



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 7, July 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118



9940 572 462



6381 907 438



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Extension of Time Analysis of Pre-Engineered Building Project Using Time Impact Analysis Method

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ABSTRACT: India's construction industry is an essential development indicator due to the opportunities it generates for investment across numerous connected industries. Pre-engineered structures have replaced conventional steel structures as an effective alternative. Primavera P6 appears to be a helpful tool for managing and monitoring construction projects, which significantly lowers the time required for an upgrade. This paper seeks to provide a review of how Primavera is used in construction project time management and delay analysis. The Time Impact Analysis (TIA) is used in this study to determine the extended amount of time needed to complete the pre-engineered building construction, which comprises delays.

KEY WORDS: Pre-engineered structure, Primavera p6, Time impact analysis, Extension of time.

I. INTRODUCTION

A revolutionary change is taking place in the Indian construction industry, moving away from conventional construction techniques and toward more modern ones. One such step is the use of pre-engineered technology, which is anticipated to increase the efficiency of the building process by optimizing the use of resources on the work site, minimizing waste production, and accelerating the completion of projects. The pre-engineered building construction method has advanced in terms of time constraint, cost efficiency, enhanced behavior of the structure, and advanced architectural outlook.

Each construction project's success depends on time and cost factors. Project management is essential for the successful completion of construction project. Project management is the technical practice of controlling several aspects of a project, including time, cost, quality, and labour management under varying task conditions. It is difficult to monitor the progress of events, to track the time and cost, to refresh work advancement, and to use regular approaches for preparation of the field task in project management. For effective project management and problems related to overspending on budget and time, various methodologies and techniques are available. The most popular project management tool in use today is called Primavera.

Delays are one of the obstacles that must be overcome when executing construction activities. Delay analysis has become necessary for construction projects because they anticipate delays, which increase construction costs. In the construction sector, time is among the most valuable things, and delays can end up causing the completion date to extend. As a result, project managers and contractors need to foresee how a certain event would affect remaining events in schedule. Time impact analysis is one of most precise techniques for obtaining such an assessment. A TIA is a schedule delay analysis method created to make it easier to grant contract time extensions for delays which is not general contractor's fault. It examines and evaluates the effects of a project completion delay on a baseline or updated project schedule. It is crucial to update overall project schedule to take changes into consideration whenever something affects on project timeline, such as the change of order, issue, or another delay. However, estimating the precise amount of time that one of these events may delay the project schedule is not always simple.

II. LITERATURE REVIEW

Lovneesh Sharma et al. (2021) [1]: The main objective in this study is comparing pre-engineered structures and conventional structures. A pre-engineered building is designed and a comparative analysis is carried out in relation to a conventional building having same configuration. The software mainly used for this whole design and analysis part was Bentley STAAD PRO. The pre-engineered building was found to provide more sustainable results compared with traditional steel infrastructures. The use of pre-engineered buildings should be implemented as its cost of constructing and maintaining pre-engineered buildings is significantly lower than in conventional steel infrastructures. The materials used to construct the prefabricated buildings were prefabricated and are assembled in a way that allows materials to be reused and recycled later. In relation with this aspect, all the structural components can be moved anywhere, fulfilling the main aspect of sustainable building.

Jeffrey Boon Hui Yap et al. (2021) [2]: By identifying the main reasons for construction project delays and exploring the underlying causes, this study adds to the theory and practise of construction schedule management. To get the opinions of 148 Malaysian construction professionals from client, consultant, and contractor organisations, a field survey was used. The five main causes are identified based on an importance index that integrates frequency and severity indices, and they are improper planning and scheduling, an excessive number of client change orders, ineffective site management and supervision, inefficient subcontractor management, and contractor financial difficulties. The five main managerial skills that affect schedule delays, according to factor analysis, are competency, communication and coordination, financial, site, and risk management. The global construction industry can benefit from these findings by reevaluating delay sources and realigning project management procedures to ensure projects are finished on time.

