

Tracking of Construction Progress Concerning Activity Wise Equipment Delay



B. Indhu, K. Yogeswari, Mehnaz Akhtar

Abstract: Delay in construction is considered as one of the major drawbacks in the construction world as the delay can increase the cost of the construction project, therefore, it is important to study the causes of it and then analyzing the factors. In this paper, various studies of literature review and a pilot study were done by taking interviews of the experts related to equipment in the construction project. The questionnaire was prepared related to delay in construction due to the equipment delay factor. These questionnaires were divided into the top 5 categories which consist of 20 major causes. The questionnaire survey was sent to the respondents through the google form and personally to the sites. Totally 200 responses were collected for 11 activities. The analysis is done in Relative Importance Index (RII) to calculate the highest factors and the lowest factors which cause or effect the delay in construction. Based on the results recommendation were given. The purpose of this project is to deliver the construction facilities rapidly, which do not only serve as a competitive lead but also serves in bringing up constructional innovation.

Keywords: Activity wise, construction progress, equipment delay, Relative Importance Index (RII).

I. INTRODUCTION

The delay is one of the major factors that affect the growth of construction projects. As the time gets extended effect on the money, quality, and safety which can lead to a huge loss [1]. However, the construction project is said to be successful when it is completed on time, with the correct specification, stakeholder satisfaction and according to the planned budget [2]. Time, cost and quality are the basis of construction for being a successful project which also includes the safety of its environment. Time and cost have a parallel equation with the increase in the time it also increases the cost [3]. Delay of project completion is a major problem in construction industries that often leads to a decrease economy [4]. Delay in construction management is a major drawback due to

improper construction Equipment Most of the projects do not finish as the time expected to be. Instead, they get completed either before or after the scheduled time due to uncertainties of events and their uniqueness [5]. Equipment delay in construction increases cost, late finishing of the project, disagreement of client and contractors [6]. This may cause disturbance to project progress, its services and also increases the time. It is also observed that the objectives are jeopardized by delays due to equipment. Equipment delays result in an extension of project time, which leads to extra overheads that increase the cost [7]. Finally, it may cause the termination of the construction project and its contract. Delay could be defined as the time over-run beyond the completion date specified in a contract [8]. Considering all the general activity which is done in the construction industries like ground clearance, excavation, footing, etc. For different activities, different equipment is used so the maintenance, spare parts of equipment and availability of skilled personnel for a different kind of equipment will differ and if the activity Equipment is not arranged on time then it will lead to delay of the work in progress.

II. LITERATURE REVIEW

Among the various studies so far, we have found that delay is the major problem in construction industries which leads to a decrease in the economy and an increase in disagreement of people working on it.

In Egyptian, Remon Fayek Aziz [2] identified 99 factors and categories into 9 major groups, the responses were collected from experts and representatives from private, public and local construction firms. The survey was analyzed by the method of Relative Importance Index (RII) and the causes were ranked based on the calculation.

Remon F. Aziz [6] identified 293 delay causes which were responded by consultants, contractors and site engineers. The top 20 highest and lowest causes were identified by the method of Relative Importance Index (RII) and are considered to be the most important causes.

Sadi A. Assaf [8] studied the differences in perceptions of owners, contractors, and consultants where 73 delay causes were identified, the causes were classified into 9 major groups. It was concluded that 45 out of 76 has experienced a delay in construction project and 70% has experienced time-overrun. Anuradha Arya [3] identified 78 delay causes and categorized it into 8 major groups, the top 10 factors were dominated by the owner, contractor and project group. The first 3 factors which delayed the progress of the project are late progress payment, financial problems of owner,

Manuscript published on 30 September 2019

* Correspondence Author

B.Indhu^{ab}, ^aResearch scholar, B.S. Abdur Rahman Crescent Institute of Science and Technology, Chennai, India; ^bAssistant Professor, SRM Institute of Science and Technology, Chennai, India.

Email id: indhu.b@ktr.srmuniv.ac.in.

K.Yogeswari, Associate Professor, B.S. Abdur Rahman Crescent Institute of Science and Technology, Chennai, India.

Email id: yogeswari@crecident.education.

Mehnaz Akhtar, Department of Civil Engineering, SRM Institute of Science and Technology, Chennai, India.

Email id: akhtar123mehnaz@gmail.com

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](https://creativecommons.org/licenses/by-nc-nd/4.0/) article under the CC-BY-NC-ND license <http://creativecommons.org/licenses/by-nc-nd/4.0/>

and improper study of design affects estimated quantity it also had a high impact on the project objectives.

Tsegay Gebrehiwet [5] studied 52 causes and categorized it into 5 major causes, the method used in this paper are relative Importance Index (RII) and correlation coefficient. Based on the comparison, the impact of delay is considered as construction stage, pre-construction stage and post-construction stage based on this the average construction stage is calculated and causes of delay are ranked.

