

Development of Conceptual Framework for Idle Construction Equipment Impact Assessment on Infrastructure Projects

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Abstract: A well-developed infrastructure is a foundation for growth in any country. Infrastructure provides the basic support system for other sectors of the economy expanding capabilities everywhere. Indian Infrastructure sector is going through revolutionary phase, as USD 1 trillion investment planned in 12th five year plan, according Planning Commission – Government of India. The role of construction equipment is very important to face challenges of 21st century India's infrastructure development.

The research paper intended to investigate the equipment management practices in Indian construction Industry. As procurement of major construction cost 36 percent of total construction project cost. Hence effective equipment management plays important role in infrastructure project management. In this research paper, we have analyzed causes and impact of idle construction equipment on infrastructure project. We have prepared a questionnaire and conducted survey on various infrastructure project. Major finding of the research is that, many time equipment are idle due to breakdown and work front unavailability. Based on survey result, we have prepared a conceptual framework for idle construction equipment impact assessment on Infrastructure project. Tools such as critical path method, float and sharing of resources discussed to mitigate impact of effect idle construction equipment on infrastructure project.

This research is of value for better understanding practices and problems relating to equipment management at infrastructure project. The study also highlights the practices that can reduce idle time construction equipment,

Key words — Construction equipment, equipment management and infrastructure project management

I. INTRODUCTION

Infrastructure construction business is a sector that depends primarily on high utilization of construction equipment. Equipment is thus very important factors for enhancing contractor's capability in performing their work more effectively. By utilizing machinery, an extensive volume of work can be completed in a shorter period of time and within the project schedule.

Idle equipment caused by idle equipment has non-trivial impact on the performance of construction projects. Despite its importance, only few construction companies pay attention to the impact of idle equipment and take managerial action to reduce it. Causes and consequences of idle equipment - especially in the context of developing countries is rarely explained in earlier research. Idle equipment is measure cause behind work hindrance at project, resulting in delaying schedule, producing panic situation to recover the

time lost. This makes contractor to increase the execution speed, finally resulting in lack of quality construction.

In this paper, we identify the generic factors related to idle equipment, and its dynamic consequences. In addition, the need for managerial efforts to minimize the impact of IDLE EQUIPMENT is highlighted, demonstrating how various factors and processes interact with each other to create down time of construction and mitigate or exacerbate its impact on the performance of a project. The framework is presented to assess the causes and impact of idle construction equipment on infrastructure project. Data collected from various engineer/executive from infrastructure project over a 2 month period illustrate the causes and impact of idle equipment on infrastructure project.

We have analyzed the causes and mitigation measure by project management techniques.

II. IDLE CONSTRUCTION EQUIPMENT FACTOR ANALYSIS

In this section, we have analyzed the impact of idle equipment qualitatively, with an emphasis on construction dynamics caused by idle equipment. We analyzed the dynamic consequences of idle equipment that may unfold during construction operation.

A. Site factors

Site-related factors are poor working conditions, uncertainties during equipment operation, and location of the site. First two factors may affect the performance of equipment. For example, difficult and rugged terrain may cause equipment to deteriorate rapidly, thereby causing sudden failure. Proactive action on the part of a contractor can have significant effects on reducing. Contractors may not aware, however, of the site conditions, either because of a lack of data or proper site investigation. The remoteness of a construction site may affect the repair time of equipment by affecting communication and the prompt procurement of parts.

B. Equipment factors

Equipment related factors are equipment age, type, quality, complexity of operation, and degree of usage. A organization's procedures and policies and site management actions can have significant influence on the selection, use and operation of equipment. Site management should have proper knowledge about equipment in terms of its capacity, complexity and technical suitability for use under the given conditions.

C. Operator-level factors

These factors are related with human aspects of Operators are involved in the equipment maintenance, operation, and production process. Operator's skill is one of the most important factors and it affects the operator's performance and the direct cost of idle equipment. In addition, misuse of equipment, induced by the negligence of the operator and lack of proper training and technical knowhow on the part of equipment supervisor results in increased frequency and cost of idle equipment. One more important aspect that may have impact on idle equipment is through morale, motivation and fatigue of the Operators. These conditions may occur when site management attempts to increase the work rate by extensive use of overtime and placing pressure on Operators. After a certain threshold level,

both these factors can have negative effects on productivity by affecting fatigue and morale.

