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Review on Delay Factors due to Improper Construction Equipment Management

B. Indhu[1,2] and K. Yogeswari[3]
[1]Research Scholar, B.S. Abdur Rahman Crescent Institute of Science and Technology, Chennai, India.
[2]Assistant Professor, SRMIST, Chennai, India.
[3]Associate Professor, B.S. Abdur Rahman Crescent Institute of Science and Technology, Chennai, India.

(Corresponding author: B. Indhu)
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ABSTRACT: A very common problem affecting the construction industry and hence the economic growth of the country today is 'Delays in construction projects'. Various causes factor in like the extensive use of machines that compete with men and exhibit a huge difference in terms of 'work progress'. On the downside, with every new technological development comes a negative impact. Past studies reveal that one of the important causes for delay is 'improper construction equipment management'. Studies in the past focused mainly on overall construction delay. It was observed that there is a significant lack of research pertaining to improper construction equipment management delay. In course of this study, all delay causes due to construction equipments was extracted from overall delay causes dealt with in past studies. The extracted delay causes are categorized into 8 major key factors. The recommendations to overcome these issues are discussed. Potential future scope has been given to further enhance research in this area.

Keywords: Construction equipment, delay management, improper equipment management, maintenance management.

I. INTRODUCTION

Given the current highly competitive economic environment the need for completing construction projects within the stipulated cost, timeframe and expected performance expectations is becoming increasingly important [1]. Delivering projects as scheduled or not has much to do with earning or losing a profit and/or a return on investment for parties [2]. Although there have been many efforts to increase the productivity of construction and infrastructural projects in recent years, the industry is still suffering due to low productivity growth.

The dynamics involved in most projects entering the construction phase, makes it necessary to revise initial project plans and decisions which may in turn result in potential delays and rework [3, 4].

Due to the technological advancements and the need for faster completion of works, construction equipments are chosen instead of relying on manual labour. These equipments are chosen for its capacity to work on time and to obtain large productivity although there are times when these equipments are also a cause of failure in construction projects.

In order to profit from the usage of advanced technologies, the project managers must ensure the availability of required equipments that can meet the submission deadline of the construction project [5].

Objective:

–To extract the causes of delay due to improper equipment management through literature survey on overall construction delays.

– To categorize these causes under various key factors.

– To provide possible recommendations to triumph over these delay issues.

II. METHODOLOGY

A wide search of journals with the key words 'delay due to construction equipment', 'construction equipment management' and 'delay management' was done from databases such as asce, taylor and francis, springer, and elsevier. Systematic literature review of 95 papers from 1993 to 2018 was assimilated and abstracts were studied. Of 95 journals surveyed 42 relevant papers that listed various delay factors were refined and a thorough study was done. It was found that there is no evidence pertaining to journals of delay exclusively due to construction equipments. Hence research was focused on extracting construction equipment causes from the overall delay causes. The extracted causes were analysed and categorised into 8 major key factors causing construction project delay. Recommendations and future scope have been given to help probe further into this area of research.

III. LITERATURE SURVEY

Inaccurate estimation may result in delay and cost overrun. In most cases delay factors are interrelated. Inaccurate schedule updates also result in inaccurate forecast which may significantly impact resource levelling and manpower estimate [6]. Important delay factors are resources, participants of the project and a group of unpredictable factors. Delays are classified as justified and unjustified causes. Justified causes are faults of the investor and may be subject to compensation and justified but not subject to compensation such as whether conditions. Unjustified causes are faults of the contractor [7]. Examples of delay factors include corruption of government officials, issues clearing imported materials and equipments from

customs, poor labour productivity, security threats to construction sites and theft of equipment, owner cash flow problems, change orders, and unexpected adverse weather conditions [8]. One of the most influential factor for time is unsettled or lack of project funding [9]. While some of the delay causes are dependent on national economic policies, others may be overcome by measures taken by public agencies and contractors [10].

The delays themselves are not always fixed in, when they might have their effects and it is felt to be important that this be recognized [11]. Delays can be avoided or minimized when their causes are clearly identified [12]. Delay analysis methods which are already in practice in construction industries are not appropriate [13]. Hence a proper delay analysis methodology needs to be framed in order to have a clear delay liability allocation where by disputes can be diminished [14]. Delay results in disputes. Better understanding methods are to be developed to reduce disputes during delay claims [15].

