy savings

The disadvantages are

- Increases investment in diagnostic equipment
- Increases investment in staff training
- Savings potential is readily seen by management

Preventive maintenance refers to a series of actions that are performed on either a time-based schedule or a schedule based on that of machine-run time. These actions are designed to detect, preclude, or mitigate degradation of a system (or its components). The goal of a preventive maintenance approach is to minimize system and component degradation and thus sustain or extend the useful

II. REVIEW OF LITERATURE

2.1 DIFFERENT MAINTAINANCE STRATEGY MODEL

Mechanical equipment used on process plants can be categorized into two main types, namely static and rotating equipment. A brief survey at a number of chemical process plants indicated that a number of maintenance strategies exist and are used for rotating equipment. However, some of these strategies are not directly applicable to static equipment, although the risk-based inspection (RBI) methodology has been developed for pressure vessels. A generalized risk-based maintenance strategy for all types of static equipment does not currently exist. This paper describes the development of an optimized model of inspection methodologies, maintenance strategies, and risk management principles that are generically applicable for static equipment. It enables maintenance managers and engineers to select an applicable maintenance strategy and inspection methodology, based on the operational and business risks posed by the individual pieces of equipment.

Based on the results obtained from the case studies, it is concluded that the newly-developed model can be applied to static equipment to establish an applicable maintenance strategy and approach, as well as applicable inspection methodologies

2.2 SELECTION CRITERIA FOR EQUIPMENT

Today's construction projects are highly mechanized and becoming more so every day. With the growing industrialization of construction work, the role of onsite equipment and machineries is vital in achieving productivity and efficiency. During the construction phase, selection of right equipment has always been a key factor in the success of any construction project. This decision is typically made by matching equipment available in a fleet with the tasks at hand. Such analysis accounts for equipment productivity, equipment capacity, and cost. However, the emerging notion of sustainability in construction has emphasized energy conservation, efficiency, green environment, economy and human wellbeing.

In this context, selecting the most appropriate equipment from the available options is highly challenging. Therefore, this paper aims to determine a selection criteria based on the fundamental concept of sustainability and provides an assessment framework. A questionnaire survey was conducted among a classified group of Malaysiance

2.3 SELECTION OF HILLY ROAD CONSTRUCTION EQUIPMENTS

Major Virender Singh Phogat, AjitPratap Singh

Planning and construction of a road in hilly region is very challenging which involves complex processes such as reconnaissance and survey to fix the alignment, formation work and construction of various layers of pavement. It has always been a daunting task for implementing agencies to select proper equipments effectively during construction of a road by taking into consideration of both tangible and

intangible factors so as to maximize the benefits of the limited resources. An application of five multi-criteria decision making (MCDM) techniques to a typical selection of equipment's used for hilly road construction is presented. Three criteria representing earthwork operations, operational efficiency and convenience of manager have been considered with six sub criteria each for selection of seven different 13
Construction equipment alternatives .Five MCDM techniques:

III. METHODOLOGY

1. site visit
2. Preparation of data
3. Conducting Interview
4. Analysis of data
5. Compoison of required data
6. Result and Conclusion

IV. EQUIPMENT MANAGEMENT IN CONSTRUCTION INDUSTRY

Equipments are main assets of a company in today's scenario with increase in infrastructure, heavy demand with increase in complexity of construction plant and equipment has become integral part of every project. In construction, plant and equipment contribute a great deal towards speed, quality, safety and efficiency of a project.

The mechanization began to show up in the 1960's in construction projects. Initially, government bodies such as Ministry of Surface Transport (MOST) and Public Works Department (PWD) imported equipments and hired them out to contractors for execution of works. The market was accordingly limited in scope. In the 1980's, the projects began to be increasingly granted on turnkey basis. Project sizes also became larger and external funding agencies started mandating the use of appropriate equipments for works funded by them. Gradually, one of the criteria for pre-qualification of contractors became the ownership of equipments. Faster project execution required state-of-the-art equipment. The average unit cost of construction equipment in the construction works became around 15 to 20 percent.

