Comparison of CPM based Delay Analysis Methodologies

Gaurav N Sachdev[1], Prof. Mukund R Apte[2]
[1, 2] Civil Engineering Department
[1, 2] Maharashtra Institute of Technology, Pune

Abstract- *Time is of the essence in any construction project to all the parties involved in the project. Hence, it is quite important for the parties involved in the project to analyze the project delays for the purpose of making right decisions on potential time and/or cost compensation claims. Over the years, existing Delay Analysis Methodologies (DAM's) have been helpful in this decision-making but have not succeeded in reducing the frequency of occurrence of disputes associated with delay claims and its resolutions. Most of the disputes are due to the limitations and capabilities of the techniques in their practical use. This paper seeks to develop a knowledge and understanding of these limitations and capabilities of these methodologies. In this paper, six CPM based delay analysis methodologies were studied. This study indicates that the methods such as 'as – planned vs as – built', 'impacted as – planned' and 'as – planned but for' are relatively inexpensive, easy to perform and understand and require less detailed information but give relatively less accurate results for a given delay claims scenario, and are more prone to manipulations, whereas the more sophisticated methods such as 'collapsed as – built', 'window analysis' and 'time impact analysis' are relatively more expensive and time consuming and require more skills and detailed project information, but, give more accurate results for similar delay claims scenario.*

Keywords- construction claims, cost escalation, critical path method, delay analysis, extension of time

I. INTRODUCTION

The duration of a project has a direct effect on the profit from the construction project from the perspective of all the parties involved in the contract [1, 2]. For the client, lost profits or benefits occur from being unable to make use of the project at the agreed date, while to the contractor, extra cost will be incurred due to prolonged stay on site. Most standard forms of contract thus have provisions that anticipate if delay is brought about by the actions and/or inactions of the contractor, the client or is outside the control of both parties.

Hence, delays in a construction projects are a major source of disputes between various parties involved in the project and most difficult to resolve [3, 4, 5]. To resolve these disputes, allocation of delay is to be done to determine the compensation to be paid by the client to the contractor, or liquidated damages to be paid by the contractor to the client. If this compensation or liquidated damages' cost is high, it will require methodologies giving more accurate results. For this purpose, analysis of delays is to be done to determine the amount of delay caused by each party resulting in the delay of the project.

This has attracted the interests of many researchers and industry practitioners to enhance the application of existing delay analysis methodologies. Despite of many contributions, none of the existing delay analysis methodologies is successful in gaining a universal acceptance for addressing all the problems that affect a project [5, 6, 7].

This paper aims at comparing different existing delay analysis methodologies to identify the advantages and limitations of respective methods over other methods followed.

II. EXISTING DELAY ANALYSIS METHODS

The existing Delay Analysis Methodologies (DAM's) are classified under two heads, i.e. the ones which follow the Critical Path Method (CPM) called CPM based methods and the ones that do not follow the Critical Path Method, called non-CPM based methods.

The following table gives a list of existing DAM's

Table 1. Existing Delay Analysis Methodologies

Existing Methodologies	
Non-CPM Based Methods	S-Curve
	Global Impact Technique
	Net Impact Method
CPM Based Methods	As-Planned Vs As-Build
	As-Planned But For
	Impacted As-Planned
	Collapsed As-Build

	Window Analysis
	Time Impact Analysis

This study is limited to the CPM based methods. Hence, only the methods that are based on the critical path method are discussed further in detail.

1. As – Planned Vs As – Built

This method simply compares the activities of original as – planned CPM schedule to those of the as – built CPM schedule. The difference in the duration of activities gives the amount of delay in the project. This method is easy to manipulate.

The main advantages of this method are:

- It is an inexpensive method
- Easy to perform and understand
- Does not take much time to perform
- Does not require project management software for analysis of delays

Limitations of this method are:

- It ignores the dynamic nature of the critical path [8]
- It does not analyze the types of delays
- It does not take into consideration the impacts of individual delays on project completion date
- It fails to consider any changes in the schedule program

2. As – Planned But For

In this method, all the delays of one party (client) are added to the as – planned schedule. The new completion date of this schedule is compared to the completion date of as – built schedule. The difference in completion dates gives the total delay for which the other party (contractor) is responsible. This delay can then be directly claimed for.

The main advantages of this method are:

- No need to consider the actual progress of work
- It considers the delay types that affect the project duration
- Can be performed quickly

Limitations of this method are:

- The as – planned schedule should be accurate and realistic
- All the information should be available at once
- It is a theoretical analysis
- It gives different results for different parties

3. Impacted As – Planned

In this method, all the delaying events are added to the as – planned schedule in a chronological order. The impact on the project completion date is calculated while adding each delay event. The impact is calculated by comparing the project completion dates before and after the addition of each delay event.

The main advantages of this method are:

- The as – built schedule is not required
- It can be used to determine individually, the effect of the owner's delay, or contractor's delay, or both together.
- It can be also used for what-if analysis to predict possible delays.

Limitations of this method are:

- It fails to consider any changed in the critical path
- The as – planned schedule should be accurate and realistic
- It may cause potential disputes over the adequacy of the as-planned schedule as it is not economically possible to schedule the entire project in detail at its inception [9]
- It is a theoretical approach

4. Collapsed As – Built

This method uses the as – built schedule instead of as – planned schedule. It involves removal of delays of one party (client) from the as – built schedule to give the effect of delay due to the other party (contractor) on the project completion date. The effect of delay is calculated by comparing the completion dates of collapsed schedule with the planned schedule. The difference in completion dates gives the delay due to the other party which can be directly used to make a claim.

