Use of Delay Analysis Techniques (DAT) to Minimize the Time Overrun in Construction Projects

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Abstract

Construction projects need to balance time, cost, and quality consistently. Out of that, one of the most crucial components of any project is time. Time management is essential to the success of every project. This study's objective was to propose strategies to minimize the time overrun of construction projects through the identification and analysis of delay-causing factors as well as the application of delay analysis techniques. A total of 63 delay-causing factors were identified after a thorough search of the literature, and they were divided into seven categories: client-related, contractor-related, consultant-related, material-related, equipment-related, labor-related, and external. The significance of the mentioned factors was evaluated using the responses to a questionnaire survey. Respondents primarily represented construction enterprises with specialists in the CS2 to C3 grades. The Relative Importance Index (RII) was used to translate the collected responses into quantitative values. The findings indicated that, among the seven categories, the material-related category is the most influencing category causing delays. Additionally, results revealed that MS project is the most used delay analysis technique in the present construction industry. In addition, motives and barriers regarding the most commonly used techniques were also highlighted. The investigation of the same data clustering the contractors for their grades is suggested as a final suggestion.

Keywords— *Construction delays,Delay causing factors,Time overrun,Delay analysis techniques*

Introduction

The construction industry plays an important role in any economy. The success of a construction project greatly depends on the project management triangle, which comprises cost, time, and quality. Of these triple constraints, time is one of the most important components of every project. Clients, contractors, and consultants all want to make sure that construction projects are completed on schedule and within budget to the expected quality standards. It has been observed that there is a time overrun in the construction industry because of not using delay analysis techniques to mitigate construction delays. Further, this industry is suffering from a major issue of time overrun or delay continuously for many years[1]. Loss of time in any project influences the project success drastically[2].

The purpose of this study was to investigate the factors that lead to construction project delays, investigate the most popular techniques for analyzing delays; and suggest the techniques that would be most effective in reducing delays.

The suggestion of delay analysis techniques to minimize the time overrun is the primary objective of this research. The importance of this kind of research can be pointed out as follows.

- Being able to finish a particular project on time
- Minimizing the effects of cost overrun
- Minimizing disputes regarding the construction project[3]

Thus, this research will be helpful for all the parties concerned in the construction industry in Sri Lanka regarding delay-causing factors, delay analysis techniques, and many more appropriate techniques to reduce time overrun.

Construction Delays

The time overrun, which is happening far off the admitted finalization date or else the date of the contractual milestone as a result of unexpected circumstances, can be defined as a delay in the construction industry. Constant disputes and claims arise due to this most common drawback in the construction industry[4]. Delays are acknowledged by construction companies as one of the major problems they face.

Work delays and productivity losses, late project completion and higher time-related costs, third-party claims, and contract abandonment or termination are all outcomes of delays. General management must closely monitor project progress to lower the likelihood of delays and/or identify them early[5].

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There are four kinds of delays, namely non-excusable delays; excusable non-compensable delays; excusable compensable delays; and concurrent delays[6, 7, 8]. When the contractor simply causes or supposes the risks, they can be categorized as non-excusable delays, while excusable non-compensable delays can be described as delays that happen because of unpredictable factors that are beyond the control of the contractor. Excusable delays, suspensions, or any kind of interruptions to the project and any breach of responsibility by the owner declared or suggested in the contract can be defined as compensable excusable delays, and when both the owner and the contractor are responsible for the delay, those can be identified as concurrent delays[9].

Effects of Construction Delays

The three most common consequences from the perspective of the contractor and consultant were time overrun, cost overrun, and dispute. Late in revising, delayed approval of design documents, delays and conflicts happen in subcontractors' work; delays happen when getting approval for major changes, which is mainly the highly inducing time overrun causes in construction projects[3].

Delay Analysis Techniques

Delay analysis is a logical method to predict the possible delays that should be carried out with the help of the project documentation and gathered data from the project site. A few frequently used delay analysis methods are mentioned below as suggested by previous researchers[6, 8, 9, 10, 11]

- Impacted as-planned method

This method consists of combining the as-planned schedules with all the delays of a particular party to form an adjusted time frame. The difference between the completion date of the amended as-planned timetable and the expected completion date indicates the time the other party is responsible for.

