

Time and Cost Overruns in the Construction Industry Due to Downtime of the Construction Equipment and Machineries.

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Abstract - Equipment downtime occurs due to planned or unplanned stops. However, the unplanned stops caused by failures and disturbances occurrence are the most common unexpected factors that have the non-trivial influence on the overall productivity. Also, this interrelation between downtime events and productivity lies in gist of economic connotation, in which cost and profit variables are inversely proportional by means of decreasing downtime cost and thereby increasing production profit. To this end, in order to decrease the downtime cost, suitable and developed costing methods are needed to calculate and trace every single cost disbursed during the stoppage juncture. The purpose of this paper is to present a sample of how Construction companies deal with equipment downtime cost, and further how they analyse its reduction. The study will be performed by conducting a survey within construction firms that have maximum employees. This study will perform analysis to assess the construction productivity losses due to downtime of the equipment's by conducting case study on a construction site at Pune. The results will be based on the survey conducted to obtain data and framework and integrated models to manage the construction equipment's efficiently will be presented.

Key Words: Downtime analysis, Management Responsibility, Relative Importance Index (RII), Productivity.

1. INTRODUCTION

In today's competitive manufacturing market, production efficiency and effectiveness are among top business priorities. Thus, production equipment becoming the central focus of interest as it is the backbone of the manufacturing process and key performance indicator of productivity. The requirements of outstanding performance force companies to substantially consider reducing their machines downtime frequency and its consequential costs. In India, Construction industry is growing rapidly and becoming increasingly competitive. In construction industry, the construction equipment itself is one of the areas in construction operation where significant gains can be made. The success of construction project largely depends on use of available resource in optimal manner such as human resource, machinery, materials, money etc. The industry must manage the construction equipment in a systematic and professional

way. If less attention has been given to the maintenance of construction equipment then it leads the construction equipment to a breakdown. The breakdown of construction equipment causes delay in the construction activities and it directly affects the project completion, so downtime tracking information is essential to correct ongoing machinery problems and deficiencies, and to fine tune the maintenance and operations management systems. It's important to remember that an overall system of maintenance should be required to speed up the construction projects.

2. AIM AND OBJECTIVES OF THE STUDY

This study is aimed to analyze and propose framework for efficient and optimum equipment management for construction sites in Pune, District, and Maharashtra.

- To define factors related to time and cost overrun.
- To define down time cost in construction project through case study.
- To prepare a framework and propose the result for cost analysis.
- To study the existing utilization and management of construction equipment.
- To recommend solution about downtime.

3. LIMITATIONS OF THE STUDY

The work for evaluation of the impact of equipment downtime on construction projects is carried out only in the construction industry of Pune. The work is limited to the case study performed at the infrastructural site only and the results will depend on the data obtained after pursuing interviews with the professionals engaged in this industry. This works limitations can be divided into following points:

- (1) The field of selected population that required to conduct the survey will be mainly chosen from the construction companies with high capital investments. According to that, the equipment downtime has a significant impact on cost and productivity.
- (2) IT companies and service providers were excluded from this work.
- (3) The improvement procedures of decreasing downtime cost will be only associated with maintenance practices, regardless other methods that could be efficient and applicable.

On the other side, the limitations were classified as uncontrolled factors whilst performing this study. The first factor was the time constraint; this work built on a survey study and required more time to assimilate much responses and analysis. The second factor was the scarce resources and literature of costing downtime in manufacturing environment, especially the works that correlated to planned stoppage costs.

4. NEED FOR STUDY

1. A sound conceptual model must exist that can be applied across a spectrum of economic decisions.
2. Develop a statistically sound methodology to support the model.
3. It is necessary to discuss issues related to the subject such as, cost categories and drivers that attributable to downtime events whether planned or unplanned.
4. The equipment management system and equipment policy always has a huge impact on the profitability of the contractors with more investment in equipment.
5. By implementing a system that can measure and analyses equipment effectiveness, manufacturers can boost equipment performance, operating measures, and maintenance processes.

5. LITERATURE REVIEW

Melissa De Iuliis, Omar Kammouh, Gian Paolo Cimellaro, and Solomon Tesfamariam (2018), Downtime estimation of building structures using fuzzy logic: The author researched on the downtime estimation of building structures using fuzzy logic. The main aim of the author was to introduce a method to predict the downtime of buildings using a Fuzzy logic hierarchical scheme. Thus in this research author divided the downtime into three components:

1. Downtime due to the actual damage (DT1);
2. Downtime due to irrational delays (DT2); and
3. Downtime due to utilities disruption (DT3).