Anita Rauzana [9] mentioned the method to examine the delay causes and time performance which are the factors of the delay. There are two proposes to the paper: (1) reason for noncompliance (RNC) which indicates the characterizes scheduling failures and (2) delay index (DI) which indicates time-performance that relates to the impacts of delay on critical and noncritical activities.

Aynur Kazaz [10] identified 34 factors that were taken into account were, "design and material changes" was the most predominant factor than "delay of payments" and "cash flow problems". In the case of importance group factors, financial factors were the first group, while environmental factors were the least effective group.

In Gujarat, Megha Desai [11] studied the 59 delay causes and categorized into 9 major groups. The analysis was done by the Relative Importance Index (RII) and Importance Index (IMPI) technique based on the degree of severity and degree of frequency. Only 5 factors were common in ranks from the top 10 factors for both methods.

Jesper Kranker Larsen [12] identified 26 delay factors from interviews and was sent to publicly employed project managers. The analysis was done using the relative importance index (RII), Friedman's test and Wilcoxon's test from which it was identified that the most influential factor for time is unsettled.

Yue Choong Kog [13] studied 23 paper to list out the 40 delay factors caused by the consultant, owner, contractor and other activities. The major problem was related to "finance and payments of completed work by owner" and "shortage of construction materials".

Zemra Rachid [14] identified 95 causes and categorized them into 5 major causes. The analysis was done in Frequency Index, Severity Index, Relative Importance Index (RII) and Spearman's rank correlation to rank the delay causes from the viewpoint of the owner, contractor and consultants altogether and independently.

Daniel W.M. Chan [15] studied 83 causes and categorized them into 8 major factors. The analysis was done by the Mean Score method and the correlation were done by using Rank Agreement Factor, Percentage Agreement and Percentage Disagreement method and rank are indicated. Its indication was based on the agreement and disagreement of the three parties the owner, contractor, and consultants.

Rodrigo S. Lopes [16] purpose was to form a maintenance or inspection team which would respond to the emergency calls needed for the maintenance of the equipment within the given period. To reduce the time delay, factors like Inspection Interval, Number of Teams for Scheduling Maintenance and Number of Teams for Corrective Maintenance were calculated and lastly the cost of the team that responds to failures was calculated.

Reza Akhavian [17] goal was to investigate the use of built-in smartphone sensors such as ubiquitous multi-modal data collection and transmission nodes to detect construction

equipment activities. It can provide a basis for productivity improvement, safety management, fuel use, emission monitoring, and control. It can also serve as a basis for activity duration extraction for construction simulation modeling.

Deon Kruger [18] investigated 48 causes and 13 effects of delay and disruption identified from the studies, these 48 causes classified into 10 major groups. The analysis was done by using Reliability Analysis, Severity Index, Frequency index and Importance Index. The result shows that the collected data are reliable which are conducted through the Cronbach's alpha reliability test.

Jinbo Song [19] studies conducted research that listed the causes of schedule delays from 140 experts that are clients, contractors, and consultants. The analysis was done in frequency, severity, and importance index using the statistical method, the top 5 major delay factors were ranked.

Alaa Ismai [20] collected the data from 122 Qatari public construction projects that were provided by ASHGHAL. The data were analyzed by ANOVA method which showed that the cost overruns and delays were not significant concerning project type, category, and size. They also showed that the cost overruns were not significant concerning the project duration. A regression analysis was done to establish the relationships between project contract prices and cost overruns.

Identifying and grouping the causes of delay by filtering the factors from the existing literature are as follows: (1) **Delay due to Non-Availability of Equipment** was considered as one of the first factors which have many related factors under it [13], [2], [3], [15], [16], [9]; (2) **Delay in Performing Inspection for Equipment** was considered as one of the second factors which have many related factors under it [7], [18], [10], [15], [16], [19]; (3) **Delay due to Imported Equipment** was considered as one of the third factors which have many related factors under it [2], [3], [5], [17], [16]; (4) **Delay due to Failed equipment** was considered as one of the fourth factors which have many related factors under it [1], [6], [2], [5], [12], [20]; (5) **Delay in the provision of on-site Equipment services** was considered as one of the final group of delay factors which have many related factors under it [4],[8], [14], [6], [16], [11].

These summaries the causes of delay in construction to reduce time and cost overrun. The causes of delay are identified through various pilot studies or by past studies and questionnaires were designed. The questionnaire survey is carried out with a comparison of the causes of delay. An Analysis is done by many statistical tools such as relative important index (RII), Friedman's Test and spearman's rank coefficient. A recommendation is given for every cause of delay. The results are given based upon the ranking position and comparative studies.

III. RESEARCH METHODOLOGY

In methodology, the literature survey concerning the delay in construction projects due to equipment delay factors was done, which is one of the major delay factors.

