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A REVIEW OF DELAY ANALYSIS TECHNIQUE

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Abstract - Construction projects are multi disciplinary and influenced by several factors. Due to the inherent risks and increasing complexity of modern construction projects, delays and cost overruns have become common facts in the industry. Researchers and practitioners have used many techniques to assess project delays and apportion delay responsibility among the parties involved. Windows delay analysis has been recognized as one of the most credible techniques for analyzing construction delays. Despite its benefits, windows analysis can produce different results depending on the window size, it does not consider owner and contractor acceleration, it does not systematically consider the impact of several baseline updates made due to changes in the duration and logical relationships of the activities, and it does not consider the impact of the progress events on resource over-allocation and its consequent delays.

1. INTRODUCTION

Construction projects generally have highly complicated situations during execution, it involve many project stake holders and interfaces, and influenced by several external factors. Therefore schedule delay in construction project are common and effect total project duration in unpredictable way. So the Delays are one of the biggest problems construction firms face. Delays can lead to many negative effects such as lawsuits between owners and contractors, increased costs, loss of productivity and revenue, and contract termination. According to Bordoli and Baldwin (1998) and the World Bank (1990), for 1627 projects completed worldwide between 1974 and 1988, the overrun varied between 50% and 80%.

In India, a study conducted by the Infrastructure and Project Monitoring Division of the Ministry of Statistics and Programme Implementation in 2004 reported that out of 646 central sector projects costing about $50 trillion, approximately 40% are behind schedule, with delays ranging from 1 to 252 months (Lyer and Jha, 2006). In the past few years, the number of claims submitted to the American Arbitration Association reached almost 25% of the 1.7 million claims submitted over the past 74 years (Kassab et al., 2006).

To recover the damage caused by delays, both the delays and the parties responsible for them should be identified. However, delay situations are complex in nature because multiple delays can occur concurrently and because they can be caused by more than one party, or by none of the principal parties. One delay may contribute to the formation of other delays.

Aim and Scope

The analysis of these delays involves not only the calculation of the delay time but also the identification of the root causes and the responsibility for delays, Such an analysis therefore becomes a basis for the financial calculations that determine penalties or other damages to be assigned to the parties responsible for the delays. The purpose of the **Delay analysis** is to calculate the contribution of each party to the total project delay. Generally the as-planned and as-built schedules are the basic data source for delay analysis. The as-planned schedule is a graphical representation of the contractor's original intentions for the completion of the project. It shows the different critical paths as well as the planned activities and their sequence.

2. METHODOLOGY

Delays are classified into two different types according to liability: excusable and in-excusable . When the contractor is responsible for the cause of the delay, it is called an inexcusable delay. Examples include failure to coordinate work, too few workers, and low productivity. The contractor can not obtain a time extension for inexcusable delays. The contractor is also liable for damages incurred by the owner as a result of the inexcusable delay.

The second type of delays, excusable delays, can be farther broken down into compensable and non-compensable delays. Compensation is required when the owner is the major cause of the delay. Examples include changes in the scope of work and the owner's failure to grant site access. When neither the owner nor the contractor is responsible for the delay, it is called excusable-non-compensable delay. . Examples include severe weather and acts of God. The contractor is entitled to a time extension if this type of delay increases the overall project duration.

When more than one type of delay happens at the same time and both, either together or independently, impact the project's critical path, a concurrent delay occurs .Concurrent delays add more complexity to the delay analysis There are some difficulties in calculating concurrent delays.. It is difficult to agree on the concurrency period of two or more delay events, The concurrent delay events may occur with respect to two or more concurrent activities which have different start and finish dates; thus only portions of these activities are concurrent. Also New critical paths could be formed because of consuming the total floats for noncritical activities, If the concurrent delays are on critical paths, and if the owner delays the critical path, the contractor can decelerate his work on the parallel critical paths in order to be critical.

Delay analysis have Several methods available. For the selection of the proper method depends upon a variety of factors including that Delay analysis is an analytical process in which the critical path method is employed together with a review of project documentation and site records in order to evaluate and apportion the effects of delays and events that have an impact on the project schedule.

Comparing the As-planned with the As-built schedule is the simplest method of analysing schedule delays. The majority of the researchers do not recommend using this method because it simply determines a net impact of all delay events as a whole rather than studying each individual delay event separately.