Hindu Odugu et al. (2020) [3]: The comparison of precast and monolithic technologies using aluminium formwork is the main objective of this study. Monolithic construction and precast construction technologies were used to estimate the construction costs of an eleven-story structure. Construction activity scheduling and tracking are done using Primavera P6. This study's primary goals are to discover emerging technologies in the field of construction, make recommendations for their use to speed up building and evaluate their cost-effectiveness. It also compares the costs of the two techniques. The paper also includes the amount of time needed to construct both techniques. Cost comparisons revealed that there is a difference, with precast construction being far more expensive than monolithic construction. According to the study's findings, the precast building is highly productive, produces the fewest wastes, depends less on the workforce, and is, also economical.

Uma Ravi Teja Macherla et al. (2020) [4]: In this paper, the viability of structural steel and concrete, as well as precast building from time and financial standpoint is examined. A 16-story structure with six floors designated as parking and remaining floors designated as offices is a case study taken into consideration for this work. The optimal amount of time needed at various stages of these two structures is calculated using Primavera P6-2017, which is intended for time schedules. The aforementioned two building systems and the details provided here are taken into account when calculating the cost of the structure. The client will have the option of a composite structure since it will reduce the construction period by 33 days. From a cost perspective, structural steel is a somewhat expensive material. Precast structures may require more time to assemble than composite structures do, but cost analysis shows that they will be more cost-effective overall.

Jawad A. Alsuliman (2019) [5]: The purpose of this article is to look into the delay factors of Saudi public construction projects. The cause of delays are classified according to the stages of construction project, namely details prior to tender award, details during the tender award, details after tender award, and general elements. A focus group was used to identify 50 delay aspects for the study. A questionnaire section is conducted to 211 construction industry members and identified 20 reasons for delays. To calculate effect of each cause of site delays, final simplified formula is constructed. Using the proposed simplified formula, case study is conducted for demonstrate percentage time delay compared to its original schedule. The study's findings are meant to offer people participating in public construction projects acceptable options for dealing with any delays.

Hesham A. Abdel-Khalek et al. (2019) [6]: The purpose of this paper is to describe a technique for producing fully documented claims quickly and efficiently utilizing the PCM software and Primavera P6. Additionally, it shows how users can perform delay analyses by using primavera contract management, which is connected to PCM program. A suitable delay analysis method was chosen with the researched project type in consideration to create exact delay and categorize it into four groups. At the conclusion of the project, the analysis was implemented from the perspectives of the owner and the contractor. This study examines the efficiency of PCM in planning and monitoring building projects. Finally, using one of web-based systems, primavera contract management, and primavera p6, this study established innovative technique to track project documents to reduce construction claims and perform delay analysis.

Pier Luigi Guida et al. (2019) [7]: The current work addresses the issue of schedule delays by collecting existing literature and expanding certain recently published solutions. They specifically establish the idea of a "float bank" as a way to divide and allocate responsibility for delays between the project's owner, contractor, and force majeure. Introduce a complete case study as well as the application of an algorithmic method that may be useful to project management practitioners and stakeholders. These techniques may be integrated with external or internal software to support current project control, legal proceedings, and the emergence of so-called forensic project management.

Diana M. Franco-Duran et al. (2019) [8]: Construction industry experts frequently resource load schedules using scheduling software without considering the ensuing critical path. This study examines the existence of phantom float (activities with float but little actual float) in Microsoft Project and Primavera P6 schedules. The actual float may be shorter than anticipated or may not exist at all after the phantom float has been removed from the schedule, causing non-critical operations to become resource-critical. Users of P6 and MS Project should be aware that the software ignores the presence of resource limits while calculating total float since it uses a time-based context (LF - EF and/or LS - ES). As a result, contrary to what the standard time-based context definition of the total float says, the float reported cannot be trusted or utilized to mitigate delayed activities.

VPS Nihar Nanyam et al. (2017) [9]: Although precast technology is regarded as a mature technology on a global scale, despite its benefits, it is not commonly used in India. The primary goal of this study is to categorize and identify precast technology problems. To address some of the issues, this study also provides a cost analysis model comparing precast technology to conventional construction. Precast technology and conventional technology were both used in the construction of two projects, and an inference was made comparing the time and cost features of precast technology. For the projects taken into consideration in the research, the cost of using precast technology is 15–30% higher than the cost of conventional technologies.

K. Joseph Shrestha et al. (2017) [10]: In order to automatically generate and visualize project and as-built schedules during and after construction, this study creates computational methods and prototype system. Using data from an actual roadway project, the algorithm is validated. The study is anticipated to considerably help State Highway Agencies (SHAs) use field data more effectively, make it easier to build as-built schedule, track construction progress more accuracy, and use an as-built schedule for productivity analysis.