D. Force majeure

Force majeure includes the events that are unanticipated by project participants, particularly those related to natural calamities and events. Incidents such as floods, landslides, vandalism, and accidents. Force majeure events may result in delays in equipment maintenance and effect on project performance. Contractors should anticipate some events, such as a heavy rainfall season, and take the necessary precautions to reduce their likely impact on idle equipment.

E. Organization's Policies

This category includes organization's policies towards equipment management decisions and may include factors such as maintenance policies, replacement decisions, inventory management and control, standby repair and maintenance facilities, and procurement systems. All the companies not able to justify the costs of carrying an inventory of spare parts, which might also be influenced by a number of available jobs on hand. An organization's policies may also reflect the corporate-level strategy and existing market conditions. In addition, maintaining a proper fleet of equipment can be of strategic importance to an organization in cases where the award of a contract is based also upon the condition and availability of equipment. Equipment management procedures and policies vary organization wide. Thus, they can have different implications on idle equipment.

F. Infrastructure Project level factors

Infrastructure project-level factors - such as the availability of spare parts, resources, and rental facilities, substitute equipment on hand, the location and sophistication of a workshop, and other project-specific requirements - vary considerably and are related to idle equipment. Construction Site management can have a certain degree of effect on some of these factors, but mostly they are influenced by other causes, such as a company's action plan and procedures, the national and international market conditions, requirements of the project and, to some extent, site-related factors. Construction Site team, for instance, may have difficulty in getting spare parts and materials to repair the equipment. Furthermore, any delay in the time required for skilled mechanics to arrive on the site may paralyze the work. Furthermore, arrival of substitute equipment on time is

another key challenge to projects that are located in remote parts of a country. Specifications and contract documents may specify the types and sizes of equipment to be used. Moreover, the availability, location and sophistication of a workshop can have considerable influence on idle equipment.

G. Site management actions

Site management may influence idle equipment in a number of ways, such as substituting broken equipment, waiting for broken equipment to be repaired, adding or changing resources, accelerating activities, transferring operator to other operations or sites, and changing the order of work. Each of these actions, when implemented properly, may reduce the impact of idle equipment; if the selected course of action is not appropriate or is implemented in an improper way, however, it may aggravate the situation. Consequently, an infrastructure project may suffer loss of productivity. Furthermore, the selection of interdependent equipment is also important to ensure economical construction operations and to idle time.

III. IDLE CONSTRUCTION EQUIPMENT IDLE IMPACT ON INFRASTRUCTURE PROJECT

In this section, we have done the qualitative analysis the idle construction equipment impact assessment infrastructure project.

A. Infrastructure Project time overrun

Idle construction equipment results in delaying the particular construction equipment associated activity, which also delay the subsequent activity, which is depending upon the finish of earlier activity. Finally there is very serious effect on project schedule, resulting infrastructure time overrun.

B. Infrastructure Project cost overrun

Idle equipment leads to infrastructure project cost overrun. Cost associated with repairing of breakdown equipment. Also cost includes the cost incurred for idle time of human resources because of idle equipment associated with breakdown equipment as well as dependent equipment that is forced to be idle as a result of breakdown. As equipment fails, wages will continue to be paid to laborers, operators and supervisors who are idle. This effect tends to continue unless substitute equipment is mobilized or the operators are transferred to other infrastructure project sites.

C. Effect on quality of construction

This is the first and most noticeable effect of idle equipment is resource idleness, which, if it lasts for extended periods, would slow down the progress of a project. Slow project progress increases schedule pressure. When project managers are under schedule pressures, they might become distracted from proper supervision and resort to hasty maintenance. This distraction tends to produce a low quality of construction. A PM under high cost overrun and time overrun pressure (due to unexpected idle equipment time and costs) might pay less attention to quality standard of construction work.

D. Cost for substitute equipment

This category of cost occurs only when management decides to substitute the breakdown equipment either from a contractor's own fleet or from an outside agency. In the former case, management still incurs the cost from the contractor because the contractor would have deployed the equipment in other projects or given it to other contractors for rent. If after a particular failure the management decides to rent a piece of equipment that otherwise would not be rented, the associated rental costs should be included.

E. Extra Contractual Cost

Extra contractual costs are costs related to the contractual commitments and clauses agreed on for the particular project and deserve particular importance to the extent they are valid and enforceable. Costs such as liquidated damages, additional claims, and late completion penalties belong to this category. Sometimes, when the project is packaged to a number of contracts with involvement of different contractors, further costs may be incurred when idle equipment in particular work interrupts the works of other entities.

F. Loss of labor productivity

Loss of labor productivity caused by idle equipment can arise because of interruption of work, crowding of workers, extended overtime, accelerated working, learning curve effects, and so on.