Author evaluates the building vulnerability, which is combined with a given earthquake intensity to obtain the building damageability. With this DT2 considers irrational components through a specific sequence, which defines the order of components repair, while DT3 depends on the location seismic hazard and on the infrastructure vulnerability. A case study illustrating the applicability of the methodology is provided in the paper. The downtime analysis is applied to buildings with low and medium damage levels. Results from the case study show that total repair time is higher within the medium damage case, because it is predicted. In both evaluations, the downtime is

influenced more by irrational components and it's different within the three recovery states.

Michal Krzeminski (2016), Construction Team Downtime Minimization Model Including Efficiency Coefficients: The literature is reviewed by the author on Construction Team Downtime Minimization Model Including Efficiency Coefficients. In this study author mentioned about the precise description of the mathematical algorithm. The model is designed specifically for flow shop construction scheduling, where schedules are created with the idea that the work are going to be organized in accordance with the Linear Scheduling Method (LSM). Such schedules are utilized within the housing industry in cases of structures which will or should be subdivided and it's expected that the next work processes administered on the subdivisions are going to be organized in accordance with the technological assumptions. Author presented an example of 5 consecutive teams working on 5 subdivisions. The results yielded by the utilization of the algorithm proved satisfactory. There was a slight, about 16%, reduction in the duration, while worker downtime has been reduced significantly, by 42%.

Jawad A. Alsuliman (2019), Causes of delay in Saudi public construction projects: The author researched on the causes of delay in Saudi public construction projects. The author investigates the causes of delays in Saudi public construction projects. The causes of delay were categorized supported the various stages of a construction project, namely

- (1) Factors before the award of tenders,
- (2) Factors during the award of tenders,
- (3) Factors after the award of tenders, and
- (4) General factors.

Author studied on identifying 50 delay factors by conducting a focus group. A questionnaire was administered and distributed to 211 participants from housing industry. The top 20 causes of delay were identified. The findings of the study are intended to provide those involved in public construction projects with appropriate solutions for countering any delays.

Madhav Prasad, Moonseo Park, Downtime model development for construction equipment management: The author researched on the downtime model development for construction equipment management. The author focused on the downtime model to address the issue by explaining the causes and consequences of downtime. The applying of the model framework by the author to the nine roads in Nepal. The impact of DT is explored in terms of its duration and price. The research findings highlight how various factors and processes interact with one another to make DT, and mitigate or exacerbate its impact on project

performance. It is suggested that construction companies got to adopt proactive equipment management and maintenance programs to attenuate the impact of DT. The model provides a framework for tracing the causes of DT and its impact on project performance. In addition, the research is a framework for further work. Future studies are needed to spot the foremost important factors and processes concerning DT.

Miss. Kalpana Gangane, Mr. Dipak Patil (2017), Downtime Cost of Equipment Used In a Construction Industry: The author researched on the downtime Cost of Equipment Used in a Construction Industry. The main aim of the author was to present a sample of how Construction companies deal with equipment downtime cost, and further how they analyze its reduction. The author thoroughly performed the study by conducting a web based survey within construction firms that have at least 200 employees. Author investigated the study and obtained result that shows the downtime cost construction about 23.9% from the total manufacturing cost ratio and also obtained 13.3% from planned production time. Author declared that the shortage of fully integrated models for assessing the downtime costs and frameworks for distinguishing the difference between planned and unplanned stoppages are the most reasons behind the continuation of cost in ascending form. So as results, as the downtime is decreased the overall delay in work due to downtime is decreased which results in the Timely completion of the project.

Sujit Shivaji Jadhav, Prof. Rohit Salgude (2019), Downtime Cost of Construction Equipment: The author researched on the downtime Cost of Construction Equipment. The main focus of the author was to highlight the heavy equipment management practices and downtime in large stone crusher plant them as a framework in constructing a downtime and corresponding cost approach.. The finding reveals that, to achieve success in downtime identification, plant manager must view their practices on equipment management as an integration of multiple feedback processes, which are inter related and interdependent with downtime. Author mentioned the objectives of the study mentioned below,

1. To identifies various reasons of failure of construction equipment
2. To determine downtime cost of crusher plant by cox and nunally models
3. To minimize downtime cost of crusher plant and hence to increase production.