The impacted as-planned method(What if) adopts the as-planned schedule as its baseline. The delays caused by either the contractor or the owner are added to the as-planned schedule, and the impact on the project duration is calculated. The impacted as-planned schedule reflects how the as-planned schedule could have been impacted as a result of owner or contractor-caused delays being inserted into the schedule

The collapsed As-built method(But For) is used by the contractors to demonstrate a schedule that they could have achieved "but for" the actions of the owner. This method adopts the as-built schedule as its baseline. The delays attributable to the owner are subtracted from the as-built schedule. The compensable delay is the difference between the as-built schedule and the but-for schedule.

The windows method or Contemporaneous Period Analysis(CPA) breaks the construction period into discrete time increments and examines the effects of the delays attributable to each of the project participants as the delays occur. It adopts the As-planned schedule as its baseline, but the As-planned schedule is periodically updated at the end of each planned time period.

Steps to Review Existing Delay Analysis

1) An As-Planned schedule is prepared prior to starting of project. The Work Break Down structure of entire project is formed. Activity is defined, Required resources include time is presumed. Perfect logical relationship between activities are established. The activity attributes are calculated from detail estimate, Schedule of rates and by expert suggestions. Scheduled prepared in Bar chart as well as network diagram.

2) After preparing As- Planned schedule, along with construction data collected in a proper manner and proper site record maintained. The As-planned schedule updated at regular interval of project and an As- Built schedule is framed. The As built schedule contain all delays with clear duration,. The delay duration and type represented along with activity.

3) Updated the As- Built schedule at end of each Delay Section(DS), starting from first DS. Check at the end of each DS, whether the delays contained in DS increment the project duration(at time of update we never need to consider any delays at Delay Section in forward direction) . If the delay increase the project duration then those delays are liable.

4) Suppose the delay is on Activity at Non-Critical Path(NCP) as per As-planned schedule, but at some sort of time, while updating the Delay section, the path turned or get converted to Critical Path(CP). Here according to existing DAMUDS technique simply the complete liability of delay duration is given to delays which occurred just after the particular DS from which the change of status of CP (as per As planned) changed to NCP. But according to review, those delay liability not only attributed to delays just after the particular DS, But all delays that previously occurred at NCP. So a backward Pass required at time of such changes in proposed Critical Path. Those liable delay equally divided among all type of delays which occurred presently and past on path NCP ..

Review of the work"critical path effect based delay analysis method for construction projects"

At this work, they conducted various delay analysis techniques based on Contemporaneous Period Analysis(CPA). Here an AS-PLANNED schedule of the project under concern is framed. Then periodically updated, and finally including all delay's an AS-BUILD schedule is done. Then selected the suitable time interval according to method , and updated at each interval and chequed the effect of each delay on critical path .At Delay Analysis Method for Delay Section,(DAMUDS), the entire As-Built schedule is divided into three type of intervals. Part without delay(only working activities), Delay Section containing a single delay, and Delay section containing Two or more delay.

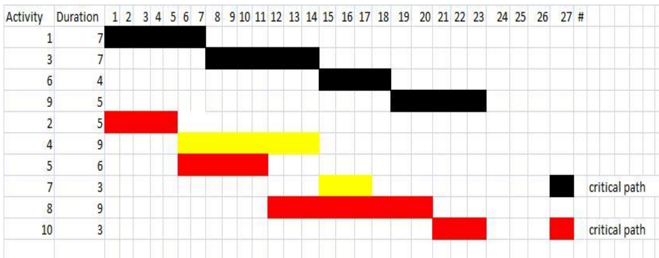

Figure 1: As-planned schedule

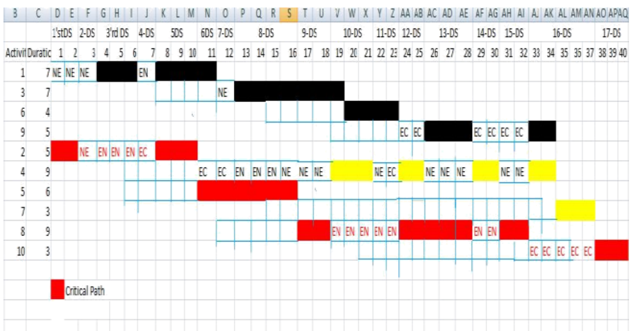

Figure 2: As-Built Schedule with Delay Section.

As-planned schedule prepared prior to starting of the project, by using detail design, detailed estimate, Schedule of Rates, and by expert judgement. Proper logical relation between Activities is fixed, and bar chart is prepared. The As-planned schedule regularly updated along with the construction, at regular interval. All delays are included and As-Built schedule framed. For such updation Daily site record needed.

