

# Comparison of Construction Delay Analysis Methods

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**Abstract:** According to the Project Management Institute over 70% of the projects are not delivered in time due to several reasons. Different delay analysis methods and programming methods have been identified by different organizations and authors for carrying out delay analysis. The need for improved methods of programming construction projects to reduce the number of unjustified claims and better understanding of delays is essential. In this paper a case study project from Sanders, M. C. (2012), is selected. The selected project has used five different methods from AACEI's Method Implementation Protocols (MIP) methods for forensic delay analyses. In this paper, authors will use the EASYPLAN software to do the daily delay analysis. The authors will compare result of EASYPLAN with the outcome of Sanders, M.C. (2012) "Forensic Schedule Analysis Example Implementation Part II" and will comment on the solution.

## 1. INTRODUCTION

Delay is an incident that increases the time required to perform a task or project under the contract. Delays will be shown as extended or delayed start to the activity and it may or may not be change the scope of work under contract. As per the principles of project scheduling delays that are not on the critical path do not affect the duration of the project as long as they are inside the total float of an activity. So it become very important to identify the responsible for delay, the owner of the project cares about the liquidated damages to pay or they have to pay additional amount to the contractor. The contractor may claim additional money for the additional work or otherwise they may have to pay compensation charges to owner due to delays. Any delay in the project will increase total cost of the project and will be additional burden to the tax payers. Bonding companies and sureties care because they have to assure contractor progress (Stumpf, 2000).

Delays can be divided into three types serial, concurrent and independent. Serial delays occur mainly due to delays that occur in the preceding activities. Independent delays are mostly single however serial delays may be dependent on other delays. Concurrent delay may involve two or more events of delay in different activities. There may be two delay events that are not related but will be concurrent because they will occur on parallel critical paths (Stump 2000).

Most of the construction projects encounter delay events hence it becomes very important to quantify these delays. In literature various papers have been written in order to identify delays and then to find the responsible for delay on different construction projects. Responsible of delays can be owner, contractor or due to some unforeseen conditions such as extreme weather conditions. Some of the preferred methods for delay analysis are but for technique and the windows technique. Unfortunately most of the commercial software does not provide

representation for delays. A delay event is normally represented by dividing the activity into parts to introduce delays on commercial software. Hence it becomes a tough manual task to perform delay analysis using such commercial software (Hegazy 2005).

In this report section 2 deals with Forensic schedule Analysis. Section 3 consists of description of Easy Plan software and its features. Section 4 deals with methodology and results. Section 5 and 6 consist of conclusion and references.

## **2. FORENSIC SCHEDULE ANALYSIS**

### ***Daily Delay Analysis Method (DDM)***

In order to improve the limitations of window analysis, Hegazy & Zhang (2005) introduced changes to window analysis method. He proposed a daily windows method for allocating concurrent delays and accelerations. This method uses a window size of one day to account for all fluctuations that occur in the project's critical paths. It is considered as an important and accurate method. "It takes into consideration the effects of baseline updates, resource allocation and the effects of actions taken by the contractor to accelerate the project and minimize potential de- lays as it usually ignored in delay analysis" (Yang & Kao, 2009).

The best approach to consider all variations in critical path is to use small window size. With this analysis some of the steps can be refined to produce more practical results like when we introduce changes to the logical relationships among activities (Hegazy & Zhang, 2005). According to Hegazy & Zhang (2005), the daily window analysis has a practical value for industry practitioners and researchers. For industry practitioners it represents an organized procedure for evaluating delay responsibility and recording site progress. For researchers it embodies significant step toward developing dynamic progress control, resolving conflicts on projects and primary corrective actions

Benefits of Daily Delay Analysis are the following: (Hegazy & Zhang, 2005; Hegazy & Menesi, 2008)

- It is a flexible approach
- It has a potential of improvements
- After entering the data some of the steps can be refined
- It clearly show progress information and any delays
- It has a great ability to provide accurate and tra- ceable results.

### ***MIP 3.1 Observational/Static/Gross Analysis***

Observational/Static/Gross analysis is performed based on the Method Implementation Protocols 3.1 (MIP 3.1). In this method, the as-planned schedule is compared to the as-built schedule which is shown in Figure 1. The critical path in the as-planned schedule is used as to identify the delays. It can be seen that there are no additive or subtractive events from the schedule. Thus, the delays are analyzed by com- paring the as planned and as built schedules after it occurs. It should be noticed that the interim updates are not analyzed. This is because they only reflect a subset of the information that is ultimately captured in the final as built schedule. Besides, MIP 3.1 re- commends the following implementation of the Source Validation Protocols (SVPs): 1.

