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# Impact of Construction Equipment Downtime in Indian Construction Sector

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***Abstract*: Equipment plays a very important role in construction industry as it allows for speedy completion of project. As sites are becoming more and more equipment intensive, it is necessary to have an equipment management policy which keeps the equipment in acceptable condition. Breakdown of equipment can cause huge cost to the contractors and delay the schedule. Literature review on breakdown of equipment and its impact has brought out lot of issues in construction industry.**

**Concreting process at residential tower site was observed to understand the working of equipment. Batching plant and Concrete pump were identified as two of the critical equipment at site. Concrete pump had a very high breakdown rate in comparison to other concreting equipment. Failure mode and effect analysis (FMEA) on equipment breakdown showed that failure of electrical nature posed higher risk than any other failure in batching plant. Similarly, in concrete pump choking of concrete in steel pipes were given a high risk priority. Analysis of working hours of equipment showed that transit mixer and pumping equipment worked in a specific proportion to the batching plant working hours in a given site. Consequential cost for breakdown of batching plant was found to be twenty-four times the cost re-ported at site. Maintenance policy of equipment was analyzed to understand issues in data collection and accounting methods at site.**

***Keywords*: Construction equipment; batching plant; Failure mode and effect analysis; Maintenance policy.**

## 1. Introduction

### *A. Background*

Historical records show that the first Mechanical Construction Equipment was developed in the latter part of the last century (Larkin and Wood, 1975). Since then, Mechanical equipment have replaced animal drawn equipment used in construction projects. The need for proper management of equipment was evident even in these early stages of construction equipment history. Management accounting and cost techniques were introduced to deal with construction equipment. Construction equipment management includes areas like acquisition, financing, selection, maintenance and replacement of equipment. Some of the research initially carried out was to formulate mathematical model for replacement analysis of equipment (Taylor, 1923). Following the work of Terborgh many researchers such as Harris & McCaffer (1982), Collier (1984), Peurifoy & Ledbetter (1985) formulated cost minimization re- placement models specifically for construction equipment. Most of these models considered that the owning and the operating costs of a particular machine, were the only important variables in making the replacement decision. Douglas (1968) introduced a model considering another variable, the profits from the equipment, and also the different objective of maximizing the profits instead of minimizing the costs. Vorster & Sears (1987) proposed a new model considering important factor, the 'downtime cost', to the replacement analysis to make it more realistic. All the previous replacement models have not been widely accepted by construction equipment companies because these models have ignored practical factors affecting the actual replacement decision of equipment.

### *B. Need for study*

Indian construction industry is increasingly getting mechanized. This is evident from the fact that the Sales for top six listed construction equipment companies in India rose at a CAGR of 14.1 per cent over the last five years (FY08-12) as shown in Figure 1. In FY12, sales grew 12.4 per cent to reach USD 2,160 million. Total sales of the construction equipment industry stood at 54,162 units in FY11 as shown in the Figure 1.2.


Fig. 1. Sales for top six listed construction equipment companies (Indian Brand Equity Foundation, March 2013)

### *C. Research objectives*

The main objective of the study is to assess the impact of downtime of construction equipment on construction project

Sub-objectives are as follows:

- To identify the factors causing Downtime of different construction equipment
- To identify major failures in concreting equipment
- To quantify the Downtime cost and its impact on project performance
- To understand the issues in breakdown and maintenance records of equipment.

*D. Scope*

The study includes equipment involved in concreting process namely batching plant, concrete pump, transit mixer and wheel loader/backhoe loader only. The site visited was high rise residential project where structural and concreting work was underway. Mini- mum concrete production of 50 m3 was being done every day. The site has an On-site batching plant having a minimum production capacity of 30m3/hour. Issues regarding breakdown of equipment and its maintenance were done through inter- view with plant and machinery in-charge at site.

