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A Case Study of Schedule Delay Analysis in Building Construction Project

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Abstract

Delays are a common challenge in construction projects, often resulting in significant impacts on budgets and schedules. This research presents a case study investigating the efficacy of various delay analysis techniques in construction projects. Utilizing data collected from a live project, the study applies a range of techniques including CPM-Based As-Planned Technique, As-Built Technique, but-for Technique, Window Analysis and non-CPM-based Global Impact Technique. Through implementation and analysis, the limitations of each technique are identified, enabling a comparative assessment of their effectiveness. The study aims to choose the delay analysis method that is best for the particulars of the project., considering factors such as accuracy, ease of application, and comprehensiveness. By providing insights into the strengths and weaknesses of each method, this research contributes to enhancing delay management strategies in construction projects.

KEY WORDS: Delay Analysis Techniques, Window Delay Analysis, but-for technique, Global impact Techniques

1. Introduction

Timely completion of construction projects is crucial, as delays incur substantial costs and affect both project outcomes and team efficiency. Project schedule, alongside cost and quality, stands as a cornerstone in the construction management process, playing a pivotal role in determining project success(K.V et al., 2019)Delays are among the prevalent types of claims in construction, often leading to complex and challenging disputes that can disrupt the industry. It is imperative to utilise delay analysis methods to address these claims effectively. However, the choice of analysis method can significantly impact the outcome. Therefore, it is vital to carefully select the most suitable technique. Analysts must consider various factors influencing the choose the Delay Analysis Technique (DAT) to ensure the most appropriate method is utilized.The construction industry holds significant importance in the economic development of any nation, playing a crucial role in its growth. However, construction projects often encounter numerous delays that impact both the duration and estimated costs of the projects (Bagrecha&AyushiBais, 2017). A construction project is considered successful when it is completed within the specified time, budget, meets the required specifications, and satisfies the owner. However, it is noted that 70% of construction projects experience time overruns. Furthermore, 76% of contractors and 56% of consultants have reported that these time overruns typically fall between 10% and 30%(Gebrehiwet& Luo, 2017).According to (Khattri et al., 2016)when a construction project experiences delays that result in 50% cost overruns from the original duration, it is a frequent occurrence. These delays create challenges for the collaboration among stakeholders (including designers, contractors, and consultants), leading to strained relationships, suspicions, claims, accusations, financial concerns, and a general sense of mutual apprehension. In light of this, it becomes crucial to identify the specific reasons for delays in order to reduce and prevent them in all construction projects.investigate, analyze, and quantify its impact on the project duration. This analysis is conducted using various Delay Analysis Techniques (DATs). Since there are multiple DATs available, each technique may yield different results from the others. This variability is a key reason why different project stakeholders opt for different DATs, as certain methods can provide more cost-effective outcomes for both parties. Additionally, different techniques require specific documentation, which needs to be further examined. The choice of which DAT to use depends on when the delay event occurred, the project documentation currently available, and the reliability of the data(Orban&Hosny, 2018).The Individual Delay Analysis (IDA) technique is developed to pinpoint and examine separate delays within a project instead of assessing delays collectively. It delves into the causes and effects of each delay, determining its specific impact on the project schedule (Alkass et al., 1996).

Despite several contributions, it is often not possible to conduct a thorough study of delayed requests that considers the effects of specific timing problems and delay(Hegazy et al., 2005). (Baks&Hmck, 2013) focuses on exploring construction delay analysis techniques specifically designed for building projects. It conducts a review and comparison of various well-known delay analysis methods, with a specific emphasis on their implementation in building construction. By evaluating the advantages, drawbacks, and practical aspects of these methods, the research aims to offer valuable insights for construction professionals, project managers, and stakeholders engaged in building projects. To ensure that delays are managed properly and peacefully, it is critical to bring these difficulties together in the delay assessment and encourage awareness of them (Braimah, 2013). Despite the numerous benefits they offer, the thorough analysis of delay claims, which accounts for the impact of various scheduling and delay issues, is often deficient in practical application(Hegazy et al.,2005.). The construction sector is essential to the expansion of the economy., serving as a catalyst that stimulates development in various sectors (Durdyev et al., 2017) Its impact extends to multiple sub-sectors, making it a significant driver of socio-economic progressThe building industry in India has grown significantly in the last several years., emerging as one of the key industries contributing about 8% of the nation's GDP (gross domestic product) and standing as the second-largest employer(Durdyev& Hosseini, 2020). Construction delays are a common issue worldwide (Mbala et al., 2019), and India is no exception. Despite increased government support, the construction industry in India continues to grapple with delaysThere are delays in several projects all around the nation (Scholarly Editions, 2013). As per the project implementation status report (IPMD, 2018) released by the Government of India, As of July 2017, there were 274 active projects worth INR 1.5 billion or more out of 1,257 total projects (22 percent) are experiencing time overruns. The evolving landscape of the construction sector in India highlights the necessity for a thorough examination and evaluation of the causes of project delays in the country, alongside the implementation of effective mitigation measures(Egwim et al., 2021). Therefore, in order to guarantee a fair and cooperative settlement of delay claims, it is imperative to raise awareness of and include these factors in delay analysis.. As part of a broader study aimed at addressing these concerns, this paper aims to: examine the most used Delay Analysis Techniques (DATs), highlight the frequently overlooked issues in the analysis, and identify areas for improvement. The overarching goal of this comprehensive study is to thoroughly investigate the practical and theoretical applications of these techniques, with the aim of developing a framework to enhance their effective utilization. This, in turn, seeks to mitigate the challenges often encountered in resolving delay claims.