SVP 2.1 (baseline validation), 2. SVP 2.2 (as-built validation), 3. SVP 2.3 (update validation) and 4. SVP 2.4 (delay ID & quantification).

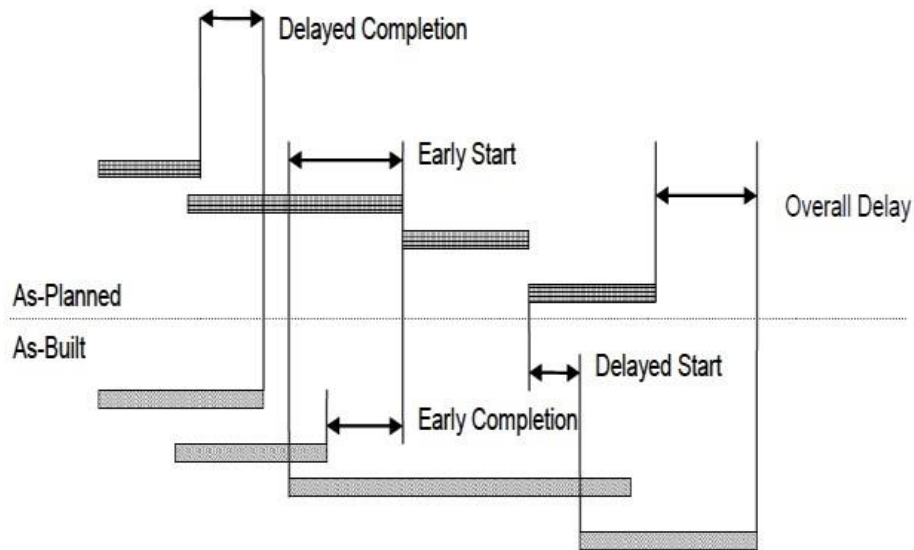


Fig. 1. MIP 3.1 Observational/Static/Gross Analysis (AACEI)

**MIP 3.2 Observational/Static/Periodic Analysis**

Observational /Static/Periodic analysis is performed based on the Method Implementation Protocols 3.2 (MIP 3.2). Similar to MIP 3.1, the as-planned schedule is compared to the as-built schedule in MIP 3.2 as shown in Figure 2. From this figure, it can be seen that the difference in MIP 3.2 as compared to MIP 3.1 is: the analysis is performed with multiple segments of the project instead of one whole continuum. In other words, MIP 3.2 is the enhanced method of MIP 3.1. Thus the method of MIP 3.2 is usually implemented after MIP 3.1. Same as in MIP 3.1, the critical path in the as-planned schedule is used as to identify the delays. As there are no additive or subtractive events from the schedule, the delays are analyzed by comparing the as planned and as-built schedules after it occurs. In addition, because the schedule is updated by the end of each period, thus the delays are analyzed by comparing the as planned and as built schedules in different periods. In MIP 3.2, same implementation of SVPs is recommended as in MIP 3.1.

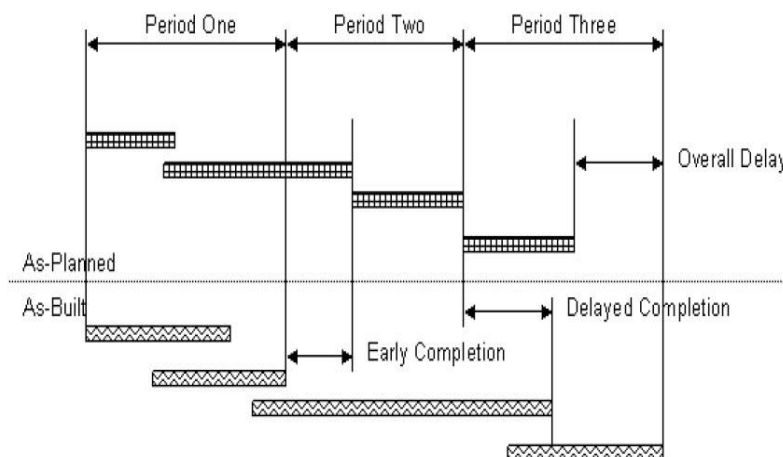


Fig. 2. Graphic illustration of MIP 3.2 Observational/Static/Periodic Analysis (AAC EI)

