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Study on Construction Sequence Delay for Road Infrastructure Projects

Asish Ram[1], Dr. Pratheeba Paul[2]
[1](M.Tech, Department of Civil Engineering, Hindustan Institute of Technology and Science, Chennai, India)
[2](Professor, Department of Civil Engineering, Hindustan Institute of Technology and Science, Chennai, India)

Abstract:*Due to the inherent risks and increasing complexity of modern infrastructure construction projects, delays and cost overruns have become common facts in the construction industry. Delays can lead to many negative effects such as lawsuits between owners and contractors, increased costs, loss of productivity and revenue, and contract termination. This paper articulates to study about the delay causes and factors that contribute to the construction sequence delay for the road infrastructure projects and how one can predict the future completion date for the delayed project using earned value management. In this context, a literature review conducted thoroughly to know about the causes and factors contributing to delays.From the intricate analysis of the reviewed literatures, it showed that questionnaire survey is the best and reliable methodology to gather the data about the causes and quantification of delay factors. The gathered data are analyzed through Relative Importance Index (RII) and the delay causes are ranked as per their significance. To validate the findings of questionnaire survey, a case study on road construction was considered and analyzed based on earned value management (EVM).*

Keywords: *Delay Causes and factors, Earned Value Management (EVM), Literature Review, Questionnaire Survey, Relative Importance Index (RII).*

I. Introduction

"DELAY IS THE ENEMY OF PROGRESS" – Eliot Spitzer.

Delay is one of the biggest problems construction firms face. Delays can lead to many negative effects such as lawsuits between owners and contractors, increased costs, loss of productivity and revenue, and contract termination. The construction companies in many countries around the world experience significant delays. So what is construction delay? Construction delay can be defined as time overrun or extension of time to complete the project. It is a situation when the actual progress of a construction project is slower than the planned schedule or late completion of the project. However, delay situations are complex in nature because multiple delays can occur concurrently and because they can be caused by more than one party, or by none of the principal parties. One delay may contribute to the formation of other delays. In complex and big projects having many activities, delays are analyzed only based on the two major parameters i.e. time and cost because recording each activity schedules is difficult. Since the delay in infrastructure projects affects the economy of the country, it is important for the projects to be completed within the budgeted cost and time.

II. Importance Of The Study

The timely completion of road infrastructure projects is an important objective. A significant annoyance to the public occurs when projects are not completed in a timely manner and when actual progress of the construction work is longer than necessary, thereby prolonging the inconvenience and disrupted business access. Economic & social welfare, and safety are all related to timely completion. In spite of the importance of timely completion, construction delays remain a common occurrence. This paperaddresses the significant causes and factors of delays in road infrastructure projects and how one can predict the completion date for the project using earned value management.

III. Literature Review

Agata Czarnigowska (2008) studied on earned value method as a tool for project control that uses information on cost, schedule and work performance to establish the current status of the project. By means of a few simple rates, it allowed the manager to extrapolate current trends to predict their likely final effect. The method based on a simplified model of a project, but proved to be useful in practice of cost control. It's being developed to account better for schedule and time aspects. The paper outlines the basic principles of the method and its recent extension, the Earned Schedule method, and, with help of a few examples, investigates into assumptions that affect their diagnostic and predictive accuracy.

Hamzah.N et al (2011)constructed a theoretical framework that causes construction delay by doing a literature review from previous international journal papers and future study about the causes of delay. The

study concluded that improvement of delays are not only limited to technical factors, but also factors in project management perspective, both from the aspect of processes involve and the influence of human attitudes, mentality, skills and behavior. The theoretical framework is categorized into: (i) Excusable delay - caused by owner/consultant; (ii) Concurrent delay – caused by the third party @ acts of god: and (iii) Non-Excusable delay.

Remon Fayek Aziz (2013)ranked the delay factorsin the construction projects after Egyptian revolution, especially after 25/1/2011 (Egyptian revolution. The research methodology was based on questionnaire survey. Ninety-nine factors are identified, that are grouped into 9 major categories: (i) Consultant Related; (ii) Contractor Related; (iii) Design Related; (iv) Equipment Related; (v) External Related; (vi) Labors Related; (vii) Materials Related; (viii) Owner Related; and (ix) Project Related. Recommendations to minimize the delays are too being laid down.