Based on the literature survey questionnaire that was prepared and a pilot study was done by visiting the sites and interviewing the people related to the construction industry, then the questionnaire was designed for 20 delay causes. Further these 20 delays factors, were divided into 5 major categories (1) Delay due to Non-Availability of Equipment; (2) Delay in Performing Inspection for Equipment; (3) Delay due to Imported Equipment; (4) Delay due to Failed equipment; (5) Delay in the provision of on-site Equipment service. This designed questionnaire was sent to various respondents that are highly experienced in the field of construction industries. The respondents are project managers, site managers, site engineers, technical office managers, procurement managers, contractors, and subcontractors, etc. Totally 200 responses were collected through google forms and site visits. The analysis was carried out by using the Relative Important Index (RII) which gives us the highest and lowest risky causes or effects of the delay.

IV. DATA COLLECTION

The questionnaire was divided into five major causes with twenty delay factors: -

1. Delay due to Non-Availability of Equipment

- a) Demand for Imported equipment
- b) Scarcity of modern equipment in India
- c) Non-tracing of availability of equipment
- d) Irregular everyday maintenance by the operators

2. Delay in Performing Inspection for Equipment

- a) Inappropriate actions are taken in maintenance operation
- b) Improper listing of inspection
- c) No proper maintenance of previous records
- d) Forming of Maintenance Management Team

3. Delay due to Imported Equipment

- a) Improper Service for Imported Equipment
- b) Spare parts not available for imported equipment
- c) Affect in the economy if not used in upcoming projects
- d) Delay in mobilization

4. Delay due to Failed equipment

- a) Limitation in Equipment age
- b) Outdated Product Design
- c) Inefficiency of equipment
- d) Insufficient analysis of previous performance

5. Delay in the provision of on-site Equipment services

- a) Cautious Maintenance
- b) Non-Enrolment of Scheduling Team
- c) Ineffective Maintenance Team
- d) Excess Use of Equipment Leads to Jamming

V. RESULT AND DISCUSSION

Relative Importance Index (RII) is used to determine the relative importance of the various causes and effects of delay using a four-point Likert scale or considering the higher value of delay. This method is used to analyses the different causes according to the relative importance indices, the analysis revealed the most contributing factors causing delays.

$$RII = \sum W / AN$$

Where,

RII=Yearly experience of Relative Importance Index of each factor for each group of respondents

W = Weighting given to each factor by the respondents

(ranging from 4 to 0) (0 = very low, 1 = low, 2 = medium, 3 = high, 4 = very high)

A = Highest weight in this study (4 = very high)

N = Total number of respondents at each variable

Table- I: Overall Relative Importance Index (RII)

Overall		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.349	8
b. Scarcity of modern equipment in India	0.329	14
c. Non-tracing of availability of equipment	0.365	3
d. Irregular everyday maintenance by the operators	0.354	5
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.243	16
b. Improper listing of inspection	0.345	7
c. No proper maintenance of previous records	0.348	6
d. Forming of Maintenance Management Team	0.272	13
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.340	8
b. Spare parts not available for imported equipment	0.322	10
c. Affect in the economy if not used in upcoming projects	0.377	1
d. Delay in mobilization	0.338	7
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.367	1
b. Outdated Product Design	0.356	2
c. Inefficiency of equipment	0.351	2
d. Insufficient analysis of previous performance	0.344	3
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.309	4
b. Non-Enrolment of Scheduling Team	0.359	1
c. Ineffective Maintenance Team	0.328	2
d. Excess Use of Equipment Leads to Jamming	0.345	1

In Table 1, Among the 20 factors the “Affect in the economy if not used in upcoming projects” has achieved 1st rank i.e. the highest factor of delay with an RII of "0.377" followed by the "Limitation in equipment age" with an RII of "0.367" and lastly the “Excess use of equipment leads to jamming" with an RII of "0.345", whereas the “Inappropriate actions are taken in maintenance operation” has achieved the rank 16th i.e. least delay factor with an RII of "0.243"



Table- II: Relative Importance Index (RII) of ground clearance

Ground Clearance		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.310	19
b. Scarcity of modern equipment in India	0.370	11
c. Non-tracing of availability of equipment	0.394	7
d. Irregular everyday maintenance by the operators	0.394	7
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.324	15
b. Improper listing of inspection	0.375	8
c. No proper maintenance of previous records	0.356	9
d. Forming of Maintenance Management Team	0.287	13
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.370	8
b. Spare parts not available for imported equipment	0.333	10
c. Affect in the economy if not used in upcoming projects	0.458	3
d. Delay in mobilization	0.347	8
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.417	3
b. Outdated Product Design	0.472	1
c. Inefficiency of equipment	0.472	1
d. Insufficient analysis of previous performance	0.403	2
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.352	3
b. Non-Enrolment of Scheduling Team	0.384	2
c. Ineffective Maintenance Team	0.329	2
d. Excess Use of Equipment Leads to Jamming	0.407	1

In Table 2, Among the 20 factors the both the “Inefficiency of equipment” and “Outdated Product Design” has achieved 1st rank i.e. the highest factor of delay with an RII of "0.472" followed by the “Excess use of equipment leads to jamming” with an RII of "0.407”, whereas the “Demand for Imported equipment” has achieved the rank 19th i.e. least delay factor with an RII of "0.310”.