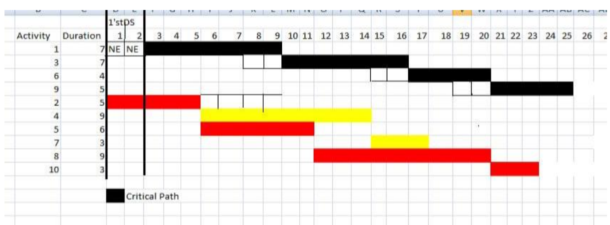

figure 3: Updating at first Delay section(DS).

Here Non-Excusable delay of duration two days at Activity 1. It's a Delay section contain only one type of delay. It causes two day increment in critical path(1-3-6-9). Now there is only one critical path(1-3-6-9) with duration of 25 days. . Here at the First Delay section, there is no critical path change, so no difference in actual and reviewed DAMDS

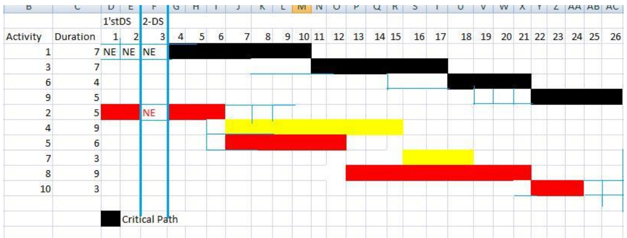

figure 4: Updating at Second Delay section(DS).

Here it is "Two or more delay occurred section" category of DS. Non-Excusable delay of One day duration occurred at Activity 1 and Activity 2. The starting of DS is at third day. delay at activity1 incremented the critical path(1-3-6-9) by one day. Here no critical path change so no difference in actual and reviewed DAMDUS

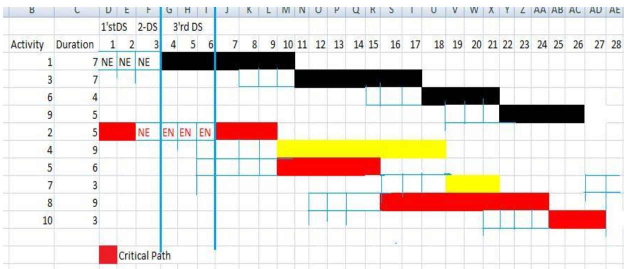

Figure 5: Updated Bar chart at Third Delay section

Here Third DS is "Single delay occurred section" category of DS. Excusable-Non compensable (EN) delay of three day duration occurred at Activity2. The starting of DS is at Fourth day. Delay at Activity2 incremented the path(2-5-8-10) by Three day. Here Before updating at Third Delay Section the critical path is (1-3-6-9). But due to the Excusable-Non compensable Delay occurred at 5'th and 6'th day (it is in 3'rd DS) the critical path changed to(2-5-8-10).

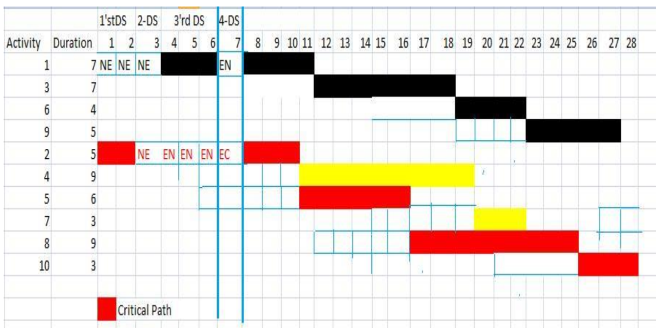

Figure 6: Updated Bar chart at Fourth Delay section

Here it is "Two or more delay occurred section" category of DS. Excusable-non compensable delay of single day duration occurred at Activity-1 and Excusable- compensable delay of single day duration at Activity-2.

