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# COMPARATIVE STUDY OF VARIOUS DELAY ANALYSIS METHODS IN CONSTRUCTION INDUSTRY

**Ombir Rathee[1] & Tanuj Singh Kalirawana[2]**
[1&2]Assistant professor, Department of Civil Engineering, Ganga Technical Campus, Bahadurgarh, Haryana, India

## ABSTRACT

The construction industry in India is a critical segment because of its huge commitment to the nation's financial advancement. This in regards to work openings and fascination of Foreign Direct Investments which is the main contributor to the nation's GDP. However due to the topographical, political, social and money related circumstance of the nation, numerous construction projects are subjected to delay. These delay often results into the dispute between the various parties involved in a project due to their own interests. The primary point of this paper is to discover the present situation in Indian construction industry about the delay analysis methods and Delay protocols utilized by the experts. In this paper various delay analysis methods are studied in detail and they are compared based upon their applicability, requirement and suitability for various kinds of construction projects. Regardless of various constructions delay analysis methods are there in industry just those are thinks about which are prescribed by SCL Delay Protocol and AACE Forensic Schedule Analysis.

***Keywords :*** *Delay analysis, SCL Protocol, AACE forensic Schedule analysis, Time Impact Analysis*

## I. INTRODUCTION

Construction is the backbone of the development of any country. Every year government invest a large amount of money into public infrastructure and other projects. Delay in completion of such kind of projects usually result in the cost overruns and the delay in operation of any such kind of facility will lead to lost revenue to the owner.

In construction, delay could be defined as "the time overrun either beyond completion date specified in a contract or beyond the date that the parties agreed upon for delivery of a project"

## II. PROBLEM STATEMENT

According to ministry of statics and programme implementation (MoSPI), Government of India, during year 2016-17 a total number of 1222 major(costing ₹150-₹1000 crore) & mega (costing more than ₹1000 crore) projects were on monitor. A total 364 projects were behind the original schedule (ranging 1 to 261 months) and the cost overruns for these delayed projects are around 20.11% w.r.t. original approved cost.

Delay of projects often leads to disputes and arbitration which again include extra cost and time. For resolving claims related to extension of time and compensation it is very important to analysis the cause of delay and its impact on the project completion based on which EoT and compensation related claims can be addressed well.

## III. AIMS & OBJECTIVE

This study aims to identify the various DAMs from literature and to identify the various methods or DAMs to analyze the delay and EOT related claims that are being used by professionals in Indian construction industry.
This research work will be carried out keeping the following activities in mind:-

- To review the state of the art in delay management.
- To study SCL protocol and AACE Forensic schedule analysis
- To review delay analysis techniques.

## IV. LITERATURE STUDY

There is a number of of DAMs that can be identified from the construction literature but the only few are globally accepted and preferred by the professionals Arditi, Pattanakitchamroon (2006) indentified four methods while six methods were identified for their comparative analysis by Nuhu Braimah (2013). Alkass, Mazerolle & Harris (1996) identified six methods and one methods Isolated Delay Technique is also proposed. Hegazy (2012) identify five methods for comparison between them.

Delay Protocol by SOCIETY OF CONSTRUCTION LAW likewise suggests 6 methods for dissecting the delay. FORENSICS SCHEDULE ANALYSIS by AACE universal acknowledge four DAMs to be utilized for examining the construction delay. A similar outcome from writing is appeared underneath tabular from.

***Table 1 : DAMs identified from literature review***

| Sr. no | Author | Year | DAMs Indetified |
|---|---|---|---|
| 1 | *Alkass, Mazerolle & Harris* | *1996* | *1. Global impact technique*<br>*2. Net impact technique*<br>*3. Adjusted as-built cpm technique*<br>*4. But for' or collapsing technique*<br>*5. Snapshot technique*<br>6. *Time impact technique* |
| 2 | *Bordoli and Baldwin* | 1998 | *1. As-built bar chart*<br>*2. Scatter diagram*<br>*3. Critical path method*<br>4. *As-built subtracting impacts* |
| 3 | *Arditi, Pattanakitchamroon* | 2006 | *1. As-planned vs. As-built method*<br>*2. Impact as-planned method*<br>*3. Collapsed as-built method*<br>4. *Time impact method* |
| 4 | *Khalid & Mohan* | 2011 | *1. Global impact*<br>*2. Impacted As-Planned*<br>*3. Time impact*<br>*4. Window-IDT*<br>*5. Window-But For*<br>6. *Window-snapshot* |
| 5 | *Hegazy* | 2012 | *1. Global impact method*<br>*2. Net impact method*<br>*3. As-planned impacted method*<br>*4. Planned but for method*<br>5. *As-built but for method* |
| 6 | *Nuhu Braimah* | 2013 | *1. As-Planned vs. As-Built*<br>*2. Impacted As-Planned*<br>*3. As-Planned But for*<br>*4. Collapsed As-Built*<br>*5. "Window" Analysis*<br>6. *Time Impact Analysis* |
| 7 | *Maduranga, Palamakumbura & Dissanayake* | 2016 | *1. As-Planned vs. As-Built*<br>*2. Impacted As-Planned*<br>*3. As-Planned But for*<br>*4. Collapsed As-Built*<br>*5. "Window" Analysis* |
| 8 | *SCL Delay Protocol* | 2017 | *1. Impacted As Planned Analysis*<br>*2. Time Impact Analysis* |