## 2. Literature review

Renata Stasiak-Betlejewska, Marek Potkany et. al. (2015) Solid appraisals of development expenses and calendars introduced by contemporary development organizations, their specialists and providers at the season of undertaking endorsement are critical for legitimizing a task on monetary ground and for arranging the methods for financing it. The monetary effect of a development cost invade is the conceivable loss of the financial legitimization for the undertaking

Tatyana Simankina, Jasmina Ćetković, NataliaVerstina, Evgeny Evseev et al., (2017) Economy emergency altogether influences fundamentally the undertaking cost administration. The article thinks about the issues of task administration in the field of lodging under states of economy emergency. Venture spending plans are lessened, their common impedance develops and structure of dangers changes. Evidently, particular methodologies are required to be created to improve the costs and certification the task usage inside the affirmed spending plan. There is viewed as residential and remote involvement as far as task cost administration with association of BIM advances.

Simon Ville, Olav Wicken et al. (2013) Australia and Norway have accomplished present day levels of improvement as asset based economies, accordingly keeping away from the purported asset revile. Their capacity to accomplish this laid vigorously on rehashed enhancement into new asset items and ventures. These procedures depended to a great extent on development, affirming the nearby ties that have existed between asset based businesses and learning creating and spreading parts of society. We build up an asset based expansion show that investigations the connection between "empowering Sectors" and asset businesses and apply it to the authentic experience of the two nations.

Flore bridoux et al. (2010) This paper broadens the asset based perspective of the firm to give a review of the associations amongst assets and rivalry. In particular, it builds up a calculated structure clarifying upper hand and execution that consolidate the asset based perspective of the firm and Porter's way to deal with aggressive condition. Based on this structure, it indicates how firms go after assets and may utilize their assets to contend.

## 3. Research methodology

This chapter discusses the methodology adopted for conducting the study. Figure 3.1 gives a schematic representation of the research methodology. In the initial stages, avail- able literature on construction equipment was studied to find issues related to breakdown and its impact on the construction project. Some of the gaps in literature were identified and objectives were formed based on the observation made in literature review.

As stated in the objectives, the project can be divided into three parts, which were worked upon simultaneously.

- Major equipment used in concreting process was identified and major types of failures for the equipment were mapped. In-depth analysis of Batching plant, Concrete pump, Transit mixers and Wheel loader was performed.
- Failure Mode and Effects Analysis was carried out to identify and prioritize potential equipment and process failure.
- To understand the impact of breakdown of equipment involved in a concreting process, previous data on productivity, rent of the equipment and time taken to complete the process was collected. Maintenance records of equipment were observed and the maintenance practices followed at site were observed.

*A. Site visit*

Residential tower construction site was visited to study the concreting process. The criticalities of breakdown of equipment in the site were studied. Production data and the working hours for batching plant, wheel loader, concrete pump, boom placer and transit mixer were taken to understand its role in concreting. Work breakdown report of the site was collected and P&M personnel were interviewed regarding the consequences of breakdown at site.

In the five years before 2004, Indian development was between INR 20,000 and 30,000 million1 yet with an ongoing sudden development to around INR 200,000 (Majie and Punia 2004). With the sudden development in development movement in the nation, the greater part of the real associations has generous ventures to execute. With globalization, expanding rivalry and consciousness of customers, there is a necessity to convey extends effectively and develop the associations (Ahuja 2007).

There has been some exploration in regards to the condition of the Indian development industry however next to no is

identified with venture administration as a whole. These incorporate Koehn and Ganapathiraju (1996), who talk about the status of the business, especially as far as the development forms in creating nations, for example, India being work concentrated activities, with the most recent and propelled development innovations just accessible to not very many temporary workers. As far as wellbeing most mischances in the Indian development industry happen because of poor instruction and preparing, and carelessness and obliviousness with respect to the specialist and administration (Koehn et al. 2000).

The discoveries of the study directed by Iyer and Jha (2005), then again, give some sign of the elements influencing the cost execution of Indian development ventures, including the degree of: unfriendly climatic and financial conditions; troublesome task particular characteristics; top administration bolster; checking, input, coordination, strife and information of the undertaking members; and hesitance to settle on convenient choices. Of these, coordination among venture members was observed to be the most huge all things considered, impacting cost execution.

## 4. Downtime of equipment

Many factors affect the productivity of construction equipment. Some factors may be identifiable prior to construction, while others may not be as evident enough and affect equipment productivity negatively. Downtime (DT) caused by non-availability of equipment and equipment breakdown is among the most common unanticipated factors that have a non-trivial impact on the equipment productivity and project and organizational performance (Edwards et al., 1998; Elazouni and Basha, 1996).