Table- III: Relative Importance Index (RII) of marking and leveling

Marking & Levelling		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.338	18
b. Scarcity of modern equipment in India	0.373	14
c. Non-tracing of availability of equipment	0.427	5
d. Irregular everyday maintenance by the operators	0.435	4
2. Delay in Performing Inspection for		

Equipment		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Inappropriate actions are taken in maintenance operation	0.331	15
b. Improper listing of inspection	0.404	6
c. No proper maintenance of previous records	0.381	9
d. Forming of Maintenance Management Team	0.300	13
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.388	7
b. Spare parts not available for imported equipment	0.373	9
c. Affect in the economy if not used in upcoming projects	0.477	2
d. Delay in mobilization	0.369	8
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.415	4
b. Outdated Product Design	0.519	1
c. Inefficiency of equipment	0.473	1
d. Insufficient analysis of previous performance	0.423	1
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.362	4
b. Non-Enrolment Scheduling of Team	0.404	1
c. Ineffective Maintenance Team	0.381	2
d. Excess Use of Equipment Leads to Jamming	0.388	1

In Table 3, Among the 20 factors the “Outdated Product Design” has achieved 1st rank i.e. the highest factor of delay with a RII of “0.519” followed by the “Inefficiency of equipment” with a RII of “0.473”, the “Insufficient analysis of previous performance” with a RII of “0.423”, the “Non-Enrolment Scheduling of Team” with the RII of “0.404” and lastly “Excess Use of Equipment Leads to Jamming” with the RII of “0.388” whereas the “Demand for Imported equipment” has achieved the rank 18th i.e. least delay factor with an RII of "0.338”.

Table- IV: Relative Importance Index (RII) of Excavation

Excavation		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.332	11
b. Scarcity of modern equipment in India	0.340	10
c. Non-tracing of availability of equipment	0.317	12
d. Irregular everyday maintenance by the operators	0.343	9
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.253	15



b. Improper listing of inspection	0.358	6
c. No proper maintenance of previous records	0.345	7
d. Forming of Maintenance Management Team	0.242	13
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.325	8
b. Spare parts not available for imported equipment	0.317	8
c. Affect in the economy if not used in upcoming projects	0.443	1
d. Delay in mobilization	0.304	8
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.358	5
b. Outdated Product Design	0.376	1
c. Inefficiency of equipment	0.361	2
d. Insufficient analysis of previous performance	0.369	1
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.291	4
b. Non-Enrolment of Scheduling Team	0.327	2
c. Ineffective Maintenance Team	0.312	2
d. Excess Use of Equipment Leads to Jamming	0.361	1

In Table 4, Among the 20 factors the “Outdated Product Design” has achieved 1st rank i.e. the highest factor of delay with a RII of “0.376” followed by the “Insufficient analysis of previous performance” with a RII of “0.369” and lastly “Excess Use of Equipment Leads to Jamming” with the RII of “0.361” whereas the “Inappropriate actions are taken in maintenance operation” has achieved the rank 15th i.e. least delay factor with an RII of "0.253".

Table- V: Relative Importance Index (RII) of foundation

Foundation		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.300	16
b. Scarcity of modern equipment in India	0.361	8
c. Non-tracing of availability of equipment	0.396	1
d. Irregular everyday maintenance by the operators	0.351	9
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.277	15
b. Improper listing of inspection	0.374	3
c. No proper maintenance of previous records	0.396	1
d. Forming of Maintenance Management Team	0.277	13
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.309	8
b. Spare parts not available for imported equipment	0.307	8
c. Affect in the economy if not used in upcoming projects	0.386	1
d. Delay in mobilization	0.287	9

4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.369	1
b. Outdated Product Design	0.369	1
c. Inefficiency of equipment	0.364	1
d. Insufficient analysis of previous performance	0.356	2
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.290	4
b. Non-Enrolment of Scheduling Team	0.312	2
c. Ineffective Maintenance Team	0.304	2
d. Excess Use of Equipment Leads to Jamming	0.359	1

In Table 5, Among the 20 factors the “Non-tracing of availability of equipment” and “No proper maintenance of previous records” has achieved 1st rank i.e. the highest factor of delay with a RII of “0.396” followed by the “Affect in the economy if not used in upcoming projects” with a RII of “0.386”, “Limitation in equipment age” and “ Outdated Product Design’ is having a RII of “0.369”, “Inefficiency of equipment” with a RII of “0.364”, the “Insufficient analysis of previous performance” with a RII of “0.423” and lastly “Excess Use of Equipment Leads to Jamming” with the RII of “0.359” whereas the “Demand for Imported equipment” has achieved the rank 16th i.e. least delay factor with an RII of "0.300".