III. OBJECTIVES

- a. To identify the activities required for the pre-engineered construction project.
- b. To plan and schedule the activities according to project requirements.
- c. To identify the delay events in PEB construction.
- d. To perform an extensive Extension of Time (EOT) analysis using Time Impact Analysis Method.

IV. METHODOLOGY

The extension of time analysis of the pre-engineered building project is conducted using the Time Impact Analysis method (TIA). Time Impact Analysis (TIA) approach was used for schedule delay analysis of a G+3 storeyed PEB educational building. An as-planned schedule was prepared to start the delay analysis. After identification of construction delays, the delay analysis method was applied using the project management software, Primavera P6. This work is conducted in four stages i.e. collection of the data, listing activities of pre-engineered buildings, determination of causes, types and liability of delays and finally conducting the EOT analysis using Time Impact Analysis. In this analysis, only the durations taken by each activity was analyzed. Original time period of the PEB construction work determined in the As-planned schedule was 374 days. The impact of this identified delays on the critical activities were calculated in terms of project completion duration. In order to determine the changes and delays in the execution of the construction, the delayed events were added to the as-planned schedule logically. The TIA approach was selected to examine the delayed events in the critical activities because these delays increased the project's duration. The project's Critical Path Method included a mark for the identified delayed activities. The first delay fragnet for the depicted delay which was "delay in preparing General Arrangement (GA) drawing" was prepared and introduced into as-planned schedule and "1st Revised Schedule" was prepared and new completion duration of the project was re-calculated into 386 days. This "1st Revised Schedule" was taken as a baseline for the next delayed fragnet which was "Difficulty in mobilizing all labourers to the site" and this delayed activity was inserted to make "2nd Revised Schedule". "2nd Revised Schedule" is formed and the new project completion duration is obtained as 392. Above steps and calculations was repeatedly updated for the remaining 6 delayed events, thereby, new revised

schedules and new project completion durations was obtained. After adding the last delayed event, the result of the final revised schedule is recorded, and total impact of the delay in the schedule is calculated in the end.

V. RESULTS AND DISCUSSION

Construction delay which impacts on the duration of the pre-engineered educational building project was analyzed using Time Impact Analysis method with help of Primavera P6. With the application of the TIA method, accuracy of records of various delays was very important. This investigation found that there were lots of issues during the whole construction process, which unavoidably caused delays in the original timeline. Results of the analysis and the discussions are presented below.

Delay No.	Identified Delays	Name of Impacted Activity	Impacted activity code (IAC)
1	Delay in preparing General Arrangement (GA) drawing	Preparing General Arrangement drawing	A1020
2	Difficulty in mobilizing all labourers to the site	Mobilizing labourers to the site	A1090
3	Problems in site marking	Site marking	A1110
4	Unforeseeable weather conditions in the casting of foundation	PCC of foundation	A1140
5	Late beginning of fabrication work at the factory	Beginning of fabrication work at factory	A1180
6	Delay in transporting erection materials to the site	Transporting erection materials to site	A1250
7	Problems in the erection of all steel columns.	Erect all steel columns on RCC columns	A1280
8	Getting late permission for site close-out	Site close-out	A1820

Table 5.1: Summary of delay identification

Activity ID	Activity Name	Original Duration	Start	Finish	Total Float
PRE-ENGINEERED BUILDING Revised 8th schedul		365	23-Oct-21	22-Dec-22	0
Pre-construction		70	23-Oct-21	12-Jan-22	0
A1840	Delay 1: Delay in preparing General Arrangement (GA) drawing	20	23-Oct-21	15-Nov-21	0
A1850	Delay 2: Difficulty in mobilizing all labours to the site	7	05-Jan-22	12-Jan-22	0
Construction		90	31-Jan-22	14-May-22	0
Substructure		18	31-Jan-22	19-Feb-22	0
Earthwork		3	31-Jan-22	02-Feb-22	0
A1860	Delay 3: Problems in site marking	3	31-Jan-22	02-Feb-22	0
Civil work		6	14-Feb-22	19-Feb-22	0
A1870	Delay 4: Unforeseeable weather conditions in casting of foun	6	14-Feb-22	19-Feb-22	0
Superstructure		53	15-Mar-22	14-May-22	0
A1880	Delay 5: Late beginning of fabrication work at factory	6	15-Mar-22	21-Mar-22	0
A1890	Delay 6: Delay in transporting erection materials to site	15	06-Apr-22	22-Apr-22	0
A1900	Delay 7: Problems in erection of all steel columns	5	10-May-22	14-May-22	0
MEP		0			0
Post Construction		7	15-Dec-22	22-Dec-22	0
A1910	Delay 8: Getting late permission in site close-out	7	15-Dec-22	22-Dec-22	0