Consideration the modern conditions under which the construction company operates in terms of modern crisis and competition, the construction works mechanization becomes actual and it plays an important role in production efficiency increase [16]. Modern and advanced projects which use heavy equipments must perform equipment scheduling and productivity analyses by simulation methods and not just by past record analyses or direct site observation reports in order to reduce significant errors in estimation and avoid delay [17]. The most common construction equipment related delay causes are: shortage in equipment/insufficient numbers; lack of skilled operators for specialized equipment; equipment productivity (efficiency); equipment failure (breakdown); slow delivery (mobilization) of equipment; lack of high-technology mechanical equipment; equipment allocation problems; tool availability; improper equipment; inadequate modern equipment [18]. Shortage of equipment'' factor is the most important factor causing delay in construction projects in Egypt at this category, with a relative importance index equals to 84.256% [19].

Due to the increase in using equipments in various construction activities, planning the maintenance of these equipments has become extremely important as it aids in meeting project deadlines [5]. Machine maintenance is to be done in such a way so as to enable just in time component replacement [20]. It is also common knowledge that maintenance does not receive enough attention in the construction industry especially in developing countries. With poor maintenance, equipment breakdowns happen quite often [21].

The construction equipment causes extracted from overall delay from the past studies is given in Table 1.

Table 1: Construction Equipment delay causes extracted after literature survey.

S.No.	Researchers	Country	Causes of equipment delay
1.	Prasad *et al.,* [22]	India	– Shortage of equipments of required capacity and numbers – Lack of skilled operators for specialized equipments – Equipment breakdown and maintenance problem
2.	Rachid *et al.,* [23]	Algeria	– Shortage in material and high technology equipments – Frequent failure of equipments and material – Delay in manufacturing of special equipments
3.	Kadry *et al.,* [8]	Countries with High Geopolitical Risks	– Issues clearing imported equipments from customs
4.	Oshungade [24]	South Africa	– Shortage of equipment – Equipment breakdowns – Low level of equipment-operator's skill – Low productivity and efficiency of equipment – Unavailability of equipment
5.	Gebrehiwet & Luo [25]	Ethiopia	– Shortages of equipment – Low efficiency and productivity of equipment – Failures of equipment and lack of spare parts – Equipment allocation or mobilization problem – Equipment outdated
6.	Chen, [26]	China	– Shortage of adequate equipment
7.	Durdyev *et al.,* [27]	Cambodia	– Frequent breakdowns of construction plant and equipment – Unskilled equipment operators – Lack of high-technology mechanical equipment
8.	Khlaifat *et al.,* [28]	Jordan	– Shortage of equipment – Failure of equipment
9.	Mahamid [29]	Saudi Arabia	– Equipment shortage – Poor equipment choice
10.	Bagaya & Song [30]	Burkina Faso	– Equipment unavailability
11. 12.	Santoso & Soeng [21]	Cambodia	– Maintenance not receiving enough attention – Equipment idleness due to delay in import of spare parts
13.	Aziz & Abdel-Hakam [18]	Egypt	– Lack of skilled operators for specialized equipments – Lack of high technology mechanical equipment – Lack of tool availability – Short ages in equipment
14.	Głuszak & Leśniak [7]	Poland	– Insufficient necessary equipment at the construction site
15.	Lopes *et al.,* [5]	Brazil	– Non-employment of scheduling maintenance team – Non-employment of corrective maintenance team – Lack of funds for inspection cost – Lack of funds for repairing a defect although the equipment is in

			working condition – Overload of the equipment – Inadequate installation – Normal wear for age – Incorrect actions in maintenance operations
16.	Gunduz *et al.,* [12]	Turkey	– Equipment allocation problem – Frequent equipment breakdown – Improper equipments – Inadequate modern equipment
17.	Gardezi *et al.,* [31]	Pakistan	– Equipment unavailability and failure – Least use of high tech tools/equipment in construction
18.	Chan & Kumaraswam [32]	Hong Kong	– Shortage of equipment
19.	Aziz, [19]	Egypt	– Low efficiency of equipment – Shortage of equipment – Slow mobilization of equipment
20.	Doloi *et al.,* [33]	India	– Lack of skilled operators for specialized equipments – Inefficient use of equipments – Lack of proper equipment planning – untimely mobilization of equipment leading to idling of resources
21.	Ghoddousi & Hosseini [34]	Iran	– Lack of proper tools and equipments on-site – The major part of equipments is fairly old and purchase of new equipments is next to impossible for many companies due to their prohibitive price
22.	Kazaz *et al.,* [35]	Turkey	– Poor maintenance of works, materials, and equipment
23.	Khoshgoftar [36]	Iran	– Equipment Unavailability and failure – Lack of suitable planning for resources, equipment and labor
24.	Al-Khalil & Al-Ghafly [37]	Saudi Arabia	– Shortage of equipment required – Failure of equipment – Inadequate equipment used for the works
25.	Al-Kharashi & Skitmore [38]	Saudi Arabia	– The required equipments and tools are not available
26.	Enshassi *et al.,* [39]	Palestine	– High equipment cost – Low quality of equipment and personnel
27.	Toor & Ogunlana [40]	Thailand	– Shortage of equipments
28.	Faridi & El-Sayegh [41]	UAE	– Shortage of equipment – Failure/breakdown of equipment
29.	Assaf & Al-Hejji [42]	Saudi Arabia	– Equipment breakdowns – Shortage of equipment – Low level of equipment-operators skill – Low productivity and efficiency of equipment – Lack of high-technology mechanical equipment
30.	Kaming *et al.,* [43]	Indonesia	– Equipment shortages – Inaccurate prediction of equipment production rate