V. ADVANTAGES AND DISADVANTAGES OF USING EQUIPMENTS

The construction planning and execution is a synthesis if speed, safety, efficiency economy, and the use of equipment offer some advantages. However there are some severe handicaps with the usage of equipment, especially in developing countries.

Advantages of using machines

O Use of machines helps in speedy construction and thereby the project facility starts to give returns earlier as compared to manual construction, which consumes much more time.
o Economic considerations of early completion such as reduction in overheads, less escalation etc.
o Machines are capable of handling tough work and can be expected with a fair degree of effectiveness.
o Where the work involved includes large quantities to be handled for long distances, machines work out to be cheaper.
o Machine's performance can be assessed more accurately than that of
the human resource and thereby adherence to schedules is easier.
o Use of mechanical equipment has long range benefit in creating technical know-how and skilled workmen who could prove assets in the country's technical development.
o Use of indigenous machines reflects on the manufacturing industry and faster industrialization of the country.

Disadvantages of using machines

o Use of equipment results in dependence for supply of spare parts and specialists services of manufacturers. The non-availability of these things causes downtime and financial losses by way of lost working time.
o Often the overall cost of working of machines has been found to be more than the first estimates showed. Some machines consume spare parts costing as much as 200 percent of original estimates.
o Sometimes the delay caused in procurement, trans-shipment, installation and commissioning may be more than offset the gain in time expected as a result of using equipment.
o The disposal of the equipment profitably after completion of a project may prove difficult, resulting in capital loss to the project. Similarly, disposal of large quantities of spare parts for obsolete models may pose serious problems.

IV. GROWTH OF CONSTRUCTION EQUIPMENTS IN INDIA

India had only a few construction equipment, in the pre-independence period. The equipment was used for the first time in construction in India in 1913 and it was a steam driven crane. Later equipment like draglines and shovels were used in the construction of Sind Barrage Canal System. A gasoline tractor was used as a hauling unit in the year 1930-33. The first known ownership of construction equipment by a contractor was in 1937. There were only 23 machines of total value of Rs.25.28 lakhs with Irrigation Department and contractors all over India.
The gross value of equipment used in India also increased since independence. In 1950, India had 95 machines

valued at Rs.0.421 cores, in 1960 it had 934machines valued at Rs.12 cores, in 1970 it went up to 643 machines valued Rs.21 cores and in 1979 it was 16048 machines valued Rs.297.5 cores. Of these l6048 machines, 1494 numbers valued at Rs.26.35 cores were owned by private companies, 7134 machines valued Rs.132.73 cores were owned by State Governments and the remaining by the Central Government. Out of the total stock of equipment in 1979, 74 percent of equipment by value was imported and these were mostly excavators, tractors, dumpers, scrapers, graders and loaders. Equipment like cranes, locomotives, belt conveyors, vibratory rollers, forklifts and pile driving equipment were imported even though indigenous stock was in hand. Some equipment like cableways, rocker shovels, ditchers and trenchers, asphalt distribution, paver finishers and spreaders were totally imported. Thus, the import component of construction equipment in India remained high till 1979. Rapid indigenization took place thereafter. The domestic production of construction equipment reached nearly USD 1.9 billion in 2000, from the previous year's output of USD 1.6 billion.

The expanding construction market is pushing up the production of technologically advanced machinery in India. Currently Indian firms manufacture a limited range of construction equipment. Major construction equipment manufacturing companies are Bharat Earth Movers Limited (BEML), Heavy Engineering Corporation, Hindustan Motors (HM), Larsen and Turbo (L & T), Escorts JCB, Ingersoll Rand etc. Other prominent manufacturers of construction equipment in the mid segment are Condequip, Alien Build well, Gujarat Apollo, Ashok Engineering, Leo Road Equipment, and Jaypee etc. Many of these companies have technical collaboration with foreign firms. The growth of construction equipment by values during the period 1940-2000 is taken from ―Construction Equipment Industry in India‖

o Maintainability:
o Ease of repair and maintenance.
o Vendors after sales and service, repairs, spares and maintenance.
o Availability of spare parts.
o Standardization consideration.