One method of assigning downtime cost to a particular year of equipment life was to use the product of the estimated percentage of downtime multiplied by the planned hours of operation for the year multiplied by the hourly cost of a replacement or rental machine (Nunnally 1977). But this approach did not recognize the impact of breakdown on other resources associated with the equipment.

Vorster and Sears (1987) suggested the concept of failure cost profiles (FCP) for his model on replacement and reassignment of construction equipment. The total cost of the team affected by the failure is produced by means of a carefully defined failure-cost pro- file for a given type of machine in a given field construction which takes into account the cost of resources associated to the failed equipment.

Vorster and De La Garza (1990) further refined the FCP concept by developing a cost model designed to quantify the intangible (consequential) costs associated with lack of availability and DT (LAD). However, in complex linked-machine production systems, it is exceedingly difficult to measure Consequential costs with precision.

There has been limited research to investigate the impact of Downtime on construction projects. DT models available cannot be applied directly as equipment contractors face a number of problems related to equipment management like lack of expertise and generally poor cost accounting practices. These kinds of equipment management-related factors, along with the working environment, affect the Repair and DT costs.

### *A. Factors causing downtime*

Site-related factors

Following are the Site related factors which influence downtime of equipment

- *Poor working conditions* - Concreting equipment like transit mixer need to haul concrete over long distances. Due to Bad road conditions and grade of road, it will exert immense stress on the engine and the equipment may deteriorate rapidly causing breakdown more often.
- *Uncertainty during equipment operation* – Equipment may be operated in differ- ent environmental conditions which might causes greater risk of equipment breakdown (Arditi et al., 1997; Edwards et al., 1998).

The location of the site, limits the type and size of equipment that can be trans- ported to the site (Day and Benjamin, 1991). Also, the remoteness of a construction site may affect the repair time of equipment by affecting communication and the prompt procurement of parts.

The contextual investigation strategy is most reasonable for this exploration, because of its reasonableness in inspecting procedures and models. Ventures are the essential focal point of task administration, and development is for the most part performed on venture hierarchical level. Notwithstanding that, the contextual analysis will encourage the reiteration of the structure among other development and recovery extends, including and changing the contributions as indicated by the materials utilized and their regular assets.

The final result of the system is a cost administration show that records for the characteristic assets that structures the volume of the development as the primary dry cost. Vitality isn't presented as dry cost, yet as a free asset, since innovation is getting towards free vitality. Additionally, with the computerization of development being under innovative work, it is relied upon to include least human communication inside development forms. For straightforwardness, the layers and the plan blend are introduced on a general scale, and the amounts of materials and normal assets are evaluated generally.

### *B. Downtime and its consequences*

Following literature discuss about the downtime and its consequences.

Downtime causes idleness of equipment and crews, work disruption, activity delays and loss of productivity. Each of the consequences interacts with site management actions, company’s procedure and policies, project-level factors, and crew-level factors etc.

Construction projects are primarily “solution driven” and

mostly focus on minimizing costs and limiting immediate consequences (Mitropoulos and Tatum, 1999). Thus, it is possible that site management may underestimate the actual impact of DT that may evolve from their action in due course. Site management, therefore, should understand the underlying phenomenon of DT and its possible impact on project performance in a systematic way.

*C. Downtime percentage for construction equipment*

The downtime consists of administrative time, maintenance time, and supply delays. Administrative time includes hours necessary to report a machine failure and give work directions for maintenance. The maintenance time is the number of hours required to carry out preventive and corrective maintenance (Komatsu, 1986). The supply delays represent the hours during which maintenance work is not possible, because of the lack of immediate availability of parts and materials necessary to perform maintenance.

Repair History was collected from a construction company having a fleet of construction equipment. The analysis involved was taken from 12 batching plant, 26 concrete pump, 16 transit mixer and 29-wheel loader. The repair history was available for the year 2012 and 2013.

## 5. Total cost analysis of equipment

*A. Consequential cost caused due to breakdown of equipment*

When concreting equipment working in close association with other equipment, breaks down at site, it affects the site drastically. The costs of breakdown can be divided into two broad categories.