Enas Fathi Taher and Pandey (2013)studied delay in project planning and design stage by identifying and ranking delay causes in the planning & design phases. A structured questionnaire was sent to engineers at the A/E companies for public construction projects in India. Based on ninety-five valid responses, study identified the delay causes and analyzed the importance and frequency of delays using relative importance index. A third-round Delphi form survey was applied as analysis techniques. The Analytical results revealed that "changes in client's requirement" are main cause of delay in both planning & design phases. The finding became good justification for many public clients who usually change their requirement during planning and design stage.

Patil et al (2013)researched on the causes of delay in Indian transportation infrastructure projects to identify the causes and to test the importance of causes of delay between parties involved in the projects and study of difference between their perceptions. The literatures were reviewed thoroughly and a questionnaire containing sixty-four possible causes was formed. The results revealed that the problem of construction delays in transportation infrastructure projects is frequent and notable. The top five important causes of construction delays in transportation infrastructure projects are mainly: (i) Land Acquisition; (ii) Environmental Impact of the project; (iii) Financial closure; (iv) Change orders by the client; and (v) Poor site management and supervision by contractor. The study also revealed that consultant as a mediator has less responsibility in construction delays.

Ravisankar et al (2014)studied on the quantification of delay factors in construction industry. The objective of the study was to identify major causes of construction delay and their effects. The scope of the research mainly focused on literature review and a questionnaire survey. Using the SPSS software, survey data's are analyzed to find out the major causes of delay. The mean score value and ranking are assigned for corresponding delay factors. The overall results indicated top five most important causes are: (i) Shortage of unskilled/skilled labors; (ii) Design changes by owner or his agent during construction; (iii) Fluctuations of prices; (iv) High waiting time for availability of work teams; and (v) Rework due to errors.

Ashwin Arun Salunkhe and Rahul S. Patil (2014)logically explored the delay factors of project and how it can be avoided or controlled. With the help of detailed literature review and interview, delay factors are grouped into seven categories, which give the parameters that could have direct effect on success of projects. The seven categories of critical delay factors are: (i) Owner related; (ii) Consultant related; (iii) Contractor related; (iv) Material related; (v) Labor & Equipment related; (vi) Project related; and (vii) External related.

Amrita Jhawar and Purnima Bajpai (2014)investigated the cause of construction delays and found out critical relationship between various critical delay parameters. The top ten factors having highest risk priority number (RPN) are identified from FMEA and structured into comprehensive systematic model portraying this complex issues which identifies crux of the problem. The major drivers for delay are: (i) Revision in design; (ii) Delay in approvals; and (iii) Bureaucracy and organizational gaps which ultimately influence the delay in land acquisition and environment clearances. The study revealed that stringent departmentization and bureaucratic environment should be minimized so as to improve the decision-making policies.

Khaled Ahmed Ali Alnaas et al (2014)proposed a practical approach that enables the contractor toprove the delays & build a well-supported claim for extension of time based on combination between theoretical information and practical experiences. The approach consist of (i) Preparing baseline programme; (ii) Proper programme updates; (iii) Accurate programme revisions; (iv) Defining and introducing the delays to the programme updates; (v) identifying the concurrent delays and splitting between the contractor and employer delays; and (vi) Preparing the evidences of delay. The contractor is requested to submit EoT claim whenever he believes that the delay event will delay the project completion date and the delay event is excusable and compensable.

IV. Objective Of The Study

To find and rank the top ten causes of delay in road infrastructure projects based on their significance.
To validate the significant causes of delay through a case study.

V. Methodology For The Study

Questionnaire survey is adopted as a methodology in accordance with the fulfillment of the objective of the study. The questionnaire believed to be the best techniques for gathering the required data as it can be analyzed scientifically and objectively.

VI. Questionnaire Survey

6.1 Questionnaire Design

Based on the literature review, a closed ended questionnaire was designed considering the objective of the study. The questionnaire consists of thee parts: The part A consist of general information of the respondent while part B consist of 9 delay related factors consisting a of total 101 delay causes where respondent have to rate each cause as per their significance and part C consist of respondent own opinion.