Table- VI: Relative Importance Index (RII) of plinth

Plinth		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.339	14
b. Scarcity of modern equipment in India	0.430	8
c. Non-tracing of availability of equipment	0.434	7
d. Irregular everyday maintenance by the operators	0.329	13
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.256	16
b. Improper listing of inspection	0.316	13
c. No proper maintenance of previous records	0.335	12
d. Forming of Maintenance Management Team	0.310	13
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.354	11
b. Spare parts not available for imported equipment	0.386	10
c. Affect in the economy if not used in upcoming projects	0.437	6
d. Delay in mobilization	0.418	7
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.475	3
b. Outdated Product Design	0.465	3

c. Inefficiency of equipment	0.500	1
d. Insufficient analysis of previous performance	0.396	4
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.316	4
b. Non-Enrolment of Scheduling Team	0.487	1
c. Ineffective Maintenance Team	0.421	2
d. Excess Use of Equipment Leads to Jamming	0.449	1

In Table 6, Among the 20 factors the “Inefficiency of equipment” has achieved 1st rank i.e. the highest factor of delay with a RII of “0.500” followed by the “Non-Enrolment of Scheduling Team” with a RII of “0.487” and lastly “Excess Use of Equipment Leads to Jamming” with the RII of “0.449” whereas the “Inappropriate actions are taken in maintenance operation” has achieved the rank 16th i.e. least delay factor with an RII of “0.256”.

Table- VII: Relative Importance Index (RII) of column and beam

Column and Beam		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.388	5
b. Scarcity of modern equipment in India	0.330	17
c. Non-tracing of availability of equipment	0.360	11
d. Irregular everyday maintenance by the operators	0.401	3
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.330	15
b. Improper listing of inspection	0.373	7
c. No proper maintenance of previous records	0.375	6
d. Forming of Maintenance Management Team	0.349	10
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.397	3
b. Spare parts not available for imported equipment	0.381	4
c. Affect in the economy if not used in upcoming projects	0.442	1
d. Delay in mobilization	0.302	9
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.388	2
b. Outdated Product Design	0.427	1
c. Inefficiency of equipment	0.358	3
d. Insufficient analysis of previous performance	0.347	4
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.366	1
b. Non-Enrolment of Scheduling Team	0.345	3
c. Ineffective Maintenance Team	0.351	2
d. Excess Use of Equipment Leads to Jamming	0.366	1

In Table 7, Among the 20 factors the “Affect in the economy if not used in upcoming projects” has achieved 1st rank i.e. the highest factor of delay with an RII of “0.442” followed by the “Outdated Product Design” with an RII of “0.427” and lastly the “Cautious Maintenance” and “Excess use of equipment leads to jamming” with an RII of “0.366”, whereas the “Scarcity of modern equipment in India” has achieved the rank 17th i.e. least delay factor with an RII of “0.330”.

Table- VIII: Relative Importance Index (RII) of slab

Slab		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.375	6
b. Scarcity of modern equipment in India	0.326	12
c. Non-tracing of availability of equipment	0.319	14
d. Irregular everyday maintenance by the operators	0.355	9
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.308	15
b. Improper listing of inspection	0.346	9
c. No proper maintenance of previous records	0.386	2
d. Forming of Maintenance Management Team	0.326	9
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.379	3
b. Spare parts not available for imported equipment	0.346	7
c. Affect in the economy if not used in upcoming projects	0.408	1
d. Delay in mobilization	0.310	8
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.371	3
b. Outdated Product Design	0.384	1
c. Inefficiency of equipment	0.371	2
d. Insufficient analysis of previous performance	0.377	1
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.324	2
b. Non-Enrolment of Scheduling Team	0.301	3
c. Ineffective Maintenance Team	0.315	2
d. Excess Use of Equipment Leads to Jamming	0.368	1

In Table 8, Among the 20 factors the “Affect in the economy if not used in upcoming projects” has achieved 1st rank which is the highest factor of delay with a RII of “0.408” followed by the “Outdated Product Design” with a RII of “0.384”, “Insufficient analysis of previous performance” with an RII of “0.377” and “Excess use of equipment leads to jamming” with an RII of “0.368”, whereas the “Inappropriate actions are taken in maintenance operation” has achieved the rank 15th i.e. least delay factor with an RII of “0.308”.