IV. DISCUSSION

The above construction equipment delay causes mentioned in Table 1 confirm 76 delay causes extracted from 29 different journals. It has been identified that out of these 76 delay causes, there are few causes which are very common in most of the countries and has repetitions. A ranking with respect to the most repeated causes is given in Table 2.

Table 2: Ranking based on most repeated common causes.

S.No.	Causes of equipment delay	Source	No. of repetition	Ranking
1.	Shortage of equipment	[19, 22, 24, 25, 26, 28, 29, 32, 37, 40, 42, 42, 43]	13	1
2.	Equipment failure/Breakdown	[12, 22, 23, 24, 27, 28, 31, 36, 37, 41, 42,]	11	2
3.	Inadequate advanced equipments	[12, 18, 23, 27, 31, 42]	6	3
4.	Improper Maintenance	[7, 21, 22, 35]	5	4
5.	Low productivity/efficiency	[19, 24, 25, 42]	4	5
6.	Unavailability of equipment	[24, 30, 31, 36]	4	5
7.	Lack of tool availability	[18, 34, 38]	3	6
8.	Demand of skilled operators for specialized equipment	[18, 22, 33]	3	6
9.	Poorly trained equipment operators	[24, 27, 42]	3	6
10.	Equipment allocation problem	[25, 33]	2	7
11.	Improper equipment planning	[33, 36]	2	7
12.	Untimely mobilization leading to equipment idleness	[25, 33]	2	7
13.	High equipment cost	[34, 39]	2	7

The causes such as 'shortage of equipment', 'equipment failure/breakdown', inadequate advanced equipments', 'improper maintenance', 'low productivity/efficiency', 'unavailability of equipment', 'lack of tool availability', 'demand of skilled operators for specialized equipment', 'poorly trained equipment operators', 'equipment allocation problem', 'improper equipment planning', 'untimely mobilization leading to equipment idleness' and 'high equipment cost' are ranked based on the maximum number of repetitions. The remaining causes are uncommon and hence it is not given any ranking.

The repeated causes are confined and narrowed down to 37 causes of equipment delay. These 37 causes are categorized into 8 main key factors as shown in Table 3. The various key factors are detailed below.

Improper maintenance: Maintenance is one of the most important measures to be followed upon after the purchase of any type of equipment to ensure its smooth working. But maintenance receives very less attention in India as well as other countries. Missing out on timely inspections leads to sudden equipment breakdown. Frequent equipment breakdown or failure affects the routine work of the day and disrupts the planned schedule. Production rate is also reduced due to improper maintenance such as timely inspection, lubrication, etc.

Inadequate maintenance management team: Past studies have reported that improper maintenance is due to inadequate maintenance management team. Proper maintenance can be carried out effectively by setting up a team of personnel exclusively for maintenance management. Absence of efficient maintenance teams result in improper maintenance leading to sudden failure of equipment.

Non-allocation of fund: For each and every stage of construction activity to proceed, sanctioning of fund from management is required. Due to insufficient funding at the right time various issues regarding quality and perfect follow up of planned schedule is compromised. Insufficient funding is a barrier hindering the setup of an efficient maintenance management team. In the absence of a good maintenance team, regular inspection is ignored and repairing of a defect while the equipment is in working condition is missed out on. Purchase of high technology mechanical equipments and modern equipments in case of obsolescence is also a challenging task. Proper and regular inventory maintenance has also been demanding due to insufficient funding.

Table 3: Delay causes categorized under various key factors.