**MIP 3.8 Modeled/Subtractive/Single Simulation**

Modeled/Subtractive/Single Simulation is performed based on the Method Implementation Protocols 3.8 (MIP 3.8). In this method, a critical path method (CPM) model is selected first. Then, a scenario simulation is carried out based on this model. As shown in Figure 3, the analysis is performed after the delay occurs. The delay events are modeled in the as-built schedule. Thus, the delays are analyzed by removing delay events from as built schedule. In other words, it is a single simulation. Due to this, this method is a static logic one. It should be noticed that there is no progressive updates in the as-built schedule. That means, it is not forensically accurate. Besides, MIP 3.8 recommends the following implementation of the SVPs: 1. SVP 2.2 (as-built validation) and 2. SVP 2.4 (delay ID and quantification); as well as the enhanced SVPs of: 1. SVP 2.1 (base- line validation) and 2. SVP 2.3 (update validation).

**3. EASY PLAN**

Easy Plan (Hegazy 2007) is a software for scheduling, estimating, resource management, project control and delay analysis which is developed by using the VBA language of Microsoft Excel (Jafar, 2011).

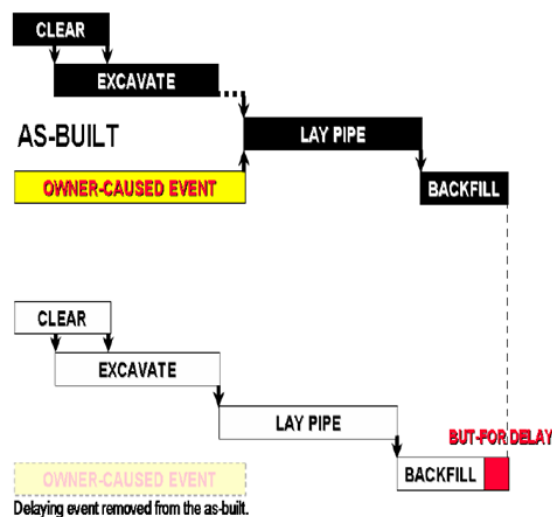


Fig. 3. Graphic illustration of MIP 3.8 Modeled/Subtractive/Single Simulation (AAC EI)

**Key features of EASYPLAN: (Jafar, 2011; Yang & Kao, 2009)**

- It allows the user to specify up to 3 estimates for each activity and to enter up to three key resources and to specify the daily limit of these resources
- It informs the user if the resource limits are exceeded and allows the user to change the method of execution of any activity.
- It permits more than one baseline to be saved.

- Daily progress of activities is entered as a percentage or as delay by each party.
- It allows the user to specify the project deadline and notifies the user if the project duration exceeds the deadline.
- It has two bars for activities: The top bar represents the baseline, and the bottom represents the progress.
- It takes into consideration all the delays, accelerations, and slowdowns.