Economic Considerations

o Owning costs.
o Operating costs.
o Re-sale or residual value after use.
o Replacement costs of existing equipment.
o Unit cost of production.

Commercial Considerations

o Use of available equipment.
o Buy second-hand or new equipment.
o Rent equipment.
o Hire-purchase equipment.
o Purchase or lease.

Equipment selection analysis considers various factors but not necessarily limited to the above mentioned. It leads to alternatives for acquiring the required equipment. It is then for the management to make decision after careful consideration of all the facts. In most cases the final equipment selection decision is likely to be a compromise between what is ideally required and what can actually be obtained economically.

VII. DATA COLLECTION AND ANALYSIS

DATA COLLECTION AND ANALYSIS
PLANNING FOR CONSTRUCTION EQUIPMENT

Equipment planning on major construction projects includes besides its selection, the decision about working shifts, number and size of machines, the matching of units working in a team, procurement schedule and the arrangement of necessary technical staff to operate, service and repair of the equipment. Planning of workshop and store facilities is also an important aspect of equipment planning.

The type of equipment selected for removal of soil usually depends upon soil and valley conditions and upon the characteristics of material to be handled. The number and size of machines selected depend upon the magnitude of work, working days available and number of shifts worked in a day. Size matching of all equipments working in a group is vital. The procurement plan must be in line with the construction schedule. Also, planned with equipment procurement should be the spare parts for it and supplies of fuels, oils, lubricants etc. for its operation. Suitable service facilities are vital to realize the planned output rate of equipments. Availability of operation and maintenance staff having adequate quality and number for the operation of equipment is essential to obtain full production. The use of mathematical models of the operation of equipment can be used for planning and selection of construction equipment

Equipment planning shall include the following aspects.

o Selection of equipment.
o Number and sizes of units.
o Matching capacities.
o Schedule of procurement.
o Arrangement of skilled staff for operation and maintenance.
o Establishment of service and repair facilities.
o Maintenance of spare parts inventory.
o Decision regarding number of shifts per operation.

A systematic approach in respect of planning for equipment is necessary, incorporating all the factors detailed above. In addition an important factor to be considered is the necessary inter-disciplinary acceptance of the planning for equipment. In a majority of the cases a Civil Engineer may head project whereas the construction equipment management will demand close liaison with mechanical and electrical engineers. It will be prudent to have detailed consultations among the disciplines before the final choice of the equipment.

VIII. SELECTION OF EQUIPMENT

A contractor is frequently confronted with the problem of the selection of the most suitable equipment as he plans to execute the project.

LIST OF EQUIPMENTS IN THE CORDIAL GROUP

Sl No	Name of the Equipment	Nos	Capacity	Identification
1	Dozer	5		BEML (D155)
2	Dozer	12		BEML (D50)
3	Motor Graders	27	155 Hp	BEML (GD 605R2)
4	Motor Graders	10	155Hp	KOMATSU
5	Wheel Loaders	22	1.7 cum	HM 20-21
6	Wheel Loaders	8	1.7 cum	L&T CASE W20
7	Excavator	13	900L	L&T Proclaim
8	Back Hoe (loader)	2	1.00cum	JCB
9	Back Hoe (loader)	14	1.00cum	L&T Case 580
10	Vibratory Roller	40	10 Ton	L&T Vibromax

