EQUIPMENT MAINTENANCE AND MANAGEMENT IN CONSTRUCTION INDUSTRY

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Abstract

Machinery and equipment have become an integral part of any construction activity. Plants and machinery now constitute a substantial portion of the construction cost. Therefore the plants and machinery cost has to be maintained to turn the project into a profit making centre for any organization. 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. By analyzing the responses from questionnaire by using SPSS software the common maintenance strategies in the construction industry has been identified. The major factors from ranking process have been drawn into the FMEA process. The factors preventive maintenance, planned maintenance, personnel and reliability improvement are the input variables and reduced downtime and less operating cost are regarded as the output variables for decision making purpose using Fuzzy logic.

I. Introduction

1.1 General

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 equipments to perform to its optimum.

Since machinery and equipment have become an integral part of the construction activity and plants and machinery now constitute a substantial portion of the construction cost in a project, has to be maintained to turn the project into a profit making one 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 an identical problem it may require a different treatment or action or process. We need equipments for technical and speedy construction and at the same time for economical and timely completion of project.

1.2 Objective

The objectives of this thesis are

-To study the various maintenance management practices that is currently being employed by large construction sector.

-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 downtime of equipment.

1.3 Scope of study

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

1.4 Planning of 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

. Equipment planning shall include the following aspects.

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

1.5 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

The proper selection of equipment judicious deployment of the same on work is one major factor, which will go a long way in helping the contractor to maintain the completion targets of his contract within

the estimated cost. Selection of an equipment to perform an assigned task depends on many interrelated factors.
These factors are outlined in further sections.

- Task consideration
- Site Constraints
- Equipment Suitability
- Operating Reliability
- Economic Considerations
- Commercial Considerations

1.6 Equipment maintenance

Maintenance of a piece of equipment is the operation of keeping its various components in their original form as far as possible with the view to ensure that safety and production in operation do not deteriorate. It includes servicing, inspection and adjustment, small repairs in the field, major repairs and overhaul in main workshops and proper is of laid-up machine. The objective of maintenance would be

- To maximize availability of machinery and facilities needed for smooth production.
- To minimize downtime due to breakdown of machinery.
- To ensure long life of the machinery to avoid high rate of depreciation of capital.

1.7 Types of maintenances

There are mainly four types of maintenance

- Reactive maintenance / Breakdown maintenance / Corrective maintenance. (Failure Based Maintenance)
- Predictive maintenance and Reliability centred maintenance. (Condition Based Maintenance)
- Preventive maintenance/ Scheduled maintenance. (Time Based maintenance)
- Proactive maintenance(Advanced Maintenance technique)

II. Literature review

2.1"INTEGRATED CONSTRUCTION PREVENTIVE MAINTENANCE SYSTEM." C. William Ibbs, A.M.Kenneth R.Terveer J.Constr.Engr.Manage., 1984. [1].

C. William Ibbs et.al. proposed the integrated construction preventive maintenance system of equipments in the building construction system in 1984. Integrated system enables to improve the overall equipment effectiveness in a manufacturing company through the implementation of innovative maintenance strategy. The methods used here are identifying and tracking repairs, monthly operating statistics report sample of equipment and theoretical checklist composition. They concluded by saying reduced unscheduled equipment downtime, increase on-shift and overall equipment availability and pinpoint machine deficiencies and initiate improvement.

2.2 "EQUIPMENT MANAGEMENT THROUGH OPERATIONAL FAILURE COST."

Athanase I.Tsimberdonis, E.Lile Murphree : Journal of Construction Engg. Management, 1984, 110(109-117) [2].

Athanase I.Tsimberdonis et.al. had done a research equipment management through operational failure cost in construction industries in 1995. The aim of the thesis is to develop and examine the usefulness means of equipment and to avoid the concept of equipment failure unit cost. Mathematical model is used here to calculate the marginal cost of failure for equipment. It is concluded that depending upon type of project, failure cost may vary and lowest OFC can provide a base level of cost to be compared against costs of renting when reassigning the related equipments.