- Snapshot/windows/time slice analysis method

This technique is a back-dated technique that splits the project duration into smaller timeframes, which are commonly known as windows, and measures the as-built critical path for each time frame. A comparison between the as-planned and as-built schedules occurs while mirroring the as-built conditions for each time frame.

- Time impact analysis method

This method differs from the window technique previously stated in that it focuses on a single delay or delaying event rather than a period that includes delays or delaying events.

- As-planned versus as-built windows analysis method

By observing a comparison between the as-planned schedule and the as-built schedule, it can be identified delayed commencements, extended durations, and overdue completions. This comparison continues to the planned commencing and finishing dates with respect to the actual commencing and finishing dates of the activities on the as-planned critical and near-critical paths[10].

- Planning and monitoring software (Ex:MS Project)

The day-to-day data collection of site work, i.e., starting time, finishing time, completed tasks, etc., is needed to analyze project delays using MS project software. These are recorded in MS Project, distinguishing between tasks and critical activities, as well as the reasons for the delays. The collected data can be analyzed using MS Project. On the other hand, the project scheduling technique used in MS Project to link activities is called the Critical Path Method (CPM). Then, the project's overall baseline duration can be determined. This includes the earned value management tool in new updates, which is a more accurate method for analysis.

Methodology

This study was carried out to investigate and analyze the delay-causing factors and the most commonly used delay analysis techniques and recommend the most appropriate techniques to be used to minimize time overrun. A questionnaire was prepared to support the identification of factors that cause construction delays, to require the opinion of construction experts such as engineers, and project managers. Through a comprehensive literature survey based on the studies done by[3, 9, 12, 13, 14, 15, 16] 63 critical factors which may cause to construction delays were identified. Those factors were categorized into seven categories namely client-related, contractor-related, consultant-related, material-related, equipment-related, labor-related and external-related. Five-point Likert scale was used to get the responses from the experts in the construction industry. Adhering to purposive sampling techniques, 102 responses have been received from the

Table 1: *Influence of Different factors on Construction Delays*

Category	Description	RII of factors	Rank of factors	RII of categories	Rank of categories
Material related factors	Shortage of construction materials in market	3.89	1	3.52	1
	Delay in material delivery	3.63	2		
	Problem with material transport and processing at site	3.58	3		
	Changes in material types during construction	3.49	4		
	Delay in manufacturing special building materials	3.49	4		
	Late procurement of materials	3.47	5		
	Quality problem with procured material	3.42	6		
	Procuring undesired or unwanted material instead	3.36	7		
	Damage of sorted material while they are needed urgently	3.33	8		
Client related factors	Slowness in decision-making process	3.72	1	3.44	2
	Late in revising and approving design documents	3.68	2		
	Suspension of work by owner	3.48	3		
	Delay in approving shop drawing and sample materials	3.45	4		
	Change orders by owner during construction	3.37	5		
	Delay to furnish and deliver the site	3.37	5		
	Poor communication and coordination	3.36	6		
	Conflicts between joint-ownership of the project	3.34	7		
	Delay in progress payments	3.17	8		
Equipment related factors	Equipment breakdowns	3.56	1	3.43	3
	Lack of heavy equipment when needed	3.55	2		
	Shortage of equipment	3.54	3		
	Lack of hi-tech and advanced equipment	3.48	4		
	Difficulty in transporting equipment	3.48	4		
	Low level of equipment-operator's skill	3.37	5		
	Low productivity and efficiency of equipment	3.37	5		
	Unavailability of special equipment	3.35	6		
	Wrong kind or verity of equipment	3.15	7		
Contractor related factors	Difficulties in financing project	3.86	1	3.38	4
	Delays in sub-contractors' work	3.49	2		
	Conflicts in sub-contractors' schedule in execution of project	3.4	3		
	Conflicts between contractor and other parties	3.37	4		
	Ineffective planning and scheduling of project	3.33	5		
	Rework due to errors during construction	3.31	6		
	Poor communication and coordination	3.29	7		
	Improper construction methods implement	3.16	8		
	Inadequate contractor's work	3.16	8		