6.2 Rating Criteria

To identify the degree to how much respondents agree or disagree on the severity of these causes based on their experience and knowledge, a 5-point Likert Scale is designed.
The ratings of scale from 1 to 5 are:
1 - Not Significant: 0% delay contributing factors;
2 - Slightly Significant: < 35 % delay contributing factors;
3 - Moderately Significant: 35 – 60% delay contributing factors;
4 - Very Significant: 60 – 75 % delay contributing factors; and
5 - Extremely Significant: > 75 % delay contributing factors.

The respondent have to rate a particular cause based upon the above scale.Thereasons for using Likert Scale are: it is most universal method and is easily understood; response is easily quantifiable; makes question answering easier on the respondent; quick, efficient and inexpensive method; and high versatility.

6.3 Data Gathering

The questionnaire believed to be the best technique for gathering the required data. As far as possible, the responses have been taken from respondents of designation who are competent of serving the best for purpose and answering the survey in the most appropriate way. The questionnaire was distributed to the respondents by visiting their firms personally. Questionnaire from 43 respondents are analyzed. The respondents experience are depicted in table 1.

Table 2: Respondent Experience

S. No.	Respondents Experience	Percentage
1	0 - 5 Years	7%
2	5 - 10 Years	14%
3	10 - 15 Years	23.20%
4	15 - 20 Years	18.60%
5	> 20 Years	37.20%

6.4 Data Analysis

Relative Importance Index (RII) is adopted for ranking the delay causes as per their significance as it is simple and most widely used for finding the significant factors and ranking of the same**.** It is a regression based statistical tools.The formulae used for calculating RII is:

$$RII = \Sigma W / (A \times N); \quad (1)$$

where, $0 \leq RII \leq 1$
Here, W = Weight given to each cause by respondent, ranges from 1 to 5;
A = Highest weight i.e. =5 (in this case); and
N = Total number of respondent.

VII. Findings

The top ten significant causes of construction delays regarding road infrastructure projects are: (i) Delay due to land acquisition; (ii) Environmental issues; (iii) Delay in progress payment; (iv) Ineffective project planning and scheduling; (v) Poor site management and supervision; (vi) Rework due to errors; (vii) Delay in approving design documents; (viii) Poor coordination between owner and other parties; (ix) Financial closure; and (x) Change order by clients. Table 2 shows the ranking of top ten significant causes of delay as per delay related factor; type of delay and RII value.

Table 2: Top Ten Significant Delay Causes

S. No.	Delay Causes	Related Factor	RII Value	Type of Delay
1	Delay due to land acquisition	Owner	0.851	Excusable
2	Environmental Issues	External	0.841	Excusable
3	Delay in progress payment	Owner	0.837	Excusable
4	Ineffective project planning and scheduling	Contractor	0.823	Non-Excusable
5	Poor site management and supervision	Contractor	0.813	Non-Excusable
6	Rework due to errors	Contractor	0.809	Non-Excusable
7	Delay in approving design documents	Owner	0.795	Excusable
8	Poor coordination between owner and the other parties	Owner	0.795	Excusable
9	Financial Closure	Owner	0.790	Excusable
10	Change order	Owner	0.781	Excusable

All the delay causes will affect the progress of the project as per their significance and occurrence. As per the parties involved in the project, consultant as a mediator has a lesser role in construction delay. Excusable delay can be compensated as per the contract terms and condition and the extension of time (EoT) can be granted for the projects. To validate the findings of questionnaire survey, a case study on road construction was considered and analyzed based on earned value management (EVM).

VIII. Case Study

The case study on Chennai – Ennore Port Road Connectivity Project was done to validate the questionnaire survey. The project involves adequate improvement on four major roads connecting the Chennai – Ennore port involving total of 30.1 kilometers. The contract value was Rs. 258.78 Crores and the actual duration of the project was 24 months. The project commences on 03-06-2011 and the completion period was 02-06-2013. Special Purpose Vehicle (SPV) was formed comprising of NHAI (National Highway Authority of India), Chennai Port Trust, Ennore Port Limited and Govt. of Tamil Nadu for looking after and funding the projects. But only 55.99% of work was accomplished in the contract period with 55.87% of total budgeted amount. Special Purpose Vehicle (SPV) was formed comprising of NHAI (National Highway Authority of India), Chennai Port Trust, Ennore Port Limited and Govt. of Tamil Nadu for looking after and funding the projects. The project was given four extension of time by NHAI itself and the fifth extension was recommended by the contractor. Even after the fifth extension of time (EoT) being granted, the project was just 91% completed till Jan 2015.Since it's a vast project consisting of four major roads, the works was carried out parallely.