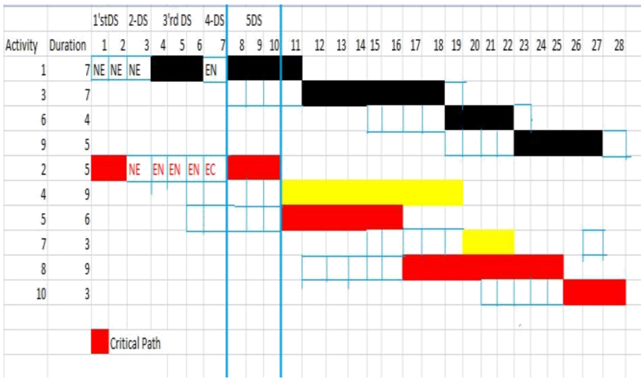

Figure 7: Updated Bar chart at fifth Delay section

It is a Delay Section category having only working activities. So no delays or no change in critical path. The starting point of delay section is at eighth day. The duration of delay section is three day. It never cause any change in As-planned schedule before and after the update.

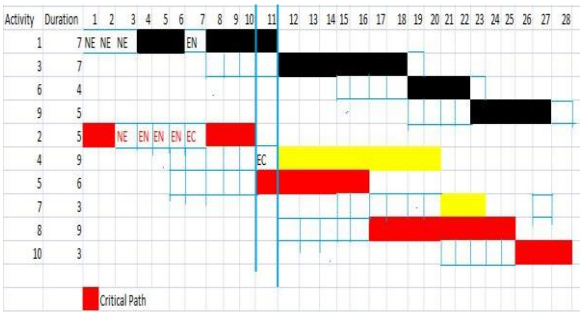

Fig 8: Updated Bar chart of sixth delay section.

Sixth delay section contain single portion of delay. The section begin at 11'th day. Section consist of a Non-Excusable delay of single day duration at Activiy-4. Which increment the duration of path (2-4-7) by one day. The path (2-4-7) is already a non critical path as per As-Planned schedule. And also even upto updation of fifth delay section this path is in is non-critical path, so this Non-Excusable delay never causing any increase in project duration. Thus the single day NE delay at this section never considerd as liable one, and also while updating at this section there is no critical path change and no difference in reviewed and actual one.

According to DAMUDS, this delay always a non liable delay irrespective of changes during future updation. But while reviewing , we can say that at future at a scenario when this path (2-4-7) get converted to critical path, then not only that particular delay, which occurred just after the conversion is only liable. Simply the delays occurred at this path during non-critical scenario utilized the float available, and which lead particular path to become critical. So a cumulative responsibility for all type of delay is there, even though such delays never cause any increase in project duration during the updation at their delay section. So sometime at future this delay may be considerd as liable delay.

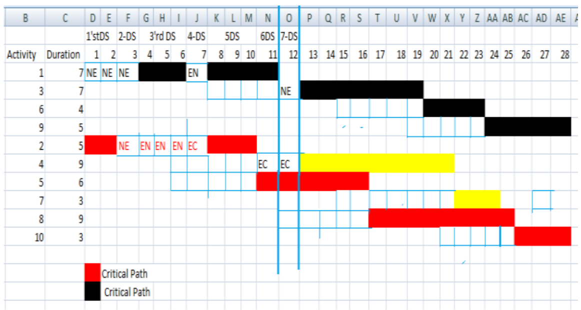

Fig 9 :Updated Bar chart of Seventh delay section

The seventh Delay-section contain Two-or more different type of delays. Section start at 12'th day and duration of section is one day. It consist of single day delay of Non-Excusable(NE) and Excusable –Compensable(EC) delay at Activity-3 and Activity-4 respectively. The NE delay is at path (1-3-6-9) it is at non critical path as per updated schedule. So NE never cause any increment in total project duration, even though it increment (1-3-6-9) by one day, so it is non- liable delay. The EC delay at Activity-4 is in path (2-4-7), which is at Non-Critical path as per AS-Planned and also as per updated schedule upto sixth delay section. So EC delay never causing any increment in total project duration, hence it is non-liable. But at future if this path (2-4-6) get converted to critical path, then this EC may be get transformed into liable one. However now this both delay is non-liable and DS never cause any change in proposed critical path. So actual and reviewed are same now.

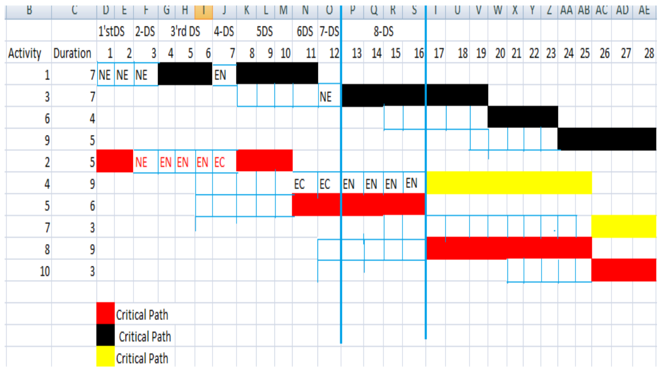

Figure 10: Updated bar chart of eighth delay section.