***Table 1**: Continued....*

Category	Description	RII of factors	Rank of factors	RII of categories	Rank of categories
External factors	Weather effect on construction activities	3.73	1	3.33	5
	Delay in obtaining permits from municipality	3.43	2		
	Effects of subsurface and ground conditions factors	3.42	3		
	Delay in performing final inspection and certification	3.37	4		
	Delay in providing services from utilities	3.34	5		
	Changes in government regulations and laws	3.29	6		
	Traffic control and restriction at job site	3.19	7		
	Civil unrest and public strikes	3.13	8		
	Accidents during construction	3.07	9		
Consultant Related Factors	Delays in producing design documents	3.47	1	3.32	6
	Mistakes and discrepancies in design documents	3.45	2		
	Delay in approving major changes in the scope of work	3.42	3		
	Insufficient data collection and survey before design	3.3	4		
	Inadequate experience of consultant	3.28	5		
	Poor communication and coordination	3.28	5		
	Unclear and inadequate details in drawings	3.27	6		
	Un-use of advanced engineering design software	3.25	7		
	Inadequate experiences	3.17	8		
Labour related factors	Low productivity level of labors	3.58	1	3.25	7
	Shortage of labors	3.51	2		
	Labor health problem when working in hazardous conditions	3.27	3		
	Labor Safety problems	3.24	4		
	Personal conflicts among labors	3.05	5		
	Labor exodus	3.05	5		
	High labor wages	3.04	6		
	Working permit of labors	2.94	7		
	Labour strikes at site	2.81	8		

questionnaire survey, which was carried out through a Google form and a physical questionnaire form. A statistical analysis was conducted to rank the significance level of delay causing factors. In addition, one section of the data collection questionnaire was utilized to determine awareness of delay analysing techniques, the most common delay analysing technique, motives for utilizing delay analysing techniques, and barriers to using delay analysing techniques.

Relative Importance Index (RII) as shown in Equation (1) was used for ranking delay-causing factors, the importance of delay analysis techniques and also their motives and barriers to use as delay analysis techniques.

$$RII = \sum \frac{a \cdot n}{N} \tag{1}$$

Where, RII - Relative Importance Index, a - Constant expression weight (1 to 5) based on five-point Likert Scale, n - Frequency of response N - Total number of responses.

Results and Discussion

The survey began by identifying the backgrounds of the respondents, including their positions, companies, etc. It aided in ensuring the accuracy of the data that was gathered.

Relative Important Index Analysis

The Relative Importance Index (RII) of each delay-causing factor was initially determined based on the responses collected. Additionally, RII was calculated for each category and the overall results are shown in Table 1 The most significant factor categories that are related to construction delays are material-related categories, which were determined by using the average RII values for each category.

Delay Analysis Techniques

There are many methods for delayed analysis. Those delay analysis techniques are stated in Figure 1 and the number of respondents who are using those techniques as a percentage.

According to Figure 1, 94.2% of respondents said they use MS Project for delay analysis in their construction projects. That's the most commonly used technique. 12.8% are using earned value management as their delay analysis method in their construction projects.

As a result of these two graphs, the most commonly used delay analysis technique is MS Project. In addition to that, earned value management is the second most commonly used delay analysis technique. Others have fewer applications.

Then the study focused on investigating the motives to use MS Project as a delay analysis technique. The majority of the respondents who use MS Project stated that they use MS Project since it is easy to monitor and user-friendly. So, the MS Project method has some special qualities. Motives to use MS Project Data are used to identify those special qualities.

According to Figure 2, 79.3% of respondents mentioned that MS Project is easy to monitor. In addition to that, 52% of respondents mentioned that MS Project is user-friendly as the most common reason for using MS Project as a delay analysis technique in construction projects.