IV. RESEARCH METHODOLOGY

Telephonic interview and survey questionnaire with project management professional used to determine the causes and impact of idle construction equipment associated with infrastructure project.

Telephonic interview: Mr. Pankaj Lohiya, Senior Planning Manager – TATA Consulting Engineers Ltd highlighted the various issues related construction equipment management in line project performance i.e. safety, quality, time and cost.

Survey Questionnaire: Online survey questionnaire on causes and impact of idle construction equipment on infrastructure projects. Google forms used for online survey, which has saved lot of time and cost for data collection

V. DATA ANALYSIS AND FINDING

Online survey floated to 200 project management professional. 125 project management professional respondent to the survey, i.e. 62.5% response. India's leading infrastructure organization's professional respondent to the survey. Some of the Major infrastructure organizations are:

- ❖ TATA Consulting Engineers
- ❖ Simplex Infrastructures Ltd.
- ❖ National Institute of Construction Management and

Research

- ❖ Gammon India Limited
- ❖ And many more
- ❖ Telephonic Interview:

Mr. Pankaj Lohiya highlighted the importance mechanization in infrastructure project. Equipment breakdown and work front clearance are the major reason for idle construction equipment. Idle construction equipment at infrastructure project resulting in time and cost overrun. It also affecting the quality of infrastructure construction

- ❖ Survey questionnaire response result:

Causes of Idle Construction Equipment

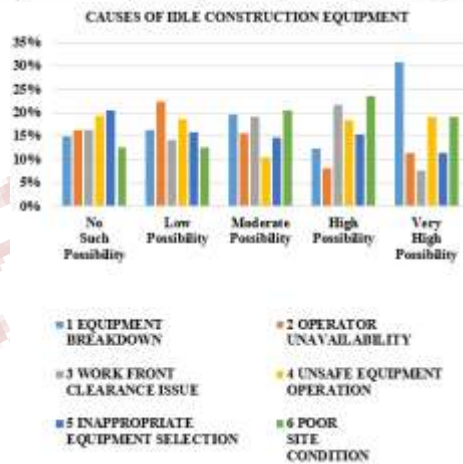
CAUSES OF IDLE CONSTRUCTION EQUIPMENT						
Sr. No.	Causes	No Such Possibility	Low Possibility	Moderate Possibility	High Possibility	Very High Possibility
1	EQUIPMENT BREAKDOWN	24	40	41	12	8
2	OPERATOR UNAVAILABILITY	26	55	33	8	3
3	WORKFRONT CLEARANCE ISSUE	26	35	40	21	2
4	UNSAFE EQUIPMENT OPERATION	31	46	22	18	5
5	INAPPROPRIATE EQUIPMENT SELECTION	33	39	31	15	3
6	POOR SITE CONDITION	20	31	43	23	5

Impact of idle construction equipment

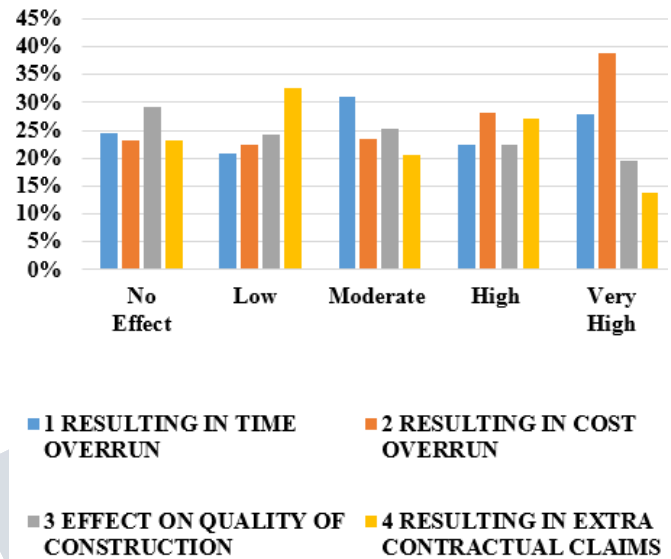
IMPACT OF IDLE CONSTRUCTION EQUIPMENT ON INFRASTRUCTURE PROJECT						
Sr. No.	Causes	No Effect	Low	Moderate	High	Very High
1	RESULTING IN TIME OVERRUN	20	25	53	20	10
2	RESULTING IN COST OVERRUN	19	27	40	25	14
3	EFFECT ON QUALITY OF CONSTRUCTION	24	29	43	20	7
4	RESULTING IN EXTRA CONTRACTUAL CLAIMS	19	39	35	24	5