Fig 5.1: Delay allocation using primavera

From the results of TIA analysis, it is shown that among the 8 identified delays, 3 delays occur from the owner, 4 delays are from the contractor and remaining 1 delay is due to unforeseeable conditions in weather. The allocation of projects delays among the parties can be shown below.

Sl. No	Liabe Party	IAC	No. of Delays	Total days of delays
1	Owner	A1020	20 days	30 days
		A1110	3 days	
		A1820	7 days	
2	Contractor	A1090	7 days	33 days
		A1180	6 days	
		A1250	15 days	
		A1280	5 days	
3	Unforeseeable weather conditions	A1140	6 days	6 days
Total Impact on Schedule				69 days

Table 5.2: Summary of allocation of delays to project parties

Thus, from the table, we can understand that the delays caused by owner extended the project by 30 days, while the delays caused by contractor is 33 days and unforeseeable conditions in weather caused a total of 6 days delay. Even though the project site works on 6 days per week with a working period of 8 hrs per day, the project finish date is extended from 12 October 2022 to 23 December 2022. That means the project got delayed by 69 days because of this eight construction delays. This means, the project duration is extended by 18.45 %.

Extension of Time (EOT) is the additional time required to complete the project due to any delay which is not the contractor's fault or delay resulting from unforeseen conditions preventing it from finishing within the specified scheduled time. In other words, an EOT can be provided for all the excusable delays that occurred in the project. The summary of project delays according to their types is given below.

Sl. No	Types of Delay	Liabe Party	Total days of delay	Net total delays
1	Excusable	Owner	30 days	36 days
		Unforeseeable weather conditions	6 days	
2	Non - Excusable	Contractor	33 days	33 days

Table 5.3: Summary of Project Delays According to delay types

Since the total excusable delays evaluated for the above pre-engineered educational building is 36 days, an extension of time of 36 days should have been given for the completion of this project which is evaluated using the Time impact analysis method with the help of Primavera P6 software.