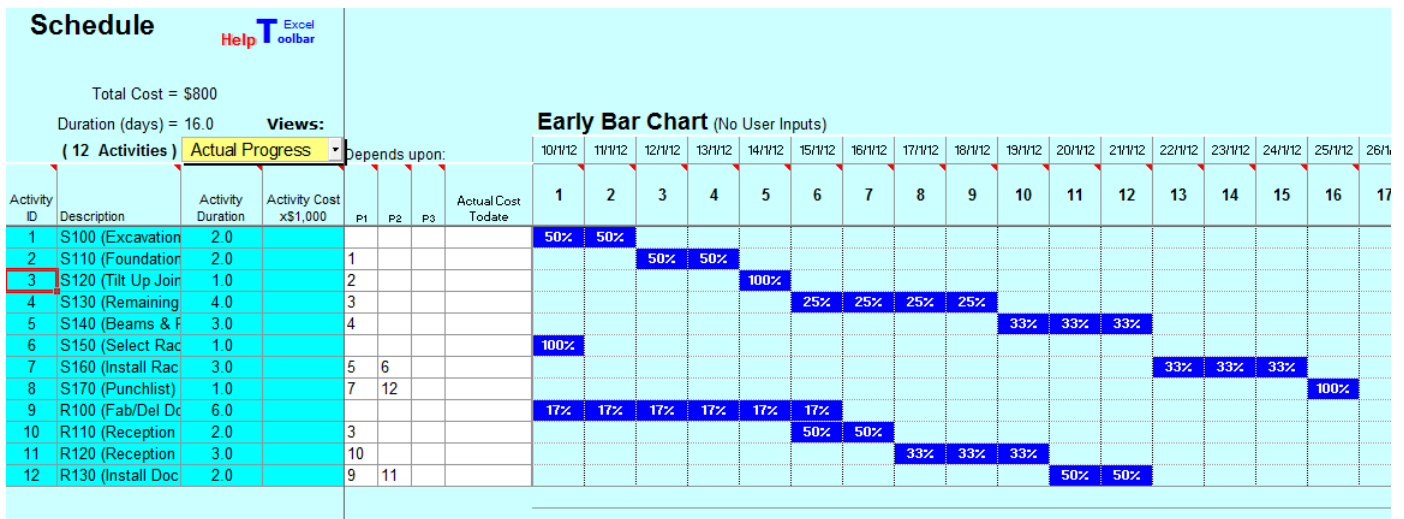


Fig. 4. As-planned schedule

#### 4. METHODOLOGY AND RESULTS

##### Methodology

The flow chart that shows the EASYPLAN procedure for performing daily delay analysis is depicted in fig. 5.

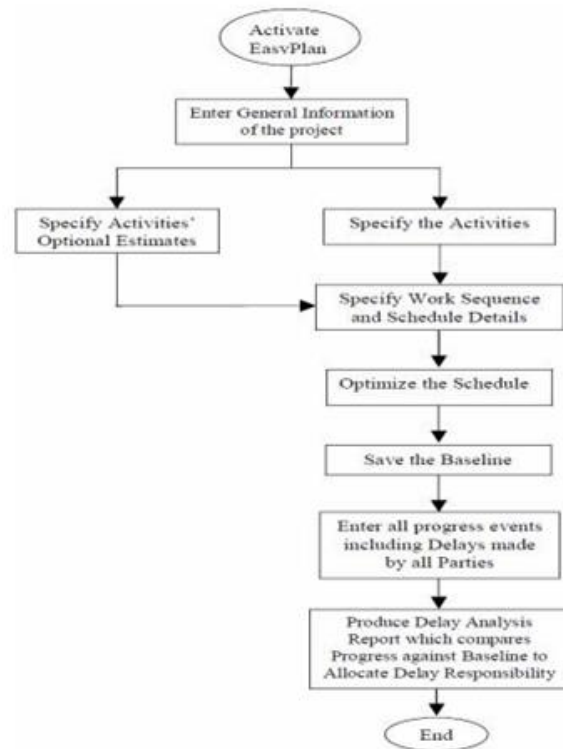


Fig. 5. Flow Chart for EASYPLAN Procedure (Jafar, 2011).

The following methodology was used to input data into EASYPLAN:

1. The data for the project (Sanders, 2012) was converted into the author's pre-defined manner for input into EASYPLAN.
2. Data including activity name, start date and activities duration were entered into MS-Project and then imported to EASYPLAN.
3. Schedule of project was prepared as depicted in fig. 4.
4. This schedule was saved as a “baseline” for the project shown in fig. 6.
5. All the progress was entered on a daily basis, using EASYPLAN "Enter daily progress" feature.
6. An As-built schedule of the project after entering all the events, in which the project finished on Day 24 with all the delays incorporated, was developed.
7. After entering the as-built progress, “Windows analysis” was selected to show a summary of delay analysis. (fig. 7)

## **Results**

EASYPLAN is user friendly software that provides a number of results for a given set of data for better understanding and analysis. For the daily delay analysis, EASYPLAN produced the following:

- A detailed schedule depicting as-planned vs. as-built (as shown in figure 8)
- Summary of the results as shown in figure 7.
- A text file that shows detailed analysis of the whole project on daily basis (including

owner and contractor delays as well owner directed or contractor's self-acceleration) and the reason for the delay. A sample of the text file is shown in table 1.

As depicted in figure 7, the results indicate that the contractor was responsible for seven days delay; owner was responsible for 3 days delays. There was acceleration of two days by the contractor.

Project As-Built Duration (days) = 24.0  
 Project Baseline Duration (days) = 16.0  
 Day: 1 (Tuesday, Jan 10 2012), Previous Duration = 16.0  
 Progress data of Day 1 is now entered. The result is:  
 Current Duration = 17.0  
 Activity 1-S100 (Excavation) has a O-delay because of Contractor uncovered Underground Storage Tank (UST) on Thursday of week 1 and asked for RFI  
 Compensable Owner delays (O) = 1.00, Owner Acceleration= 0.00.  
 Contractor delays (C) = 0.00, Contractor Acceleration= 0.00.  
 Excusable delays (N) = 0.00.