LIST OF EQUIPMENTS IN THE TRINITY GROUP

Sl No	Name of the Equipment	Nos	Capacity	Identification
1	Crane	5	20MT	Komatsu
2	Crane	1	30MT	Tfi
3	Crane	2	75MT	TATA
4	Crane	1	20MT	Navin
5	Concrete Pump	1	30cum/Hr	Greaves
6	Mobile Concrete pump	2	52 Cum/Hr	Schwing
7	Wheel Dozers	6	2MT	TATA
8	Wheel Dozers	10	2MT	Hindustan
9	Wheel Dozers	3	3Cum	Volvo
10	Excavater	3	0.9Cum	Caterpillar

IX. FAILURE MODE EFFECT ANALYSIS (FMEA) AS A TOOL FORCARRYING OUT MAINTENANCE COST

INTRODUCTION TO FAILURE MODE EFFECTS ANALY

Create severity, occurrence, and detection ratings.

Once the failure mode has been defined and the potential effects of failure have been determined, the team must assess the severity, occurrence and detection of failures and give those aspects numeric ratings. Severity means how serious the failure will be. Give it a rating from one to ten, where ten is the most severe failure.

In the same way, you rate the occurrence of failure - how frequently you see the failure. Detection indicates how easily that fault or failure can be detected. The detection scale is the reverse of the other 2 scales, with 1 being the easiest or most detected and 10 being the hardest or most difficult to detect. Obviously, for this rating system to work, its vital that all team members understand what constitutes a failure. Each potential effect of failure is given a severity, occurrence and detection rating. Those numbers are multiplied to produce a Risk Priority Number (RPN).

Example: One potential failure is that a worker gets his arm cut off in a 60 A FMEA is a stable and seasoned design tool, Often called a Failure Mode Study, this design and maintenance engineering tool has existed and matured for some time, as engineers try to figure out why a machine unexpectedly broke down or how a part slowly came out of tolerance.

By contrast, FMEA is a formal process that allows in-house experts to concentrate on failures and fix them. Failure Mode and Effects Analysis is important because it focuses on failures and potential problems. If it's done early enough in the process, we can anticipate problems and engineer them out of the system. And the earlier you catch potential failures, the more money you save.

X. CONCLUSION

Software can be developed to enhance the efficiency of the Failure model analysis (FMEA). For the present study only four parameters are considered for analyzing modes and defects of failure. But software is used for the analysis more parameters can be used in the analysis. There by level of risk of failure can be reduced and more saving in the cost of maintenance can be achieved

a) Both the companies followed a combination of preventive maintenance and breakdown maintenance.

b) On an average (considering a group of 9 equipments) it is found that utility of Cordial was 13.76 percent more than Trinity
c) On an average (considering a group of 9 equipments) it is found that total expenditure on maintenance of Cordial is 33.14 percent more than that Of Trinity.
d) For maintenance of plants such as hot mix ,batching plant, crushing plant rather than simply relying on preventive maintenance a better option is to
go in for a combination of breakdown (minimum, percent),preventive predictive(maximum percent) maintenance also known as reliability centered maintenance.
e) From the analysis it is found that Cordial are in a better position as compared to Trinity in optimizing equipment utility, usage and total maintenance cost.

RECOMMENDATIONS

a) Breakdown maintenance should be avoided as far as possible.
b) A combination of Preventive maintenance and predictive maintenance will give better results for equipment.
c) Reliability centered maintenance should be followed for maintenance of plants.
d) Proper manpower planning and maintenance scheduling synchronized with optimum utilization should be aimed at for improving interdepartmental conflicts.
f) FEMA can effectively use to find out in advance the failure modes and hence precautionary measures can be taken.
g) In a tower crane risk priority number is more for improper inspection and improperly trained operator.
h) In a motor grader risk priority number is more for improperly trained operators, which indicates that the operator must be trained properly.
i) In a concrete-mixer risk priority number is more for adjustments and repairs not done by a competent designated person.
Thus failures vary for each equipment due to RPN value. Thus RPN plays a vital role for each equipment failures.

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