2.3 "IMPLEMENTATION OF TOTAL PRODUCTIVE MAINTENANCE AND OVERALL EQUIPMENT EFFECTIVENESS EVALUATION." Islam.H.Afefy 13101-IJMME-IJENS-ASCE @February 2013. [3].

Islam.H.Afefy et.al. had done a research implementation of total productive maintenance and overall equipment effectiveness evaluation in 2012. The aim is to study total productive maintenance and evaluating overall equipments efficiency. The data were collected through reviewing the technical documents available in the statistical population. Based on results the company needs to work hard to improve their system machines and reduce the waste time

III. Methodology

3.1 General

The methodology chapter discusses and explains the project design which is to be analyzed. The questionnaires are prepared according to the literature survey and are distributed to various companies. After some days collect the questionnaires from the companies and evaluate by using ranking techniques in order to analyse using various methods and comparing results and finally concluded.

- Literature Study
- Identification of maintenance procedures from literature
- Questionnaire survey
- Data collection
- Analysis of data
- Model proposal
- Result and Conclusion

3.2 Questionnaire survey

The data collection is by using questionnaire survey. The questionnaire was distributed to various organisation through emails and google forms. The questionnaire contains questions to collect respondent's background, organiational background and survey questions regarding factors affecting the equipment maintenance management.

3.3 Data collection

Data collection is the process of gathering information in a systematic manner for the prepared questionnaire. Data is collected from various construction companies both in India and abroad. The software of Statistic Package for Social Sciences (SPSS) is used to process the data and to rank the factors. The variables are ranked based on its mean and standard deviation.

3.4 Ranking

The factors greatly affecting the maintenance of equipments in construction projects are found by ranking. Ranking is done to find the position of the variable in the hierarchy. Ranking is done in SPSS. The procedure involved in ranking is as follows:

1. Reliability Testing
2. Ranking

Reliability Testing

The term reliability means the degree to which the result of a measurement, calculation can be depended on to be accurate. The reliability is measured by means of Cronbach's alpha value. The Cronbach's alpha value should be greater than 0.6 for reliable data set. If not eliminate the variable which contains a greater value in the 'Cronbach alpha if item deleted'.

Cronbach's Alpha	N of items
0.645	66

Table 1 Reliability Statistic

Ranking

Once the alpha value is greater than 0.6, calculate the mean of each variable. Arrange the variables based on mean and standard deviation.. Ranking is done in SPSS software. Using ranking process, the major factors which affect the maintenance of equipments in construction were found out based on the highest mean.

Variables	N	Mean	Std. Deviation
Repair work orders generated.	10	2.80	0.422
Operating personnel.	10	2.70	0.483
PM procedures current & accurate.	10	2.60	0.516
Formal periodic preventive system.	10	2.50	0.527
Corrective action is performed.	10	2.40	0.516
Well maintained to get best productivity.	10	2.40	0.508
Scheduled maintenance task are done.	10	2.30	0.483
Everyone's responsibility.	10	2.20	0.422
PM procedures reviewed when breakdown occurs.	10	2.10	0.316
Weekly maintenance schedule is always prepared.	10	1.90	0.316

Table 2 Ranking Table

3.5 Failure mode effect analysis. (FMEA)

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, but is still ignored by many design teams and organizations. While the last thing design, development and maintenance engineering needs is another acronym, Failure Mode and Effects Analysis (FMEA) may be one of the easiest concepts to understand and apply. Best of all, it delivers significant financial returns quickly.

When to use FMEA

- When a process, product or service is being designed or redesigned, after quality function deployment.
- When an existing process, product or service is being applied in a new way.
- Before developing control plans for a new or modified process.

Working with FMEA

- Isolates and describes the potential failure modes.
- Team discusses the potential effect of each failure. Team must assess the severity, occurrence and detection of failures and give those aspects different and meaningful numeric ratings.
- Ratings are typically from 1 to 10, with 1 being the least severe, least occurring, or most easily detectable.
- 10 would be those faults that are most severe, most catastrophic and those hardest to detect.