Table 1. Portion of EASYPLAN output for delay analysis

| Time (Day)                  | Owner Delay | Contractor Delay | Contractor Acceleration | Net Delay |
|-----------------------------|-------------|------------------|-------------------------|-----------|
| 1                           | -1          | 0                | 0                       | -1        |
| 2                           | -1          | 0                | 0                       | -1        |
| 3                           | -1          | 0                | 0                       | -1        |
| 4                           | 0           | 0                | 0                       | 0         |
| 5                           | 0           | 0                | 0                       | 0         |
| 6                           | 0           | 0                | 0                       | 0         |
| 7                           | 0           | 0                | 0                       | 0         |
| 8                           | 0           | 0                | 0                       | 0         |
| 9                           | 0           | 0                | 1                       | 1         |
| 10                          | 0           | -1               | 0                       | -1        |
| 11                          | 0           | -1               | 0                       | -1        |
| 12                          | 0           | 0                | 0                       | 0         |
| 13                          | 0           | 0                | 0                       | 0         |
| 14                          | 0           | -1               | 0                       | -1        |
| 15                          | 0           | -1               | 0                       | -1        |
| 16                          | 0           | -1               | 0                       | -1        |
| 17                          | 0           | 0                | 0                       | 0         |
| 18                          | 0           | 0                | 1                       | 1         |
| 19                          | 0           | -1               | 0                       | -1        |
| 20                          | 0           | 0                | 0                       | 0         |
| 21                          | 0           | -1               | 0                       | -1        |
| 22                          | 0           | 0                | 0                       | 0         |
| 23                          | 0           | 0                | 0                       | 0         |
| 24                          | 0           | 0                | 0                       | 0         |
| Total delay for the project |             |                  |                         | -8        |

Table 2. Detailed daily delay analysis for project

The daily delay analysis for the project carried out using EASYPLAN is provided in table 2.

The comparative results for different forensic analysis method including Daily Delay Method (DDM) are shown in table 3.

| Method | Owner Delay | Contractor Delay | Contractor Acceleration | Net Delay |
|--------|-------------|------------------|-------------------------|-----------|
| DDM    | 3           | 7                | -2                      | 8         |



|         |   |   |    |   |
|---------|---|---|----|---|
| MIP 3.1 | 3 | 8 | -3 | 8 |
| MIP 3.2 | 3 | 8 | -3 | 8 |
| MIP 3.3 | 3 | 5 | 0  | 8 |
| MIP 3.7 | 3 | 5 | 0  | 8 |
| MIP 3.8 | 3 | 8 | -3 | 8 |

Table 3: Delay comparison for different methods

The MIPs have the same result for Owner's delay; however different methods differ in results of Contractor delay and Contractor acceleration. MIP 3.3