| | |
|---|---|
| | 3. *Time slice window analysis*<br>4. *As planned vs. as Build window analysis*<br>5. *Retrospective Longest Path Analysis*<br>6. *Collapsed As Built Analysis* |

After going through the various research papers, journals, conference proceedings and unpublished sources following six DAMs are found to be most commonly used:-

a) Impacted As Planned Analysis
b) Time Impact Analysis
c) Time slice window analysis
d) As planned vs. as Build window analysis
e) Retrospective Longest Path Analysis
f) Collapsed As Built Analysis

## V. DELAY ANALYSIS METHODS (DAMS)

### 5.1 The impacted as-planned analysis method

The impacted as-planned analysis method is based on inserting the delay events in form of sub-networks into as planned schedule and the critical path method (CPM) programming software are generally used in order to access the infleuence of these delays have on the scheduled/expected completion dates shown in the baseline planned schedule. Before involving oneself into the analysis, the analyst needs to check that the logic and durations for the works shown in the schedule are reasonable, has the realistic duration, achievable in stated time duration and has the well defined logic in the activity sequences, so as to check the risks that the schedule contains flaws which cannot be overcome. In general it is seemed to be easiest and cheapest method of delay analysis but it doesn't consider the actual progress and any change in the schedule during the project This DAM will indicate the impact of each individual activity on the baseline schedule. In some cases it is the best suited for EOT assessment. Some of such conditions include where the impacted as-planned method is prescribed in the contract conditions and/or where the delay events being considered occur during the course of the project.

### 5.2 The Time Impact Analysis

The time impact analysis (TIA) involves first creating the sequence of logically linked activities for the change order and then introducing this sub network into a logic-linked baseline/schedule programme and then impact of this update is calculated using CPM programming software so as to determine the prospective impact this particular delay event on the expected completion date. The baseline programme for every analysis should essentially be the most recently updated baseline programme (i.e. an Updated Programme); this is because it may bo possible that the revised contemporaneous (updated) programme may have logic changes / activity / resource changes from the original baseline (scheduled) programme. So, first of all the analyst needs to check that the baseline (scheduled) programme's past events reflect the actual progress of the works in the project and its future activities and their durations for the works are reasonable, realistic to achieve them and properly logically linked to each other within the software. Any mitigation and pace in the past activities had already been incorporated into the updated baseline programme need to be considered as these can mislead the analyst in calculating the impact of delay on project. The number of delay events occurred in a particular project has a great impact on the complexity involved in analysis and cost incurred in deploying this method. This method generally does not consider the eventual actual delay caused by the delay events as subsequent project progress is not considered.