Sl No	Parameter	D	S	O	RPN
1	Repair work orders not generated.	5	7	4	140
2	Improperly trained operator.	8	6	6	288
3	Improper usage of Preventive maintenance procedures.	8	6	2	96
4	Improper formal periodic preventive system.	2	7	8	112
5	Corrective action is not performed.	6	7	2	84
6	Scheduled maintenance task are not accurately done.	8	5	3	120
7	PM procedures not updated or reviewed.	6	8	6	288

8	Refresher skill training is not regularly done.	2	5	8	80
9	Improper inspections.	8	8	5	320
10	Equipment downtime is not tracked and reviewed periodically	3	7	4	84

Table 3 FMEA Result

- The parameter 'Improper inspection' has the most RPN value.
- Lack of updated or reviewed PM procedures and Improper trained personnel having the successive RPN values.
- These high RPN values show how the above parameters affect the project severely

3.6 Fuzzy model

A fuzzy set is a set whose elements have degrees of membership. Fuzzy set determines "how much" the element belongs to the set. This is the basic principle of fuzzy set. Fuzzy logic measures the certainty or uncertainty of how much the element belongs to the set. By means of fuzzy logic, it is possible to find the solution of given task from rules, which were defined for analogous tasks.

The calculation of fuzzy logic consists of three basic steps:

1. Fuzzification: transforms real variables to linguistic variables using their attributes. The variable has usually from three to seven attributes. The attribute and membership functions are defined for input and output variables.
2. Fuzzy inference: defines the behaviour of system by using of rules of type <If>, <Then> on linguistic level. The rules are created by the user or expert himself.
3. Defuzzification: transfers the results of fuzzy inference (numerical values) on output variables by linguistic values. It describes results verbally.

Decision making through fuzzy logic.

The Fuzzy logic toolbox of the MATLAB software was used for creating the decision making model. At first, it is necessary to design the variables, attributes and their membership functions. The developed expert decision-making fuzzy model system consists of four input variables with four attributes, one rule block and one output variable with four attributes. The input variables are preventive maintenance system, personal training, planned maintenance and reliability improvement. The output from the rule block is downtime and operational cost. (Fig 2)

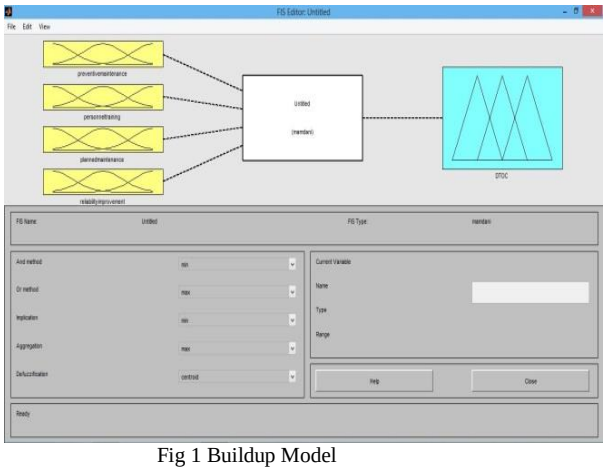

Fig 1 Buildup Model

Figure 3 shows the input variable falling objects with four membership functions: VL-very low, L-low, H-high, and VH-very high. The parameters of membership functions are adjusted for each of the variables. Similarly all the other three input variables have the same membership functions and parameters.

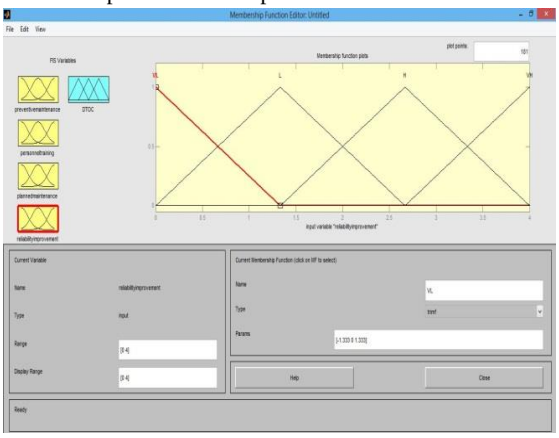

Fig 2 Membership functions of the input variables

Figure 4 shows the rule box with five rules and degree of support that set up the relationship between the input and output variables. The module allows you to set rules and work with them.