Key Factors	Delay causes
Improper maintenance	– Incorrect actions in maintenance operations – Frequent equipment breakdown – Maintenance not receiving enough attention – Low productivity
Inadequate maintenance management team	– Non employment of scheduling maintenance team – Non employment of corrective maintenance team
Non-allocation of fund	– Inspection cost – For repairing a defect even when the equipment is in working condition – Improper equipments – Inadequate modern equipment – Shortage of equipment – Lack of high technology mechanical equipment – Lack of tool availability – Low quality of equipment – Replacement of outdated equipment
Improper inventory management	– Equipment idleness due to importing of spare parts – Lack of spare parts – Lack of tool availability at the right time
Non replacement of equipments	– Low efficiency of equipment – Normal wear for age – Outdated equipments – High equipment cost
Accidents	– Overload of the equipment
Inexperienced site in-charges	– Inaccurate prediction of equipment production rate – Equipment allocation problem – Inefficient use of equipments – Lack of suitable planning for equipment – Untimely mobilization of equipment leading to idling of resources – Poor equipment choice – Inadequate installation
Excusable reasons	– Slow mobilization of equipment – Demand of skilled operators for specialized equipments – Issues clearing imported equipments from customs – Short life in equipment – Poorly trained equipment operators – Delay in manufacturing of special equipments – Unavailability of equipment

Improper inventory management: Unavailability of required spare parts in the inventory leads to equipment idleness. Imported equipment spare parts are not available immediately for repairs to be carried out. Delayed import time results in delay of equipment maintenance and repair until which the equipment works will be delayed.

Non-replacement of equipments: Any equipment has to be replaced when it is exposed to normal wear and tear. Use of equipment even after wear, leads to low efficiency and low productivity.

Accidents: Overload of the equipment causes accidents. Accidents are high risk that may lead to the death of the operator as well as people working around the equipment. This may lead to stoppage of entire work until legal issues are cleared.

Inexperienced site in-charges: Inexperienced professionals in a particular field lead to inaccuracy in selection of equipment which is followed by insufficient necessary equipment availability at the right time. Inaccurate prediction of equipment production rate cause delays in the delivery of the product. Lack of suitable planning for acquiring equipment causes inefficient use of equipments and untimely mobilization leading to idling of equipment. Lethargic actions cause inadequate installation of equipments.

Excusable reasons: There are some causes of delay due to construction equipments for which a particular individual or team is not responsible. Slow mobilization of equipment is mainly raised as a problem in congested areas where buildings are stood up around the construction area. Demand of skilled operators for specialized equipments is a cause for concern because not enough training programmes are available for operators. Spare parts acquisition for imported equipments is time consuming since it is dependent on custom clearance which takes time.

There are few types of equipment with a short life cycle and delays occur due to late replacements of these. Imported tools and availability of highly equipped personnel across the globe, further causing delay in manufacturing of special equipments.

Not all the causes of equipment delay can be completely eliminated but actions can be taken to reduce the maximum delay by considering the following recommendations.

1. Effective maintenance can be done by setting up a team of personnel exclusively for maintenance management with respect to three divisions: preventive maintenance team, corrective maintenance and repair maintenance.
2. A balanced inventory has to be maintained to overcome both zero stock to avoid non-availability of the equipment at the right time and to avoid excessive stock which increases the cost for storing excess spare parts than required.
3. The people in-charge employed for a particular type of project has to be well experienced in the field of interest. Change in type of project takes time for them to get adapted to, leading to improper planning for availing the right choice of equipment. The person in-charge must be aware of the working conditions and production rate of equipments required for the project and should be able to make a proper selection of equipments.
4. Equipment idleness has to be avoided by proper planning and timely scheduling of equipments making it available at the right time as per its availability.
5. Downtime of equipment has to be reduced by detecting and diagnosing the fault during maintenance.
6. Quick replacement of equipments with respect to deterioration (normal wear and tear), obsolescence (outdated equipment) and inadequacy (change in product design) has to be ensured.

V. CONCLUSION

At present, very limited information is available pertaining to 'construction equipment delay' which has been identified as one of the most important factors affecting the completion of construction projects on schedule. The equipment has become one of the most important resources in the recent decade only. This is the reason why there is a limitation in the information. But the future will see a huge demand in construction equipment needs and research in this area will have tremendous scope.

VI. FUTURE SCOPE

This study has paved the way for further research by identifying the most risky factor affecting the construction project and taking effective measures to overcome this issue.

Conflict of Interest. There is no conflict of interest for any of the authors in this paper.

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