Table- IX: Relative Importance Index (RII) of brick work

Brick Work		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.350	14
b. Scarcity of modern equipment in India	0.324	17
c. Non-tracing of availability of equipment	0.354	13
d. Irregular everyday maintenance by the operators	0.393	2
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.278	15
b. Improper listing of inspection	0.369	8
c. No proper maintenance of previous records	0.385	4
d. Forming of Maintenance Management Team	0.276	13
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.372	6
b. Spare parts not available for imported equipment	0.365	6
c. Affect in the economy if not used in upcoming projects	0.406	1
d. Delay in mobilization	0.344	8
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.391	1
b. Outdated Product Design	0.380	2
c. Inefficiency of equipment	0.391	1
d. Insufficient analysis of previous performance	0.361	2
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.350	3
b. Non-Enrolment of Scheduling Team	0.357	2
c. Ineffective Maintenance Team	0.333	2
d. Excess Use of Equipment Leads to Jamming	0.374	1

In Table 9, Among the 20 factors the “Affect in the economy if not used in upcoming projects” has achieved 1st rank i.e. the highest factor of delay with a RII of “0.406” followed by the “Limitation in Equipment age” and “Inefficiency of equipment” with a RII of “0.391” and lastly “Excess use of equipment leads to jamming” with an RII of “0.374”, whereas the “Scarcity of modern equipment in India” has achieved the rank 17th i.e. least delay factor with an RII of “0.324”.

Table- X: Relative Importance Index (RII) of plastering

Plastering		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.325	16
b. Scarcity of modern equipment in India	0.300	18
c. Non-tracing of availability of equipment	0.320	16
d. Irregular everyday maintenance by the operators	0.370	6

operators		
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.300	16
b. Improper listing of inspection	0.358	10
c. No proper maintenance of previous records	0.353	10
d. Forming of Maintenance Management Team	0.363	7
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.363	7
b. Spare parts not available for imported equipment	0.370	6
c. Affect in the economy if not used in upcoming projects	0.404	2
d. Delay in mobilization	0.315	9
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.406	1
b. Outdated Product Design	0.385	1
c. Inefficiency of equipment	0.363	3
d. Insufficient analysis of previous performance	0.375	1
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.344	2
b. Non-Enrolment of Scheduling Team	0.329	3
c. Ineffective Maintenance Team	0.339	2
d. Excess Use of Equipment Leads to Jamming	0.373	1

In Table 10, Among the 20 factors the “Limitation in Equipment age” has achieved 1st rank i.e. the highest factor of delay with a RII of “0.406” followed by the “Outdated Product Design” “Inefficiency of equipment” with a RII of “0.385”, the “Insufficient analysis of previous performance” with a RII of “0.375” and lastly “Excess Use of Equipment Leads to Jamming” with the RII of “0.373” whereas the “Scarcity of modern equipment in India” has achieved the rank 18th i.e. least delay factor with an RII of “0.300”.

Table- XI: Relative Importance Index (RII) of flooring

Flooring		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.360	16
b. Scarcity of modern equipment in India	0.331	18
c. Non-tracing of availability of equipment	0.363	14
d. Irregular everyday maintenance by the operators	0.392	8
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.333	15

b. Improper listing of inspection	0.398	7
c. No proper maintenance of previous records	0.422	3
d. Forming of Maintenance Management Team	0.417	3
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.382	7
b. Spare parts not available for imported equipment	0.349	10
c. Affect in the economy if not used in upcoming projects	0.441	1
d. Delay in mobilization	0.331	9
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.417	2
b. Outdated Product Design	0.390	3
c. Inefficiency of equipment	0.425	1
d. Insufficient analysis of previous performance	0.384	2
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.401	1
b. Non-Enrolment of Scheduling Team	0.368	2
c. Ineffective Maintenance Team	0.363	2
d. Excess Use of Equipment Leads to Jamming	0.382	1

In Table 11, Among the 20 factors the “Affect in the economy if not used in upcoming projects” has achieved 1st rank i.e. the highest factor of delay with an RII of "0.441" followed by the "Inefficiency of equipment" with an RII of "0.425", "Cautious Maintenance" is with an RII of "0.401" and lastly the “Excess use of equipment leads to jamming" with an RII of "0.382", whereas the “Scarcity of modern equipment in India” has achieved the rank 18th i.e. least delay factor with an RII of "0.331".

Table- XII: Overall Relative Importance Index (RII)

Other activities		
Factors	RII	Rank
1. Delay due to Non-Availability of Equipment		
a. Demand for Imported equipment	0.311	19
b. Scarcity of modern equipment in India	0.350	13
c. Non-tracing of availability of equipment	0.348	13
d. Irregular everyday maintenance by the operators	0.339	13
2. Delay in Performing Inspection for Equipment		
a. Inappropriate actions are taken in maintenance operation	0.317	15
b. Improper listing of inspection	0.370	8
c. No proper maintenance of previous records	0.390	3
d. Forming of Maintenance Management Team	0.354	9
3. Delay due to Imported Equipment		
a. Improper Service for Imported Equipment	0.390	3
b. Spare parts not available for imported equipment	0.303	11
c. Affect in the economy if not used in	0.415	1

upcoming projects		
d. Delay in mobilization	0.331	9
4. Delay due to Failed equipment		
a. Limitation in Equipment age	0.392	1
b. Outdated Product Design	0.360	4
c. Inefficiency of equipment	0.372	3
d. Insufficient analysis of previous performance	0.380	2
5. Delay in the provision of on-site Equipment services		
a. Cautious Maintenance	0.352	3
b. Non-Enrolment of Scheduling Team	0.388	1
c. Ineffective Maintenance Team	0.333	2
d. Excess Use of Equipment Leads to Jamming	0.356	1