Rule number one is a situation where:

<If> = preventive maintenance = VL <And> personnel training = VL <And> planned maintenance = VL <And> reliability improvement = VL <Then> operational cost = very high & equipment downtime = high.

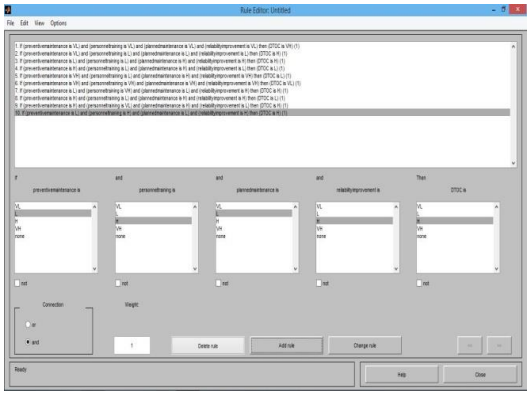

Fig 3 Rule box & Rules

Figure 5 shows the correlation between inputs and output variables. This picture shows graphical correlation between two input variables falling objects and falls and the output variable safety. Graphical display of dependencies of input and output variables allows you to check the set parameters of fuzzy model.

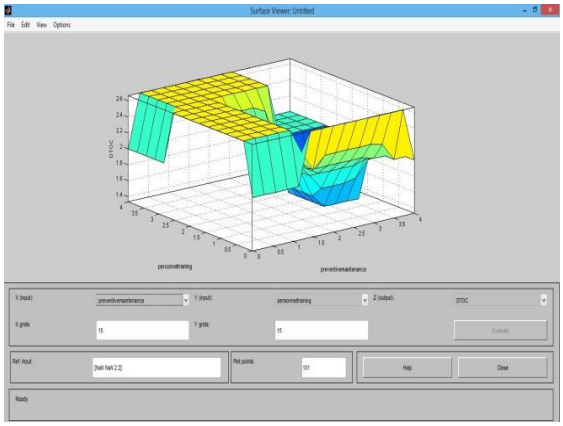

Fig 4 Correlation between variables

Figure 5 shows the evaluation of maintenance strategies of the project. The input variables are setup at preventive maintenance = 2.04, personnel training = 2.01, planned maintenance = 2.15 and reliability improvement = 1.89. It leads to the result (output) downtime and operating cost = 2.06. The model was verified in this manner.A mathematical model usually describes a system by a set of variables and a set of equations that establish relationships between the variables. Variables may be of many types; real or integer numbers, values or strings.

Fig 5 Rule Viewer

IV. Result and discussion

- From Literature survey, the major factors which affect the maintenance strategies of equipment in the construction site were found out and the questionnaire was framed.
- Questionnaires sent to various construction companies and the data were collected.
- SPSS software is used to analyse the data collected from the questionnaire surveys. From the ranking process important factors which affecting maintenance strategies were found out.
- Some significant factors are generation of repair work orders, operating personnel, preventive maintenance procedures, corrective action performance, scheduled maintenance task, reviewing of PM procedures when break down occurs, etc...
- FMEA (Failure Mode Effect Analysis) process is used to identify and prioritize potential equipment failures. It objectively ranks potential failures and provides recommendations for corrective action.
- Improper inspection and lack of updated or reviewed periodic maintenance are found to be most critical parameters that causing failures to the equipment by using FMEA process.
- A decision making model using fuzzy logic was created to evaluate maintenance in uncertainty.

V. Conclusion

Since the objective of this thesis is to study the maintenance management practices that are currently being followed by large construction company and to identify better practices for effective maintenance management a fuzzy model for decision-making regarding equipment maintenance management is proposed. It is believed that the proposed method will be helpful for the maintenance practitioners in the construction industry. During the construction phase, selection of right equipment has always been a key factor in the success of 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. Failure Mode Effect Analysis (FMEA) objectively ranks potential failures and provides recommendations for corrective actions. However, the emerging notion of sustainability in construction has emphasized energy conservation, efficiency, green environment, economy and human wellbeing.

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