Further, it was investigated whether there are any barriers to use MS Project as a delay analysis technique. The received responses are shown in Figure 3.

According to that, 59.2% of respondents mentioned that lack of practice is the top most barriers to use MS Project. In addition to that, a lack of expertise is the second reason that the respondents have identified as a barrier.

Conclusions and Future directions

When considering projects separately, the success of a project depends on how it achieves project objectives, which are to be completed within the estimated time duration, the estimated budget, and the required quality. Because of this matter, identifying delay-causing factors and using techniques to minimize time overrun is very important.

This study was focused on investigating and analyzing delay-causing factors, the most commonly used delay analysis techniques, and recommending the most appropriate techniques to be used to minimize the construction delay in construction projects. Through searching for the relevant literature, 63 delay-causing factors under seven different categories namely client, contractor, consultant, material, equipment, labor, and external-related factor categories were identified. The questionnaire survey was conducted among the professionals in construction companies that have registered in CS2 to C3 grades. Analysis was done for 102 responses.

As per the respondents' view, the material-related category is the most affecting category for construction delays. Then, the usage of delay analysis techniques and the most commonly used techniques were identified. More than 50% of respondents are using delay analysis techniques. The most commonly used technique for delay analysis was found to be MS Project, and the second most commonly used tech-

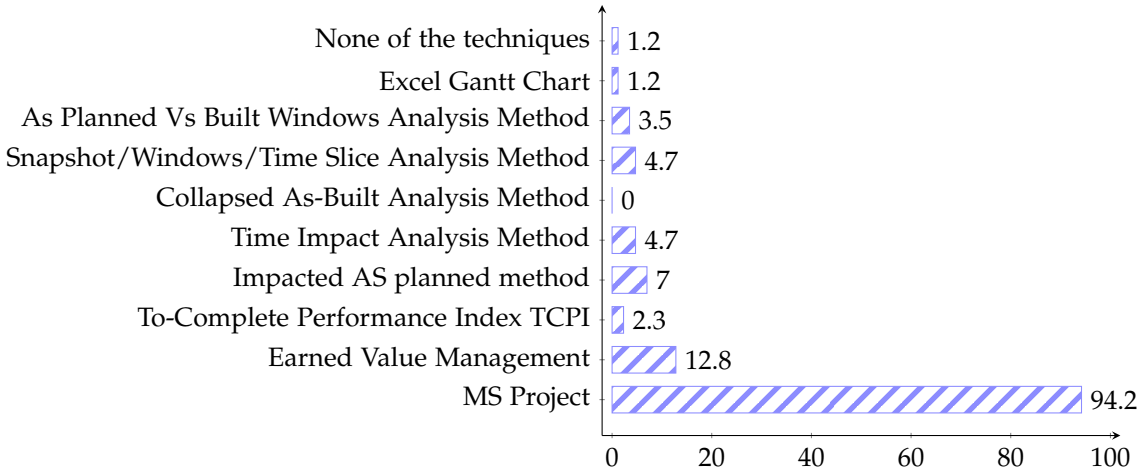

Figure 1: *Use of Delay Analysis Techniques*

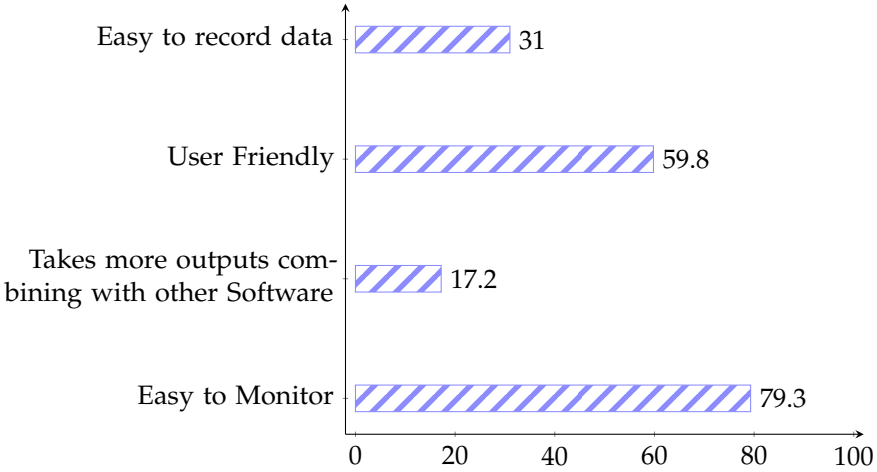

Figure 2: *Motives to use MS Project for delay analyzing*

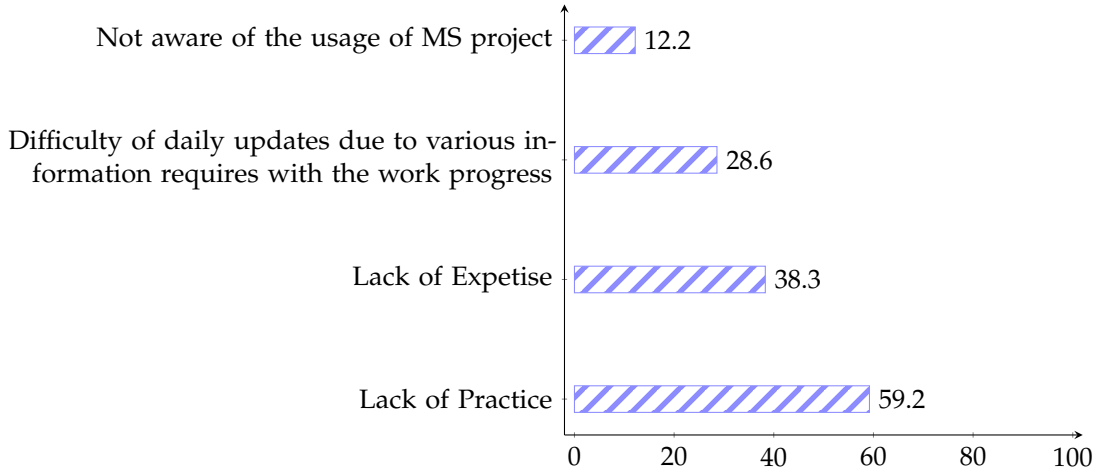

Figure 3: *Barriers to use MS Project for delay analyzing*