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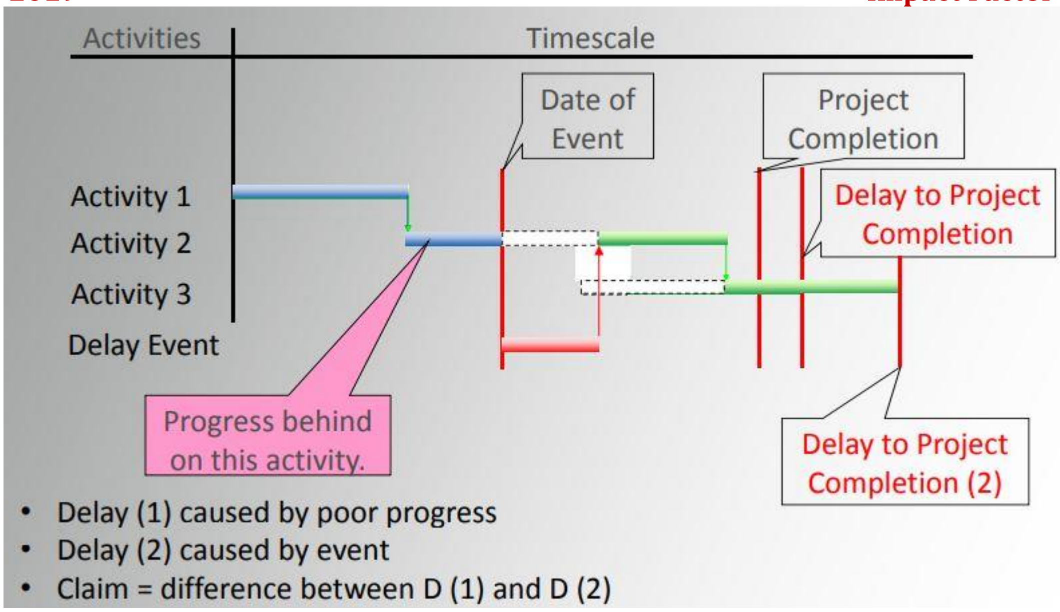


***Figure 1 Time Impact Analysis***

***<u>5.3 The Time Slice Window Analysis Method</u>***

In this method the analyst first check (or develop) the baseline schedule of the project or revise the schedule as per the latest actual progress of the work. The whole project is divided into a number of time slices/ windows of equal durations. The windows may be of weekly, monthly durations or from one milestone to another. The series of time slice programmes reveals the contemporaneous or actual critical path in each time slice period as the works progressed and the critical delay status at the end of each time slice, thus allowing the analyst to conclude the extent of actual critical delay incurred within each window. Then analyst examine each window individually and the delay occurred is each window will be reflected the completion date at the end of the window. The rest project or time slices are adjusted accordingly.