This Delay Section(DS) contain single type of delay. It begins at thirteenth daywith duration of DS is four day. The Excusable-NonCompensable(EN) delay of four duration occurred at Activity-2. It incremented the duration of the path (2-4-6) by four day. The path (2-4-6) is non-critical as per As-planned schedule and also before eighth schedule update. Here even at end of eighth DS it never crossed critical path duration. So the indicated four day EC delay at eighth delay never cause for project duration, hence those delay are non liable according to DAMUDS. Here also it never lead to critical path change so no difference between actual and revised DAMUDS.

According to DAMUDS this EN delay at eighth duration always Non-liable, But according to revised DAMUDS, either liability on Non-liablity of particular delay depends on the future updation as said earlier. Because the path (2-4-6) is Non-critical path(NCP) as per As- planned ie, it is already proposed NCP. So float is distributed to each activity in this path. So here Activity-2 utilize the float, and if at future when this path (2-4-6) become critical path(CP) then not only the delay just after that particular DS is liable, but also all delay which occurred past or utilized the float is responsible. So according to revised this delay may get converted to liable future.

Figure 11: Updated bar chart of ninth delay section

It is a delay section contain only one type of delay. It starts at seventeenth day with a duration two days. The delays at this section is Non-excusable(NE) delay of two day duration at second activity. Actually the path (2-4-6) is Non-Critical Path(NCP) as per As-planned schedule. Even though it never crossed critical duration at previous DS(eighth) it reached to critical duration. So here those NE delay at , at critical path(cp) during the beginning of updation at ninth DS. So this delay incremented two day duration on path(2-4-6) which is CP now, and hence increased the project duration by two days so the NE delays are liable according to DAMUDS.

Here the path (2-4-6) is CP as per AS- Planned Schedule and it is proposed CP, here there is change in proposed critical path, so definitely there is difference between actual and revised. Here actual DAMUDS gave liability of this two day delay completely given two the NE delay at this ninth DS. But as said earlier according to revised DAMUDS this two day delay is liable to all type of delays which occurred at past on activities in this proposed NCP, which is (2-4-6). So a Backward pass required to identify which all delays happened previously at this path (2-4-6). Such delays actually utilize the float and they are also responsible for the conversion path (2-4-6) to critical one and increase in project duration. So here first we are listing out those previously occurred delays on path.

Table 1: Calculated Various delay duration upto 9'th DS

SL NO: of Delay Section(DS)	Starting point of Delay Section (day)	Duration of Delay Section(DS) (days)	Delay duration based on DAMDUS			Delay Duration based on Reviewed DAMDUS		
			NE	EN	EC	NE	EN	EC
1	1	2	2	-	-	2	-	-
2	3	1	1	-	-	1	-	-
3	4	3	-	2		-	2	-
4	7	1	-	-	1	-	-	1
5	8	3	-	-	-	-	-	-
6	11	1	-	-	-	-	-	1/4
7	12	1	-	-	-	-	-	1/4
8	13	4	-	-	-	-	1	-
9	17	2	2	-	-	1/2		

CONCLUSIONS

The DAMUDS is a delay analysis technique, at which As-planned schedule is the baseline. The As-planned schedule updated at regular interval with help of site recorded data. Whole delay with delay type, and delay duration included in As-planned Schedule and represented as Bar chart. So the Bar chart contain activity along with the type and duration of delay occurred to each activity. Such schedule is called the As-Built schedule. Then the As-Build schedule is divided through out into Delay Sections(DS) . Then starting from the first DS to last the As-Built schedule is updated. We need to cheque whether the delay contained in the particular DS increase the project duration or not, without considering delays at forward DS. If delay contained in DS increment Project duration or it is in critical path at end of DS then it is consider as liable delay.

As per As-planned schedule there is Critical Path(CP) and Non-Crritical Path(NCP), the float available is need to be equally shared by all activities in that path. As the updation along the DS proceeds, suppose at any DS the status of a NCP(as per As-planned) changed, then not only that delay in particular delay at transition point but also whole delays that occurred in that path are liable or liability should be equally shared. Based on this statement we reviewed some works based on DAMUDS delay analysis technique.

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