Further author presents the figure showing the percentage of downtime cost by NUNALLY model,

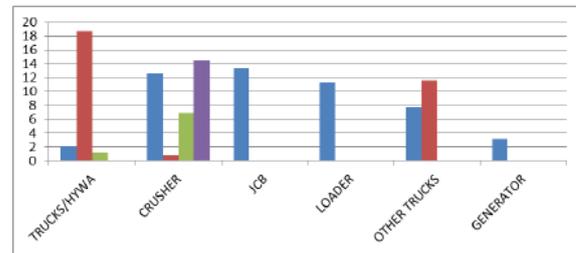


Chart-1: Percentage of DT cost by Nunally Model

Bhushan B. Malusare, Hemant Salunkhe (2019), Implementing a systematic approach towards the downtime cost: The author researched on the implementing a systematic approach towards the downtime cost. The main research of the author was to focus on presenting a sample of how Indian manufacturing companies deal with equipment downtime cost, and further how they analyze its reduction. Author considered a survey of 50 employees. Results obtained from the investigation show that the estimated downtime costs constitute about 23.00 – 30.00 % from the total manufacturing cost ratio, and 13.00 – 15.00 % from planned production time. Author analysis the attempts of decreasing downtime events and thus costs were based on schedule maintenance tactics that supported by overall equipment effectiveness (OEE) tool, as an indicator for affirming improvements The analysis indicates the need for optimized maintenance tactics by incorporating reliability-centered maintenance (RCM) and total productive maintenance (TPM) into companies' maintenance systems. As result, the improvements will emphasize on areas with less cost saving opportunities. This will affect the assembly efficiency and effectiveness which reciprocally has its influence on costs and thereby profits margin.

Some of the objectives were mentioned by the author in this study:

1. To study different methods used for analyzing the downtime.
2. Investigating sites and to check how they deal with the downtime.
3. Offering suggestion for minimizing the downtime and effective utilization of equipment's.

M.Manikandan, Prof. M. Adhiyaman, Dr.K.C.Pazhani (2018), A study and analysis of construction equipment of management used in construction projects for improving productivity: The author researched on the analysis of construction equipment management used in construction projects for improving productivity. Author aimed was to elevate the benefits of implementing total Productivity. While purchasing, leasing or renting the equipment, and guide in optimizing the profitability. Author research on the utilization of the machines and match their capacities to specific project requirements. The time and cost of project is most important constraint for the success of project author acquired the data from equipment rental

companies, construction companies and multiple construction projects. The equipment's show almost 81.5% of producing system. This research work revealed various factors of machinery management. Factors causing cost within the construction projects were ranked on the idea of Relative Importance Index (RII). Author considered five factors identified that shows equipment breakdowns, maintenance of equipment, insufficient number of equipment, performance and efficiency of equipment and inadequate modern equipment systems.

Abubaker Shagluf; A. P. Longstaff; S. Fletcher, Maintenance Strategies to Reduce Downtime Due to Machine Positional Errors: The author researched on analyzing the Maintenance Strategies to Reduce Downtime Due to Machine Positional Errors. Author focused the aim to analyze the increase wasting of the equipment's in industry. To maintain machine tool, an appropriate technique needs to be finalized by the author that helps in managing the hidden costs associated with production losses. Author used Total productive maintenance (TPM) is a maintenance program that involves concepts for maintaining plant and equipment effectively. The study explains review on the maintenance management to find out perfect decision to overcome the wasting of productive equipment's. Author further improves the manufacturing performance and determined on how they could be applied to reduce downtime due to inaccuracy of the machine. Lastly author mentioned that the work which redefines the role of maintenance management techniques and develops a framework to support the method of implementing a predictive calibration program as a prime method to supporting the change of philosophy for machine calibration deciding.

Prajeesh. V. P , Mr. N. Sakthivel (2016), Management of Equipment & Machinery in Construction: The author researched on the Management of Equipment & Machinery in Construction. In this author studied the management of equipment's practices in Construction Industry and to present the most popular practices of the contractors and to compare the equipment management policies with a Case study of a construction industry. Author managed to utilize the project management in construction regarding labor, materials and equipment. And the selection of the acceptable type and size of construction equipment often affects the specified amount of your time and energy and thus the job-site productivity of a project. After this author collected data on surveying questionnaires by dividing it into three grades of contractors for finding possible significant differences in contractor's practices. The results on findings analyzed by the author that the conducted survey of questionnaire show significant answers related to the equipment management practices.