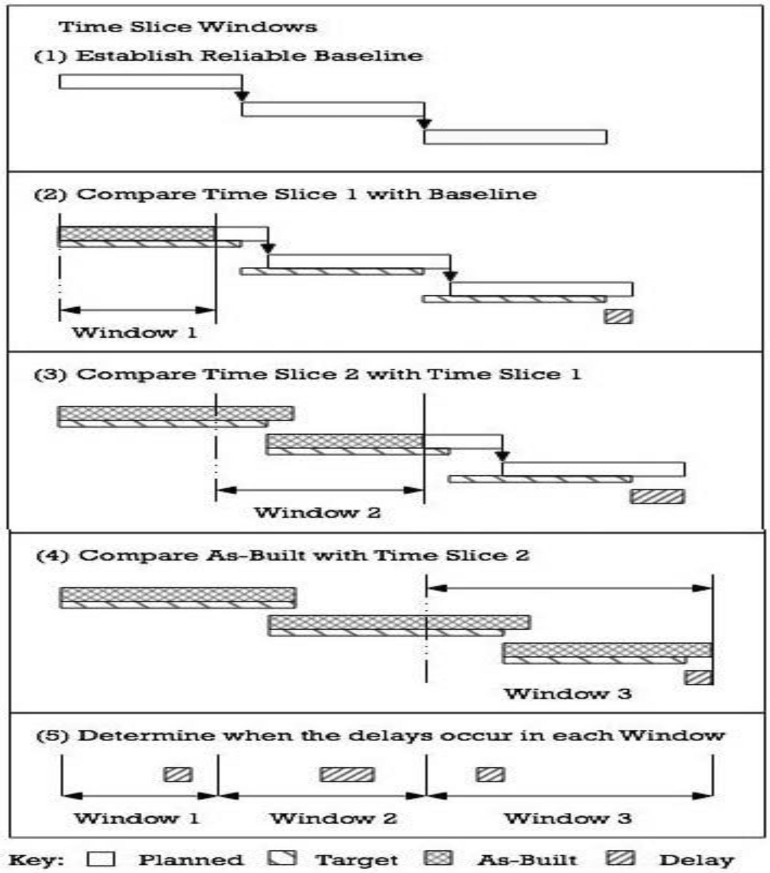


*Figure 2 The Time Slice Analysis Method*

**5.4 As-Planned Versus As-Built Windows Analysis Method**

The as-planned versus as-built windows analysis method is the second of the 'windows' analysis methods. As distinct from a time slice analysis, it is less reliant on programming software and usually applied when there is concern over the validity or reasonableness of the baseline programme and/or contemporaneously updated programmes and/or where there are too few contemporaneously updated programmes. In this method, the duration of the works is broken down into windows. Those windows are framed by revised contemporaneous programmes, contemporaneously updated programmes, milestones or significant events. The analyst determines the contemporaneous or actual critical path in each window by a common-sense and practical analysis of the available facts. As this task does not substantially rely on programming software, it is important that the analyst sets out the rationale and reasoning by which criticality has been determined. The incidence and extent of critical delay in each window is then determined by comparing key dates along the contemporaneous or actual critical path against corresponding planned dates in the baseline programme. Thereafter, the analyst investigates the project records to determine what delay events might have caused the identified critical delay. The critical delay incurred and the mitigation or acceleration achieved in each window is accumulated to identify critical delay over the duration of the works.

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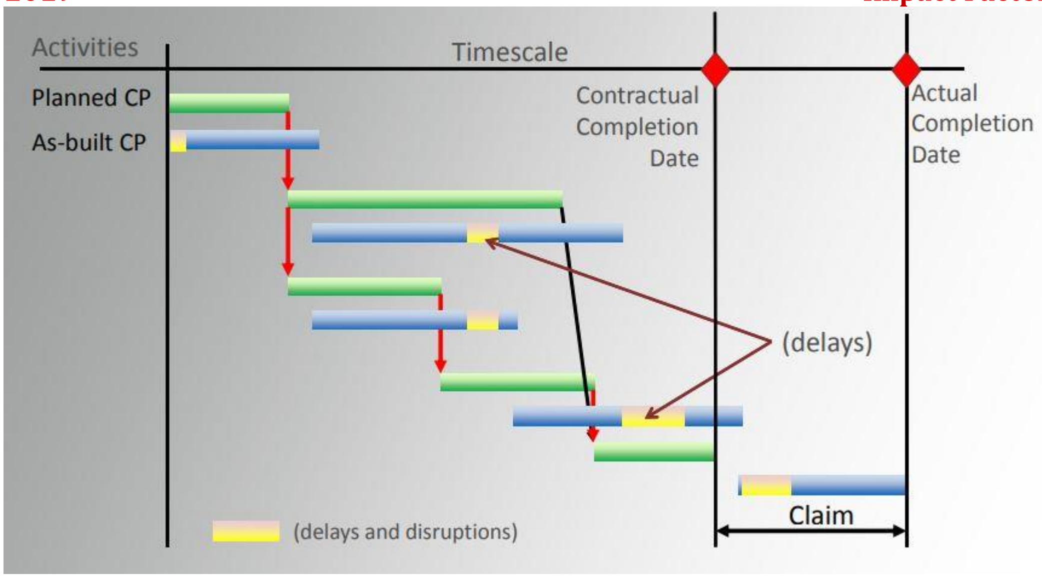


*Figure 3 As Planned vs As Built*

**5.5 Retrospective longest path analysis method**

The retrospective longest path analysis method involves the determination of the retrospective as-built critical path (which should not be confused with the contemporaneous or actual critical path identified in the windows methods above). In this method, the analyst must first verify or develop a detailed as-built programme. Once completed, the analyst then traces the longest continuous path backwards from the actual completion date to determine the as-built critical path. The incidence and extent of critical delay is then determined by comparing key dates along the as-built critical path against corresponding planned dates in the baseline programme. Thereafter, the analyst investigates the project records to determine what events might have caused the identified critical delay. A limitation to this method is its more limited capacity to recognize and allow for switches in the critical path during the course of the works.