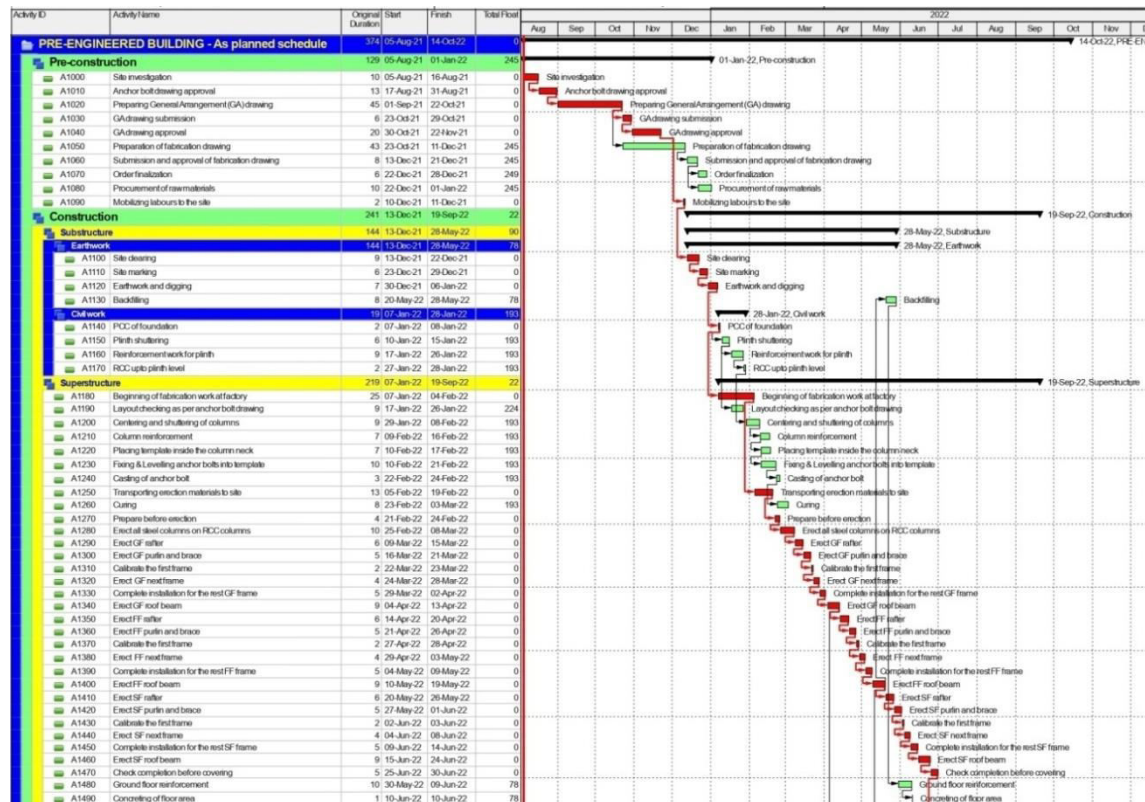


Fig 5.2: As-planned schedule prepared in primavera p6

VI. CONCLUSION

This study is conducted to analyze some of the delays that are likely to occur in the construction of G+3 storeyed pre-engineered educational buildings and to evaluate the impact of the identified delays on the project completion duration to find out the extension of time. The Extension of Time (EOT) analysis is carried out with the help of one of the delay analysis methods named Time Impact Analysis (TIA) method by using Primavera P6 software. As Pre-engineering building is a newly emerging technology in our places, this study helped in acquiring some knowledge related to the different construction stages of PEB and its structural details. These details are used in the preparation of As- Planned Schedule needed for this delay analysis process. The schedule of PEB is entirely different from the schedule of a conventional building. The identification of delays served as the basis for the delay analysis. Determining project delays and their clear causes is essential for the accuracy of the schedule delay analysis. To determine which party was in charge of these issues, analysis was carried. The delay's causes and responsible parties were collated in a tabular form. Finally, the delay types were identified and presented side by side based on how easily they could be compensated. The following are the significant critical activity delays that the Time Impact Analysis approach took into account:

1. Delay in preparing General Arrangement (GA) drawing
2. Difficulty in mobilizing all labourers to the site
3. Problems in site marking
4. Unforeseeable weather conditions in casting of foundation
5. Late beginning of fabrication work at the factory
6. Delay in transporting erection materials to the site
7. Problems in the erection of all steel columns.
8. Getting late permission for site close-out

From the study, following conclusions were made.

- Pre-engineered structures come with plenty of advanced techniques of construction, integrated sources, cost-

effective design, etc. Thus, it concludes that the fastest-building type in terms of construction time is a pre-engineered building.

- Delays in construction schedule can cause major issues for both the contractors and owners as it will result in overshooting of time, cost, and assigned resources for the entire project which leads to a conflict between them.
- Time Impact Analysis (TIA) method helps to show the progress of construction activities step by step with the help of Primavera software.
- Main advantage of TIA method is that the situation of construction on the updated dates can be pictured clearly.
- To arrive at an accurate analysis of construction schedule delays, it is critical that the delay analysis able to reflect the actual process of the construction.
- The delayed events are entered into as-planned schedule respectively to see the changes in project. Therefore, this analysis method is most realistic.
- In this study, a total of 16 delays are identified among which 8 are critical delays that affect the critical activities and the project duration while the remaining 8 are non-critical delays that did not impact the total duration.
- The critical delays are included in the Time Impact Analysis method.
- As per the analysis, the difference between the original duration of the As-planned schedule and the delay introduced revised schedule is 69 days. That is, the impact of critical delays in this project is 69 days.
- With a total of 69 of days delay, 36 days of delay are excusable delay which is out of the contractor's control. So we can conclude that this project is able to demand a claim for an extension of time of 36 days.

Thus, from this study, we can conclude that Time Impact Analysis is the best technique to determine the extension of time caused due to construction delays in a construction project.

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