The major causes and factors that delay the project to this extent are found out to be: (i) The delay and litigation in land acquisition process; (ii) Delay due to non-shifting of Project Affected Families (PAF's), around 540 families as well as fishing stalls in front of gate no. 1 of Chennai port, from the allignment of road in two small stretches by Govt. of Tamil Nadu, for which Chennai Port and NHAI is pursuing for early completion; (iii) Even the obstructions like encroachment, temples, sewage pipes affected the progress of the project. (iv) Sea erosion is one of the environmental factors that too causes the delay in this particular project in one of the four roads that runs along the sea coast; and (v) Delay occurred also due to the several bottlenecks including non-cooperation from the Tamil Nadu govt. with NHAI.

As per Feb 2105, a meeting was conducted involving all the parties involved in the project to discuss about the faster completion of the project as the project got halted due to resettlement of fishing hamlet in the 1.6 Km stretch. Once the hamlet being resettled, the project can be executed further for completion as only work on this 1.6 km stretch is being pending.

The earned value management is applied on the project at the end of original two-year contract period. The reasons for using EVM is because it relate time phase budgets to specific contract task or statements of work, provide the basis to capture work progress assessments against the base line plan and provide valid, timely, and auditable data/information for proactive management action. After applying the EVM, the following parameters are being found out:

(a) Earned Value (EV): The earned value was found to be 144.89 as compare to the actual cost (AC) of Rs. 144.59 Crores.

$$EV = (\text{Actual \% complete}/100) * \text{Budget At Completion (BAC)} \quad (2)$$

Here, BAC is Rs. 258.78 Crores.

(b) The project has unfavorable schedule variance (SV) of -113.89 and schedule variance % of -44.01 %. So, the project was 44.01% behind schedule.

The project has a cost variance (CV) of 0.3 and cost variance % of 0.21 %. So, the project is 0.21 % under budget for the work performed.

$$SV = EV - PV;\ SV\% = (SV/PV)*100 \quad (3)$$
$$CV = EV - AC;\ CV\% = (CV/EV)*100 \quad (4)$$

Here, PV is the planned value of the project.

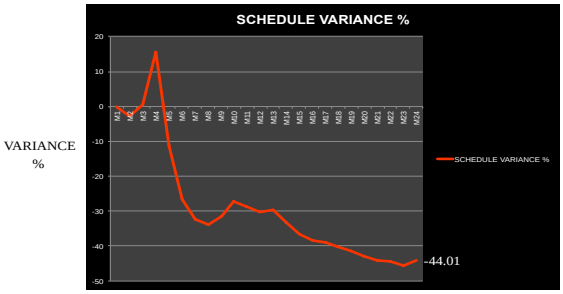

Fig. 1: Schedule Variance %

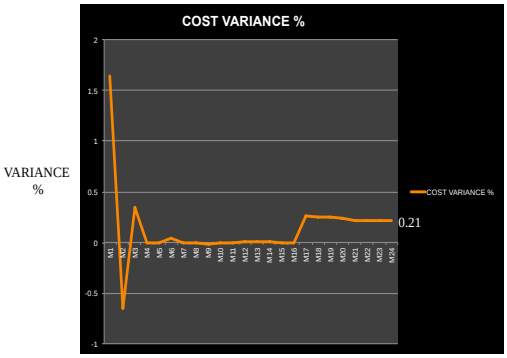

Fig. 2: Cost Variance%

(c) In the two-year contract period, Cost Performance Index (CPI) value is 1. This implies that for every project rupee spent, 1 rupee is in earned value is accomplished.
And in the same two-year contract period, Schedule Performance Index (SPI) value is 0.56.This implies that for every Rupee of work the project had planned to accomplish at this point in time, 0.56 rupee worth of work was actually done. As the cost ratio (CR) is 0.56, the overall performance is POOR.