Survey questionnaire response Interpretation:

CAUSES OF IDLE CONSTRUCTION EQUIPMENT %						
Sr. No.	Causes	No Such Possibility	Low Possibility	Moderate Possibility	High Possibility	Very High Possibility
1	EQUIPMENT BREAKDOWN	15%	16%	20%	12%	31%
2	OPERATOR UNAVAILABILITY	16%	22%	16%	8%	12%
3	WORK FRONT CLEARANCE ISSUE	14%	14%	19%	22%	8%
4	UNSAFE EQUIPMENT OPERATION	19%	19%	10%	19%	19%
5	INAPPROPRIATE EQUIPMENT SELECTION	21%	16%	15%	15%	12%
6	POOR SITE CONDITION	13%	13%	20%	24%	19%



IMPACT OF IDLE CONSTRUCTION EQUIPMENT ON INFRASTRUCTURE PROJECT



CAUSES OF IDLE CONSTRUCTION EQUIPMENT: According to our survey, equipment breakdown is the major reason (31%) behind idle construction equipment. Poor site condition and unsafe equipment operation is the second highest factor (19%).

IMPACT OF IDLE CONSTRUCTION EQUIPMENT ON INFRASTRUCTURE PROJECT: According to our survey major impact of idle construction equipment on infrastructure project results in cost overrun (39%). It also result in time overrun, which is second highest impact (28%). There is not much effect on quality any extra-contractual claims.

VI. CONCEPTUAL FRAMEWORK FOR SOLUTION TO IDLE CONSTRUCTION EQUIPMENT

Idle construction equipment is major problem for infrastructure organization. Following are the ways to mitigate the occurrence and consequences of idle construction equipment:

- A. Breakdown Equipment:** Preventive maintenance of construction equipment. Also maintaining inventory of spare parts for major equipment.
- B. Operator unavailability:** Multiskilling of crew-level staff.
- C. Work Front Clearance:** Idle cost can be minimized by incorporating appropriate clause in contract.

IMPACT OF IDLE CONSTRUCTION EQUIPMENT ON INFRASTRUCTURE PROJECT %						
Sr. No.	Causes	No Effect	Low	Moderate	High	Very High
1	RESULTING IN TIME OVERRUN	24%	21%	31%	22%	28%
2	RESULTING IN COST OVERRUN	23%	23%	23%	28%	39%
3	EFFECT ON QUALITY OF CONSTRUCTION	29%	24%	25%	22%	19%
4	RESULTING IN EXTRA CONTRACTUAL CLAIMS	23%	23%	20%	27%	14%

D. Unsafe equipment operation: Follow standard operating procedure strictly. Ensure Firm ground before equipment installation.

E. Inappropriate Equipment Selection: Proper pre-construction planning.

F. Poor Site Condition: Detailed analysis of site condition before bidding for the contract by physical site visit. Mitigating measure for the same to be incorporate in pre-construction planning.

G. Resource Levelling/Smoothing: This is most appropriate technique of project management, in which we will utilize float availability for all the activity.

H. Sharing of construction equipment: Sharing of resource between various infrastructure projects to minimize idle cost of construction equipment.

VII. CONCLUSION

Research on idle construction equipment is limited. Moreover, the research conducted to date is of little value in illustrating the causes and consequences of idle construction equipment. In addition, it is of limited application in determining the impact of idle construction equipment for any given project. After all, they cannot address the issues involved with equipment management aspects in the context of a developing country where contractors face a number of problems related to equipment. The model presented in this paper has identified generic factors and processes related to idle construction equipment, and portrayed graphically how they may interact to cause idle construction equipment and its consequences. We have also discussed why addressing the impact of idle construction equipment is important and how managerial actions at the company or project level can eliminate, reduce or exacerbate the impacts of idle construction equipment.

We have used data from 125 professional from various infrastructure development organization in India. The variation in idle construction equipment and its impact on different projects reflect the condition of the equipment, the quality of the equipment, the quality of maintenance, the company's operating policies, the location of the projects, and the nature of the work. At the project level, a PM should emphasize timely, but quality, maintenance. Also, a PM must understand the causes and possible ramifications of idle construction equipment while taking any managerial actions in order to avoid the impact of idle construction equipment. Moreover, more studies, particularly in the context of developing countries, are needed to provide insight into

equipment management and to improve the competitiveness of industries.

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