In Table 12, Among the 20 factors the “Affect in the economy if not used in upcoming projects” has achieved 1st rank i.e. the highest factor of delay with a RII of “0.415” followed by the “Limitation in Equipment age” with a RII of “0.392”, “Non-Enrolment of Scheduling Team” with an RII of "0.356" and lastly the “Excess use of equipment leads to jamming" with an RII of "0.382", whereas the “Demand for Imported equipment” has achieved the rank 19th i.e. least delay factor with an RII of "0.311”.

VI. CONCLUSION

The delay in construction can be improved by considering these 20 delay factors. From various literature survey and pilot studies a questionnaire was prepared which was divided into 5 major categories: (1) Delay due to Non-Availability of Equipment; (2) Delay in Performing Inspection for Equipment; (3) Delay due to Imported Equipment; (4) Delay due to Failed equipment; (5) Delay in the provision of onsite Equipment services. The ranking was done by the Relative Importance Index (RII) method, which identifies the highest causes of delay which are (1) Affect in the economy if not used in upcoming projects, (2) Inefficiency of equipment, (3) Outdated Product Design, (4) Non-tracing of availability of equipment, (5) No proper maintenance of previous records, (6) Limitation in Equipment age, (7) Excess use of equipment leads to jamming, (8) Non-Enrolment Scheduling of Team and (9) Insufficient analysis of previous performance. It also identifies the lowest Causes of delay which are (1) Inappropriate actions are taken in maintenance operation, (2) Demand for Imported equipment and (3) Scarcity of modern equipment in India. Based on the ranking proper planning can be done to avoid the delay factors which are identified.

REFERENCES

1. A. S. Faridi and S. M. El-Sayegh, “Significant factors causing delay in the UAE construction industry,” *Constr. Manag. Econ.*, vol. 24, no. 11, pp. 1167–1176, 2006.
2. R. F. Aziz, “Ranking of delay factors in construction projects after Egyptian revolution,” *Alexandria Eng. J.*, vol. 52, no. 3, pp. 387–406, 2013.
3. A. A. Dr.Rajeev, “Analysing Delays of Construction Projects in India : Causes and Effects,” *Int. J. Sci. Technol. Eng.*, vol. 3, no. 06, pp. 66–74, 2016.