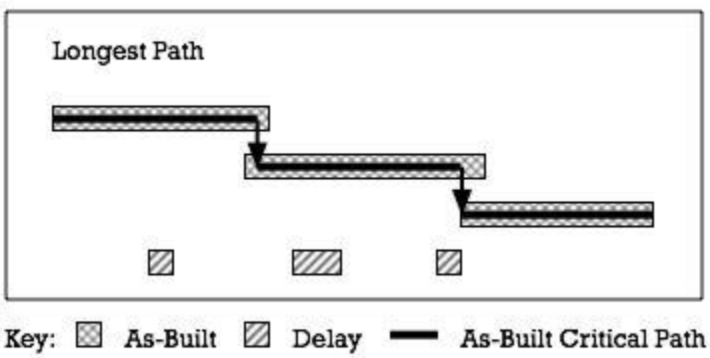


*Figure 4 Retrospective Longest Path Method*

**5.6 Collapsed As-Built (Or But-For) Analysis Method**

The collapsed as-built (or but-for) analysis method involves the extraction of delay events from the as-built programme to provide a hypothesis of what might have happened had the delay events not occurred. This method does not require a baseline programme. This method requires a detailed logic-linked as-built programme. It is rare that such a programme would exist on the project and therefore the analyst is usually required to introduce logic to a verified as-built programme. This can be a time consuming and complex endeavor. Once completed, the sub-networks for the delay events within the as built programme are identified and they are 'collapsed' or extracted in order to determine the net impact of the delay events. This method is sometimes done in windows, using interim or contemporaneous programmes which contain detailed and comprehensive as-built data. A limitation to this method is that it measures only incremental delay to the critical path, because the completion date will not collapse further than the closest near critical path.

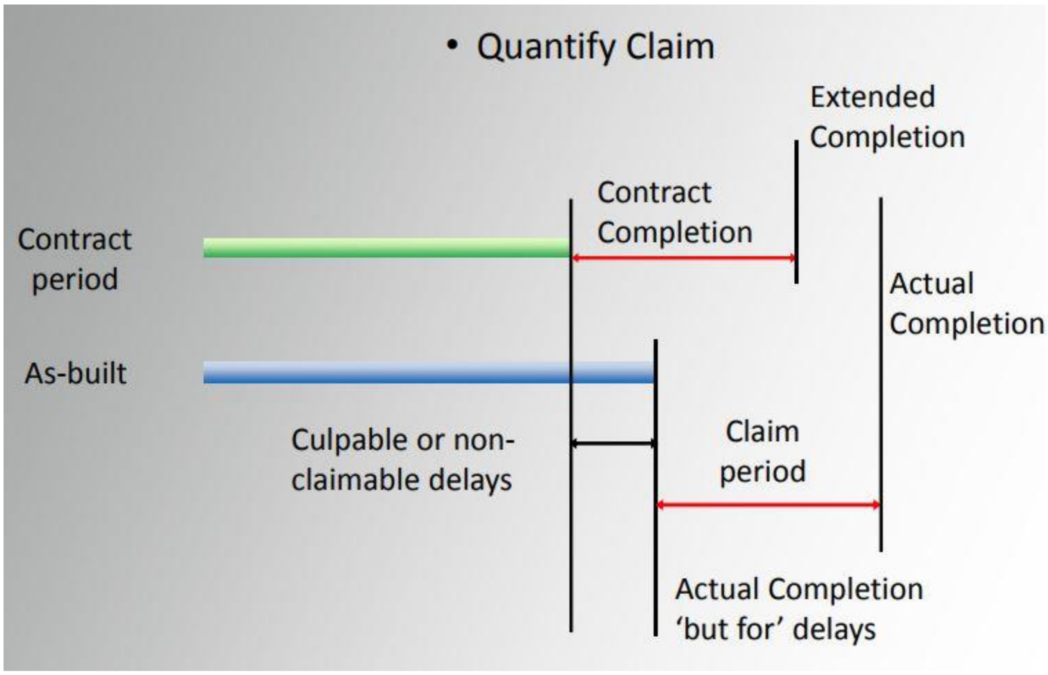


*Figure 52 Collapsed As-Built (Or But-For) Analysis Method*

## VI. CONCLUSION

In the previous section all six DAMs are applied to the real project in order to give an basic idea of their application and applicability.

The selection of a particular DAM will depen upon the data required, time allowed for analysis and scope of the analysis. There is no single DAM that can satisfy all the condtionds or that can be used for every type of project. But still the most important factor on which selection of DAM depends is the data available for the analysis. Below table represent the type of data that will be required to use that particular DAM.

*Table 2 : Data required for Various DAMs*

| DAMs | Data Required for the Analysis | | |
|---|---|---|---|
| | **As planned ( Baseline) Schedule** | **Most Recently Updated Schedule** | **As Built Schedule/Recordes** |
| As Planned v/s As Built | ✓ | | ✓ |
| Impacted As Planned | ✓ | ✓ | |
| Collapsed As Built | | | ✓ |
| Time Slice Window Analysis | | ✓ | |

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| | | | |
|---|---|---|---|
| Time Impact Analysis | | ✓ | |
| Retrospective Longest path | ✓ | | ✓ |