The main advantages of this method are:

- It is based on actual events on the project
- It gives fairly accurate results

Limitations of this method are:

- It fails to consider any changes in the critical path
- The removal of the delays from the as – built schedule could result in an unrealistic As – Built But For schedule
- It becomes very difficult to identify the as – built critical path
- This method requires high level of experience to get accurate results

5. Window Analysis

In this method, the total project duration is divided into a number of time periods or 'windows'. The dates defining the boundaries of these windows are often determined by major project milestones, occurrence of major delay events and dates for the issue of schedule revisions or updates. These factors determine the number of windows and their durations for the whole project duration. The number of windows is directly proportional to the accuracy of the analysis.

Schedule within the each window is sequentially updated using the as – built information including all the delays encountered in that period, while, the remaining as – planned schedule beyond that window is left unchanged. The difference between the project completion date of the schedule resulting from the current window and that prior to it gives the amount of project delay as a result of the delays within that window. This analysis is then performed for each of the remaining windows to determine the effect of all other delay events on the project completion.

The main advantages of this method are:

- It divides a complicated network into a manageable one
- It takes into account all the changes in the critical path
- It offers a very effective approach for analyzing delays
- It gives highly accurate results
- We can decide the number of windows according to the desired accuracy of results

Limitations of this method are:

- It is a time consuming process
- It is costly to perform
- It requires detailed project records which are often not available
- It is very difficult to decide the number of windows as the results change with changes in the number of windows and their respective durations[10]

6. Time Impact Analysis

This method is a variant of the window analysis method, with the difference being that the time impact analysis focuses on a specific delaying event and not on the time periods containing these delaying events. A snapshot of the project is developed each time it experiences a major delaying event. The schedule is then updated at this delay event and the effect of the delay is analyzed to establish a new completion date. The difference between the new completion date and the completion date prior to this delay event gives the delay caused by that particular delaying event.

The main advantages of this method are:

- The delays are analyzed using real time CPM schedule
- It can be used both, during the project duration as well as after the completion of the project
- This is the most reliable technique
- It takes into account the dynamic nature of critical path

Limitations of this method are:

- It is a time consuming process
- It is costly to perform
- It requires detailed project records which are often not available
- It may not be practical or realistic to use if there are a high number of delay causing events

III. CONCLUSION

It is well documented that claims related to project delays are now a major source of dispute in the construction industry. Consequently, there has been much desire to reduce or completely avoid this problem and this has created considerable research interest among researchers and practitioners.

Six different methodologies for analyzing delays (DAMs) have been reported in the literature. These are not only referred to by different terminologies, they also differ based on their mode of application, the type of programming technique and the baseline programme used. As such, they produce different results of staggeringly different levels of accuracy when applied to a given claims situation.

None of the existing DAMs is perfect as each has its own strengths and weaknesses. The more sophisticated methods are reported as being more accurate and reliable than the simplistic ones, although the former group requires more expense, time, skills, resources and project records to operate than the latter.

There is also no single DAM that is universally acceptable for all claims situations. The methodology selection for any given situation depends on a number of criteria. However, apart from the fact that these criteria may vary from analyst to analyst, they are qualitative, subjective and imprecise in nature, making their use in methodology selection open to challenge and disputes.

Thus, the methods such as 'as – planned vs as – built', 'impacted as – planned' and 'as – planned but for' are relatively inexpensive, easy to perform and understand and require less detailed information but are relatively less accurate and more prone to manipulations, whereas the more sophisticated methods such as 'collapsed as – built', 'window analysis' and 'time impact analysis' are more expensive and time consuming and require more skills and detailed project information, but, give more accurate results for similar delay claims scenario.

Hence, the selection of a delay analysis methodology depends on the cost and time allocated for analysis, skill of persons performing the analysis, nature of project, whether a detailed information about the project is available or not, the effect of delay on the project and the quantum of delay claims, i.e. how much would a claim cost to either party, as higher claims would require methods which would give more accurate results.

REFERENCES

[1] Akintoye, A.S.; Skitmore, R.M. Profitability of UK construction contractors. J. Construction Management Economics 1991, 9, 311–325.

[2] Majid, M.Z.A.; McCaffer, R. Factors of non-excusable delays that influence contractors' performance. J. Construction Engineering Management ASCE 1998, 14, 42–49.

[3] Finke, M. R. Window analysis of compensable delays. J. Construction Engineering Management ASCE 1999, 125, 96–100.

[4] Society of Construction Law (SCL). Protocol for Determining Extensions of Time and Compensations for Delay and Disruption; SCL: Burbage, UK, 2002.

[5] Pickavance, K. Delay and Disruption in Construction Contracts, 4th edition; Sweet & Maxwell: London, UK, 2010.

[6] Hegazy, T.; Zhang, K. Daily window delay analysis. J. Construction Engineering Management ASCE 2005, 131, 505–512.

[7] Peters, T.F. Performing forensic delay analyses from deep within the black tent. AACE Int. Trans.2007, 2, CDR.01.1–CDR.01.9.

[8] Stumpf, G.R. Schedule delay analysis. J. Cost Engineering 2000, 42, 32–43.

[9] Schumacher, L. Quantifying and apportioning delay on construction projects. J. Cost Engineering 1995, 37, 11–13.

[10] Zhang, K. Daily window delay analysis. J. Construction Engineering Management ASCE 2005, 131, 505–512.