$$CPI = EV/AC \quad (5)$$
$$SPI = EV/PV \quad (6)$$
$$CR = SPI \times CPI \quad (7)$$

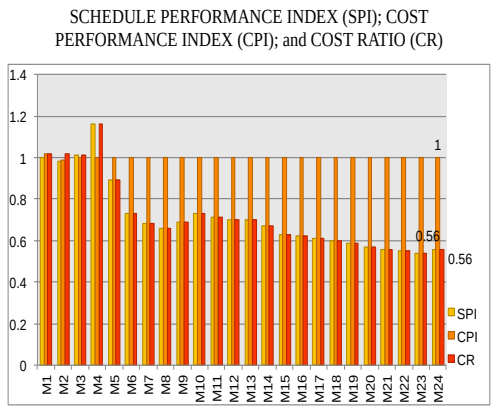

Fig. 3: SPI, CPI and CR

(d) Additional Time to Complete: The additional time to complete the project was found to be 18.87 months i.e. approximately 19 months.

$$\text{Additional Time to Complete} = \text{EACt} - 24\ (\text{Duration}) \tag{8}$$

Here, EACt is Estimate At Completion time and is given by:

$$\text{EACt} = (\text{BAC}/\text{SPI})/(\text{BAC}/\text{Duration}) \tag{9}$$

Where, duration is 24 months.

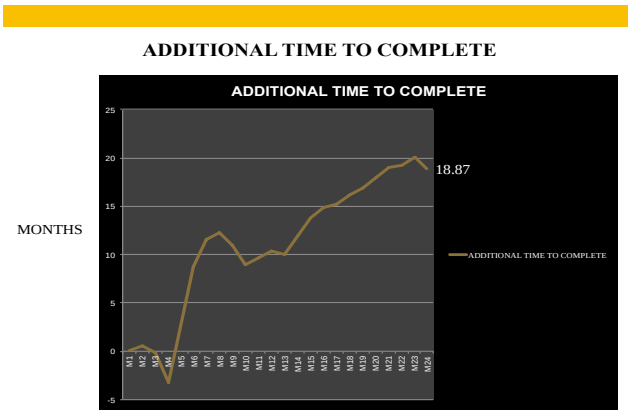

Fig. 4: Additional Time To Complete

(e) Estimate At Completion (EAC): It is manager's projection of total cost of the project at completion. The EAC was found out to be Rs. 258.78; same as that of BAC as CPI is 1.

$$\text{EAC} = \text{BAC}/\text{CPI} \tag{10}$$

(f) Variance At Completion (VAC): VAC was found out to be zero.

$$\text{VAC} = \text{BAC} - \text{EAC} \tag{11}$$

(g) To Complete Performance Index (TCPI): The TCPI for the project was 1. TCPI greater than 1 implies performance must be increased and less than or equal to 1 implies that it should be maintained. Performance in terms of cost.

$$\text{TCPI} = (\text{BAC} - \text{EV})/(\text{BAC} - \text{AC}) \tag{12}$$

IX. Conclusion

Most of the government initiated infrastructure projects are delayed and get finished years after there scheduled completion. From the intricate analysis of the questionnaire survey and the case study, it has been found that delay in land acquisition is the major cause for the delay in the road infrastructure projects. The delay in land acquisition is an owner or client related delay factor that is an excusable type of delay. The two major parameters that determine the success of the project is overall project cost and time. In the case study project, it has been found that there is an unfavourable schedule variance while the cost variance is favorable. By looking through all the parameters of the earned value management that is applied in the case study, it has been found that the root cause for the delay in the road infrastructure projects are delay in land acquisition which is an owner/client related factor and excusable type of delay. So, the contractor can claim for extension of time (EoT) if the delay is excusable. Since for executing any road projects, the client should provide the necessary land acquisition and sort out any other disputes related to land acquisition before the beginning of the project. Even the removing of all encroachment in the project area i.e. in the land acquired for the project should be sorted out well ahead to avoid delays. There should not be any bottlenecks between the state and the central government for any infrastructure projects. Since infrastructure brings economy to the country, any delays have to be avoided by clients and the contractors. In case of any delays, EVM is found to be helpful in finding out the probable completion time for the projects.

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