Rodrigo S. Lopes, Cristiano A.V. Cavalcante, Marcelo H. Alencar, Delay-time inspection model with dimensioning maintenance teams: A study of a company leasing

construction equipment: The author researched on Delay-time inspection model with dimensioning maintenance teams. This study probably enhances the system of company with acquiring the construction equipment on lease. Author analyzed that the builders can lease equipment's where the responsibility of equipment's is totally on the builders to maintain in a good way. The maintaining of the equipment's needs to be done in systematic estimated budget. The main aspect of the author was to propose a policy for the establishment of inspection times for preventive maintenance for which the number of maintenance. The result declares that it is possible to schedule the maintenance of the equipment's by conducting inspections thoroughly. With this the model developed, the decision maker can measure the alternatives of the teams in terms of cost. The decision maker can also design the team to attend to an established service level, thus ensuring maximum maintenance time.

Ilias Naskoudakis, Kleopatra Petroutsatou (2016), A Thematic Review of the Main Research on Construction Equipment over Recent Years: The author researched on a thematic review of the main research on construction equipment over recent years. Author aimed to research studies on construction equipment. Many topics were discussed and analyzed, and various conclusions have been reported. Author analyze was done by the author on construction machinery through a systematic database that optimize the productivity and automation. Author obtain that this paper will facilitate future researchers to develop a body of knowledge of progress on construction equipment and its potential functions and provide future research directions on this issue.

The conclusions made by the author regarding this study are mentioned below:

1. The academic research work regarding CE over the last decade has focused on the following thematic areas:
2. Optimization; Maintenance/Downtime; Productivity; Operator's competence /H&S; Robotics/Automation; Innovation; Environment.
3. The themes cannot be viewed as discrete items regarding the interrelationships between them.
4. The areas on which the construction equipment industry has currently focused are embraced by the academic research community and vice-versa.

6. METHODOLOGY

The data collection for the study involved two stages. The primary data was gathered through a questionnaire survey targeted at some contractors, clients, and consultants in construction projects in Pune and some of the local tradesmen's and businesses. The secondary data were obtained from the literature. Using this approach, some of the causes that are helpful in analyzing the impact of Equipment management on the productivity will be identified. A questionnaire is then developed to assess the

perceptions of clients, consultants, and contractors, locals on the relative importance of causes and effects of factors in the Pune construction industry. Respondents will be asked to rank the questions from one to five based on their importance like very low, low, medium high and very high. Relative importance index was used to determine the relative significance and ranking of the causes

The data has been collected by interviewing the officials of the construction industry. The study has been broadly undertaken as follows:

- Identified the projects, which are emerged as huge landmarks in the Pune region
- Study all the available Historical cost outcome, estimates, types of equipment used and work procedures in detail and collected all the relevant data about the project.
- Analyzed the data obtained and compared the costs and actual estimates the builder and locals has gained from the purchase and maintenance of equipment
- Examined the reasons for the impact through either personal interviews or questionnaires.
- Listed out all the shortcomings.
- Identify the recommendations for possible negative impacts through a general survey of opinion from Consultants and Contractors and suggest the possible remedial solutions.

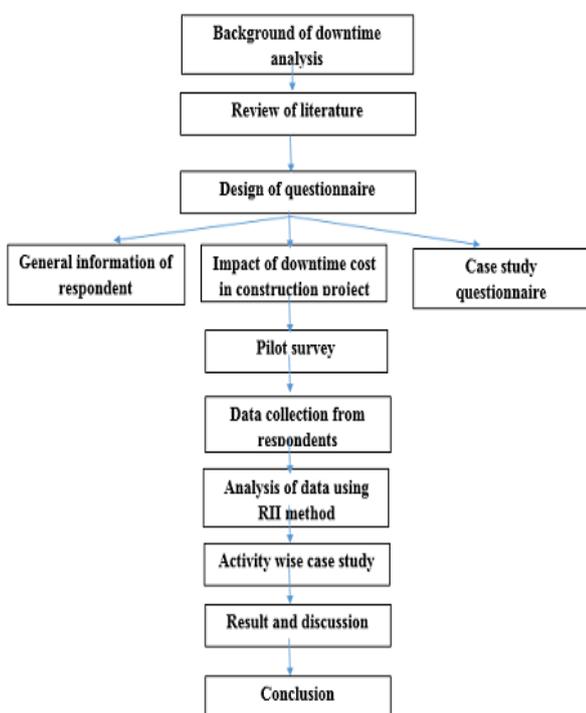


Chart-2: Flow chart

7. RESEARCH GAP

From the available literature review it is noted that there is no significant research been done to analyze the impact of Equipment management in construction industry of Pune in terms of its productivity effects. Pune is a developing city where there are multimillion projects going on simultaneously and contribute to the major share of employment for the human resource. With this consideration, work is undertaken to analyze the downtime cost of the equipment's and machineries in the city in Pune area by MSP and propose recommendations to improve the performance of construction industry to cope with the probable negative impacts.