nique was earned value analysis. These are the most appropriate techniques to be used to minimize construction delays. According to the results, there are some motivations and barriers to using MS Project and earning value analysis. The suggestions have been summarized according to the analyzed results for both techniques.

- Train the relevant employees (site engineers, technical officers, etc.) to give practice these techniques and help them become an expert using those techniques.
- Conduct awareness campaigns to emphasize the importance of MS Project and value management.
- Conduct a program to give regular updates about these techniques to workers

So, these activities will help to improve the skills of these techniques for professionals and to use as delay analysis techniques to minimize delays for those who do not use these kinds of techniques. Using the right techniques, such as MS Project and earnvalue management, the critical delay causes among the seven delay categories that were found from the questionnaire data can then be reduced.

This research was conducted with some limitations, this study can be extended to all construction sectors in Sri Lanka and provide a common solution such as delay analyzing techniques to minimize time overrun considering the whole construction industry in Sri Lanka. Therefore, that study can be done using contractor categories C4 to C10, government-funded projects, semi-government projects, mega projects, etc. These parties can be classified as public and private sectors, as well as clients, consultants, and contractors, and the above mentioned conclusion can be validated for all sectors of the Sri Lankan construction industry. In addition to that, there is another way to carry out this study, which is to analyze the same information by clustering the contractors for their grades for further study. With that, specific delay-causing factors which cause time overrun and specific delay analysis techniques which are used to minimize time overrun for different grades of contractors can be identified.

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Conflicts of Interest

The authors declare that there are no financial interests or non-financial conflicts or conflicts of interest related to this research that could have influenced this research.

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