- Tangible cost of the labor, materials, and other resources needed to repair the machine
- Intangible, or consequential, costs that arise from the failure like idleness of other equipment, crew idleness, and other factors that impact the organization as a whole

Tangible costs can be estimated using normal cost-accounting methods. Consequential costs present an entirely different problem in that they cannot be assessed with any degree of certainty except under very rigid, well-defined circumstances. To understand the impact of breakdown of batching plant, in a construction site and the cost of breakdown caused by the idleness of other equipment, following technique of utilization ratio was utilized. For calculating the costs due to idleness of equipment and crew, following assumptions were made.

- Effective rent of the equipment was calculated as the Internal hiring charges divided over the average working hours of the equipment and not the entire month.
- Breakdown of Batching plant will bring the concreting process to a halt causing idleness of transit mixer, concrete pump, boom placer and spreading operation.

Internal hiring charges for construction equipment were obtained from the Cost Plan statement of the company. Average working hours for 3 months of equipment (having the same configuration) was calculated. To calculate the loss of Internal Hiring Charges (IHC) cost for equipment during breakdown, internal hiring charges per working hour was calculated. As shown in Table 8.1, this value was then multiplied with the utilization ratio for each of the equipment and added up.

*B. Consequential cost due to idle labor*

Similarly, to calculate the loss of labor, due to idleness of equipment during breakdown, labor cost per working hour is multiplied with utilization ratio of equipment for which operators and helpers are required. The total value obtained is the loss of labor in the event of breakdown of batching plant. Batching plant had 2 operators for two shifts, 2 scraper operators and 2 helpers. For transit mixer, concrete pump and wheel loader, 2 operators were available. Spreading operation at site involved 5 members of pipe gang and 10 masons. Each operator was paid Rupees 15,000 per month and helpers were paid Rupees 10,000 per month. Pipe gang crew had a salary of Rupees 9,000 per month.

The total cost obtained by both IHC loss and labor loss is Rupees 7,868 per hour for Batching plant breakdown. The IHC loss and labor cost for Batching plant, being the highest i.e. Rupees 1,553 per hour.

In the current accounting method, the IHC is distributed across the entire period of 26 days and hence the IHC loss for Batching Plant breakdown is reported very low. Considering 26 working days in a month and 12 hours per day the IHC loss is as calculated.

IHC loss = Rupees 679/ hour

As seen from the analysis for the site, it is evident that breakdown of batching plant, has a very high impact on site. The consequential cost of breakdown is around Rupees 8000 per hour which is very high, when compared to cost captured at site based only on the internal hiring charges of the particular equipment which broke down.

## 6. Conclusions

Construction equipment plays a very important role in construction projects. It helps the project to be completed on time and with a predetermined quality level. As construction sites are becoming equipment intensive, breakdown of equipment can cause a huge impact on the sites progress. The concreting process for residential construction sites were extensively studied to understand the working of equipment, working conditions and maintenance of equipment.

Previous literature on construction equipment breakdown and equipment management was studied to find out factors causing downtime and its impact on construction site. Factors causing downtime were classified into site related factors, equipment related factors, Crew-level factors etc. It was found that literature on major failures in concreting equipment like

batching plant, concreting pump, transit mixer etc. was not available. Hence the repair history from a leading construction company for the past 2 year was analyzed to identify the major failures in concreting equipment.

To understand the impact of failure of concreting equipment at site, failure mode and effect analysis was conducted. Plant managers were asked to give rating for each failure mode for detection, occurrence and severity scale. Failures modes were judged based on risk priority number.

Analysis of working hours of all the concreting equipment involved at site was done to understand the dependency of Batching plant to other equipment. This was useful in calculating the consequential cost for batching plant breakdown. Consequential costs calculated and found to be 12 times higher than actual cost reported at site.

The study focused on identifying breakdown issues in concreting equipment like Batching Plant, Concrete pump, Transit mixer and wheel loader. It also focused on understanding the concreting process and dependency of one equipment over other. Failure mode and effect analysis was performed to find the failure modes having major risk. Issues in maintenance policy of equipment were brought out.

Factors causing Downtime of equipment

Based on literature study done, following factors were found to cause equipment down- time in different ways.

- Site-related factors and Crew-related factors
- Equipment-related factors
- Company procedure and policies
- Project- level factors
- Site management actions.

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