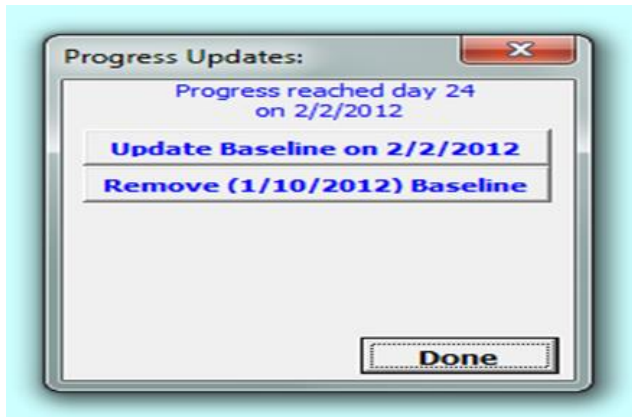


Fig. 6. Saved baseline in EASYPLAN

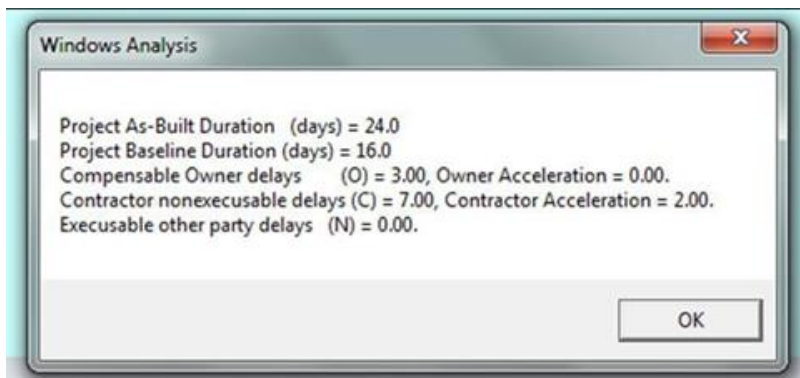


Fig. 7. EASYPLAN summary result for DDM



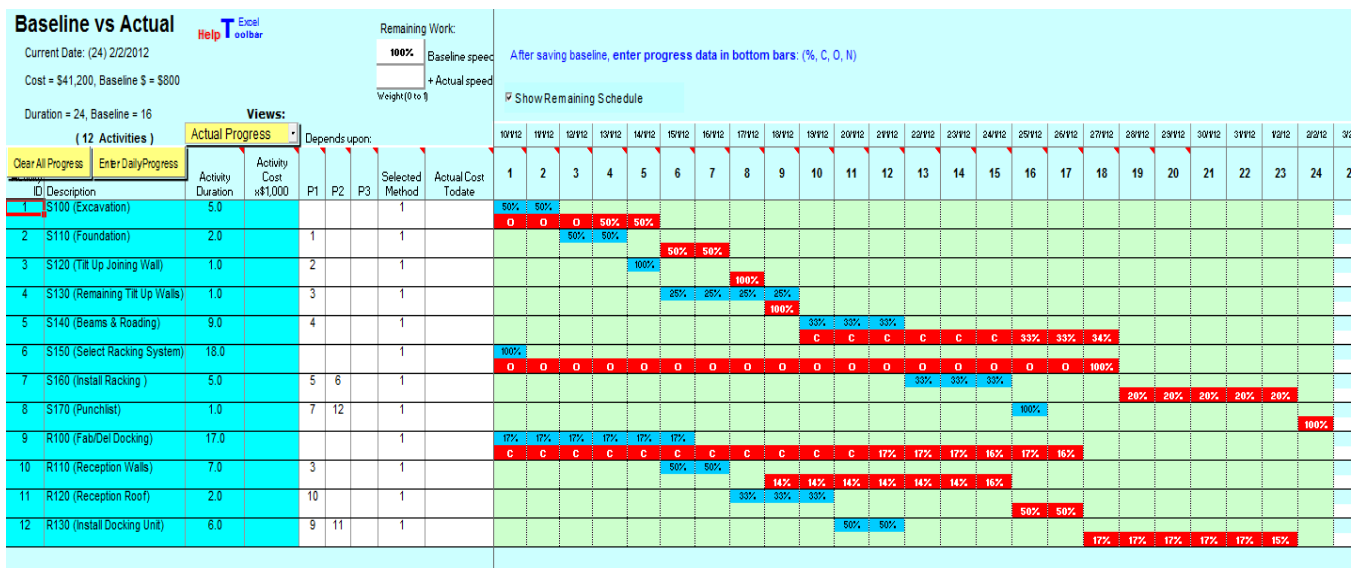


Fig. 8. EASYPLAN result for as-planned vs. as built plan.

and 3.7, have zero contractors' acceleration which means that these two methods do not consider the contractor's acceleration. The net delay for all the methods are same but from claim point of view MIP 3.3 & 3.7 are less likely to be used by the contractor; since, these two methods does not recognize contrac- tor's effort for completing project in time.

## 5. CONCLUSION

The result of Daily Delay Analysis Method matches with result MIPs for Owner's delay i.e. 3 days, however it differs from other MIP results in Contractor's delay and acceleration. These differences can be attributed to the reason that EASYPLAN's size of window for analysis is one day throughout the project for which the critical path is calculated with change in every day. This gives more accurate and repeatable results considering all the variations in the critical path thorough out the project. DDM is a relatively new technique; however, as presented in this paper the results are based on logical methods and procedures. It may take some time for courts to accept this as the most reliable method; however, it could be readily used in court presentations in conjunction with other widely acceptable methods.

Other conclusions that are drawn from this study are as below:

- This method provides accurate result and all the progress of project is compiled on one sheet.
- If a presentation has to be made by contractor to claim delays. This analysis can be used to sup- port the claim.
- It is very detailed and considers all the delays, acceleration and the responsible for the delays during the project.

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