8. CHOICE OF STUDY AREA

The study was carried out within the city of Pune, Maharashtra. The choice of the location was based on three main factors:

- Pune is currently experiencing a high concentration of multi-million physical development projects (PDP) compared to other parts of the country both by private developers and government agencies.
- the current urban renewal projects that have either been completed or are under construction have a complete team of various stakeholders that are responsible for analytical causes that was useful to the study and
- Most of these projects were being financed by banks and other development partners coupled with the high level of investments in them; the developers are under pressure to complete on time, within budget and to the desired quality so as to put them to use immediately to get quick returns to service the loans and therefore time is of great concern to the developers

9. SURVEY WORK AND DATA COLLECTION

The data collection to Productivity as the primary objective for assessment of the importance of equipment management in the construction industry will be done through a survey by explorative questionnaire to the respondents involved in construction firms and small business holders in various regions in the central Pune region of India. The questionnaire will be designed so that respondents can give the rank to their answers based on the LIKERT scale. The analysis of these data will be done by RII method and using Microsoft Excel.

For data collection, we have considered the following sites in Pune. They are a residential project site as well as infrastructure which taken as a case study.

Table-1: Study Population

Organization	Project	Address	Selection criteria
Capacite infraproject ltd	Phoenix market city	Wakad	Internship site
Sahyadri associates	Commercial complex	Wadgaon bk	Random
Manoj mandhare and associates	Residential complex	Katraj	Random
Norvica realities pvt. Ltd.	Residential complex	wakad	Random
Bhagirath Narayan construction	Industrial complex	Bhosari	Random
R k Buildcon	Residential complex	Bavdhan	Random

The research will ensure that both local tradesmen and well trained educated contractors constituted the study population. The purpose of this survey is to collect information regarding the use and maintenance methods of the equipment's adopted by the industry and to know the perception of the employees and owners regarding the economics of the purchase or sell of equipment.

10. SURVEY PLANNING

For the research study, personalized interviews will be conducted to perform the survey questionnaire. Collecting general information and information critically needed to analyze the downtime cost of the equipment's and in Pune is the basic aim of the survey. The purpose and approach used in the survey was fully explained to the respondents. Guidelines will be provided to the respondents to ensure that the procedure is followed properly to reduce errors. During the survey period, some oversights will be provided to help ensure the process is going smoothly and consistently. The data will be stored in order to maintain confidentiality, and the output will be received from the Group Discussion Center (GDC) in the form of electronic mail, which included raw data sheets, summary sheets, and computer databases. Results included the overall statistics as well as individual statistics.

11. QUESTIONNAIRE DESIGN

This research has implemented field survey methodology to collect information for downtime analysis of construction equipment's and machineries and its profitability to the construction industry. To identify the main issues and methodologies for analysis, literature reviews and case study analysis are carried out. After that, a questionnaire is prepared. The designed questionnaire will be randomly

distributed to major construction parties (owner, consultant and contractor) in different sites. For each factor, the respondents were requested to answer the severity impact of it on the time, cost, and duration and life cycle costs. A five-point scale of 0 to 4 k is considered for evaluating the impact of each factor. These numerical impact values are assigned to the respondents' rating:

- 1 Very Low; strongly disagree
- 2 Low; Disagree
- 3 Medium; unpredictable
- 4 Good; Agree
- 5 Very good; strongly agree

In the structured part of the questionnaire, 58 questions are drawn which were listed in 6 respective categories.

11. QUESTIONNAIRE CONTENT

The questionnaire included six parts related to the factors that are critical aspects to analyze the impact of Equipment management in Pune.

Parts of the questionnaire are:

- Equipment profitability
- Development of project
- Rate of the service done by the equipment according to the market rate
- Equipment analysis
- Equipment profitability
- Factors related to owner

12. CONCLUSION

In this paper, methods are presented and discussed in detail used in the investigation of the impact of downtime of the machines used. This paper describes the methodology in detail used for the study. The topic has been introduced, the literature has been reviewed, and the basic model has been defined. In continuation wherein the structural and statistical issues concerning the data will be discussed and analysis of the case studies will be carried out.

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