4. M. I. Al-Khalil and M. A. Al-Ghafly, "Important causes of delay in public utility projects in Saudi Arabia," *Constr. Manag. Econ.*, vol. 17, no. 5, pp. 647–655, 1999.
5. T. Gebrehiwet and H. Luo, "Analysis of Delay Impact on Construction Project Based on RII and Correlation Coefficient: Empirical Study," *Procedia Eng.*, vol. 196, no. June, pp. 366–374, 2017.
6. R. F. Aziz and A. A. Abdel-Hakam, "Exploring delay causes of road construction projects in Egypt," *Alexandria Eng. J.*, vol. 55, no. 2, pp. 1515–1539, 2016.
7. S. S. S. Gardezi, I. A. Manarvi, and S. J. S. Gardezi, "Time extension factors in construction industry of Pakistan," *Procedia Eng.*, vol. 77, pp. 196–204, 2014.
8. S. A. Assaf and S. Al-Hejji, "Causes of delay in large construction projects," *Int. J. Proj. Manag.*, vol. 24, no. 4, pp. 349–357, 2006.
9. A. Rauzana, "Analysis of Causes of Delay and Time Performance in Construction Projects," *IOSR J. Mech. Civ. Eng.*, vol. 13, no. 05, pp. 116–121, 2016.
10. A. Kazaz, S. Ulubeyli, and N. A. Tuncbilekli, "Causes of Delays in Construction Projects in Turkey," *J. Civ. Eng. Manag.*, vol. 18, no. 3, pp. 426–435, 2012.
11. "Critical Causes of Delay in Residential Construction Projects: Case Study of Central Gujarat Region of India," *Int. J. Eng. Trends Technol.*, vol. 4, no. 4, pp. 762–768, 2013.
12. J. K. Larsen, G. Q. Shen, S. M. Lindhard, and T. D. Brunoe, "Factors Affecting Schedule Delay, Cost Overrun, and Quality Level in Public Construction Projects," *J. Manag. Eng.*, vol. 32, no. 1, p. 04015032, 2015.
13. Y. C. Kog, "Major Delay Factors for Construction Projects in Nigeria," *Int. J. Archit. Eng. Constr.*, vol. 6, no. 2, pp. 46–54, 2017.
14. Z. Rachid, B. Toufik, and B. Mohammed, "Causes of schedule delays in construction projects in Algeria," *Int. J. Constr. Manag.*, vol. 19, no. 5, pp. 371–381, 2019.
15. D. W. M. Chan and M. M. Kumaraswamy, "Reasons for delay in civil engineering projects - the case of hong kong," *HKIE Trans. Hong Kong Inst. Eng.*, vol. 2, no. 3, pp. 1–8, 1995.
16. R. S. Lopes, C. A. V Cavalcante, and M. H. Alencar, "Delay-time inspection model with dimensioning maintenance teams: A study of a company leasing construction equipment," *Comput. Ind. Eng.*, vol. 88, pp. 341–349, 2015.
17. R. Akhavian and A. H. Behzadan, "Construction equipment activity recognition for simulation input modeling using mobile sensors and machine learning classifiers," *Adv. Eng. Informatics*, vol. 29, no. 4, pp. 867–877, 2015.
18. O. O. Oshungade and D. Kruger, "a Comparative Study of Causes and Effects of Project Delays and Disruptions in Construction Projects in the South African Construction Industry," *J. Constr. Eng. Proj. Manag.*, vol. 7, no. 1, pp. 13–25, 2017.
19. O. Bagaya and J. Song, "Empirical Study of Factors Influencing Schedule Delays of Public Construction Projects in Burkina Faso," *J. Manag. Eng.*, vol. 32, no. 5, p. 05016014, 2016.
20. A. Senouci, A. Ismail, and N. Eldin, "Time Delay and Cost Overrun in Qatari Public Construction Projects," *Procedia Eng.*, vol. 164, no. June, pp. 368–375, 2016.



Ramapuram, Chennai

Mehnaz Akhtar is currently pursuing her M.Tech in Construction Engineering and Management in SRM Institute of Science and Technology, Kattankulathur, Chennai. She has completed her B.E in Civil Engineering from SRM Institute of Science and Technology,

AUTHORS PROFILE



B.Indhu is currently working as an Assistant Professor in the Department of Civil Engineering in SRM Institute of Science and Technology, Kattankulathur, Chennai. She is also pursuing her Ph.D. in Construction Management in B.S.A.Crescent Institute of Science and Technology, Vandalur, Chennai. She has completed her B.Tech in Civil Engineering and M.Tech in Construction Management from SRM Institute of Science and Technology. Till date, she has presented in three International conferences and published papers in six Scopus indexed journal.



K.Yogeswari is currently working as an Associate Professor in the Department of Civil Engineering in BSA Crescent Institute of Science and Technology, Vandalur, Chennai. She did her Ph.D. in Sustainable planning in B.S.A. Crescent Institute of Science and Technology, Vandalur, Chennai. She has completed her B.Tech in Civil Engineering and Masters in Town Planning from, School of planning, Anna University. Till date, she has presented in six International conferences and published papers in eight Scopus indexed journals.

APPENDIX

QUESTIONNAIRE SURVEY

Name of the Respondent:

Experience:

Designation:

Form of Organisation:

Type of Present project:

Delay in the Present project (%):

Current Activity in Site: (Tick the current activity in site)

Ground Clearance	
Marking & Levelling	
Excavation	
Foundation	
Plinth	
Column & Beam	
Slab	
Brick Work	
Plastering	
Flooring	
Other Activity	

1. Delay due to Non-Availability of Equipment

Causes	0	1	2	3	4
a. Demand for Imported equipment					
b. Scarcity of modern equipment in India					
c. Non-tracing of availability of equipment					
d. Irregular everyday maintenance by the operators					

2. Delay in Performing Inspection for Equipment

Causes	0	1	2	3	4
a. Inappropriate actions are taken in maintenance operation					
b. Improper listing of inspection					
c. No proper maintenance of previous records					
d. Forming of Maintenance Management Team					

3. Delay due to Imported Equipment

Causes	0	1	2	3	4
a. Improper Service for Imported Equipment					
b. Spare parts not available for imported equipment					
c. Affect in the economy if not used in upcoming projects					
d. Delay in mobilization					

4. Delay due to Failed equipment

Causes	0	1	2	3	4
a. Limitation in Equipment age					
b. Outdated Product Design					
c. Inefficiency of equipment					
d. Insufficient analysis of previous performance					

5. Delay in the provision of on-site Equipment services

Causes	0	1	2	3	4
a. Cautious Maintenance					
b. Non-Enrolment of Scheduling Team					
c. Ineffective Maintenance Team					
d. Excess Use of Equipment Leads to Jamming					