2.Types of Delays

Delays in construction are categorised into two categories: Non-excusable delays and excusable Delay

Inexcusable delays: (non-excusable delays): The delay is only caused by the contractor and its suppliers. Delay is the responsibility of the contractor, and the customer may be entitled to remuneration(Bagrecha&AyushiBais, 2017; Omran et al., 2009)(Jamaludin et al., 2018)

Excusable delays: Delay causes by the owner and unexpected activities.Non-compensable Delays These delay unexpected activity that goes outside the contractor's control. Natural disasters, unusual weather, strikes, acts of the government within its sovereign authority, etc. are typical examples..Compensable Delays: These are owner-caused delays.. For example, the late release of drawings by the owner Delay in contractor payment by the owner (Bagrecha&AyushiBais, 2017; Omran et al., 2009)(Jamaludin et al., 2018)

Concurrent Delay: When multiple delays happen simultaneously and overlap,

(Jamaludin et al., 2018; Omran et al., 2009)

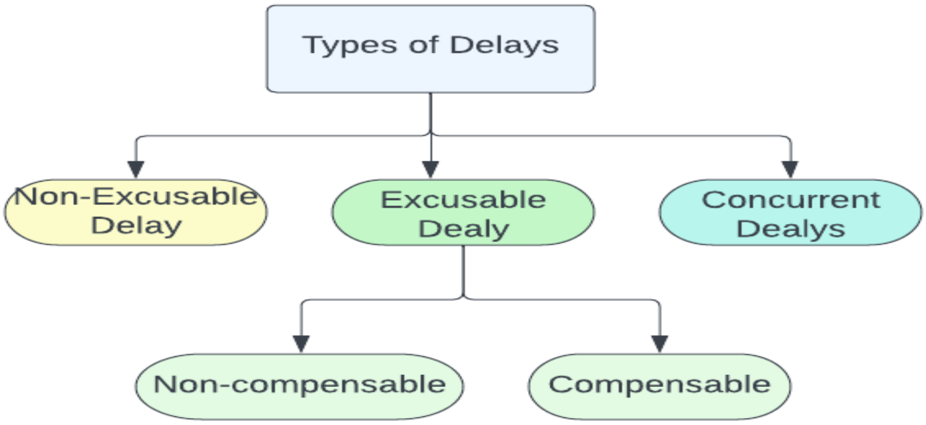

Fig1. Types of Delays

Source:(Tayade&Mahatme, 2020)

3.Methodology

Data Collection:

In order to obtain relevant information, conversations with the project manager and the client were held throughout the ongoing construction project where data for this study was gathered. Over the course of five months, on-site inspections were made to obtain up-to-date information on project timelines, progress reports, and any delays that may have occurred. Extensive documentation of project schedules, tasks, and interruptions was kept to guarantee the precision and dependability of the dataset.

3.1Delay Analysis Techniques Implementation:

The data gathering stage, the gathered data was subjected to a number of delay analysis techniques. These methodologies encompassed Window Analysis, Time Impact, Global Impact, As-Built, and CPM-Based As-Planned methodologies. Each method was applied methodically to examine how delays affected the project timeline, enabling a comprehensive analysis of its advantages and disadvantages.

***3.2Data Analysis*:**

Each delay analysis technique's application yielded results that were painstakingly examined to determine its advantages and disadvantages. To choose the best method for the project, comparative analyses were carried out, considering aspects like precision, scope, and usefulness. After that, the analysis's results were combined to produce insightful conclusions and suggestions for enhancing delay management techniques used in building projects

4.Result & Discussion

As you can see from the Fig 2&3, the total duration of the project in the planned schedule is 105 days. The project began on time, however many schedule impact events hindered development, causing the overall project duration to expand to 123 days. The subsequent sections evaluate the most popular Global impact and CPM-based DATs to determine liability for delay damages that depend on some of the DAI that must be addressed during the analysis process.

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As-Planned Schedule

Act. No	Task Name	Duration	Predecessors
1	GENRAL EXCAVATION	3 days	
2	FOUNDATION EXCAVATION	2 days	1
3	FOUNDATION PCC	6 days	2Fs-1 day
4	FOUNDATION RCC	11 days	3SS+2 days
5	PEDESTAL	10 days	4FS-7day
6	BACK FILLING	10 days	5
7	PLINTH BEAM PCC	6 days	6FS-4 days
8	PLINTH BEAM RCC	7 days	7SS+3 days
9	GRADE SLAB PREPARATION	6 days	8FF+4 days
10	GRADE SLAB PCC	2 days	9
11	COLUMN UPTO FLOOR SLAB	6 days	8
12	GROUND FLOOR SLAB PREPARATION	11 days	11,10
13	GROUND FLOOR ROOF SLAB STEEL BINDING	8 days	12
14	GROUND FLOOR SLAB RCC	1 day	13
15	GROUND FLOOR BRICK WORK	20 days	14fs +3day
16	PLASTER WORK	15 days	15fs-10 days
17	GROUND FLOOR GRADE SLAB	15 days	16
18	ROOF WATER PROOFING	10 days	14FS+10 days
19	TOILET PLUMBING WORK	10 days	15

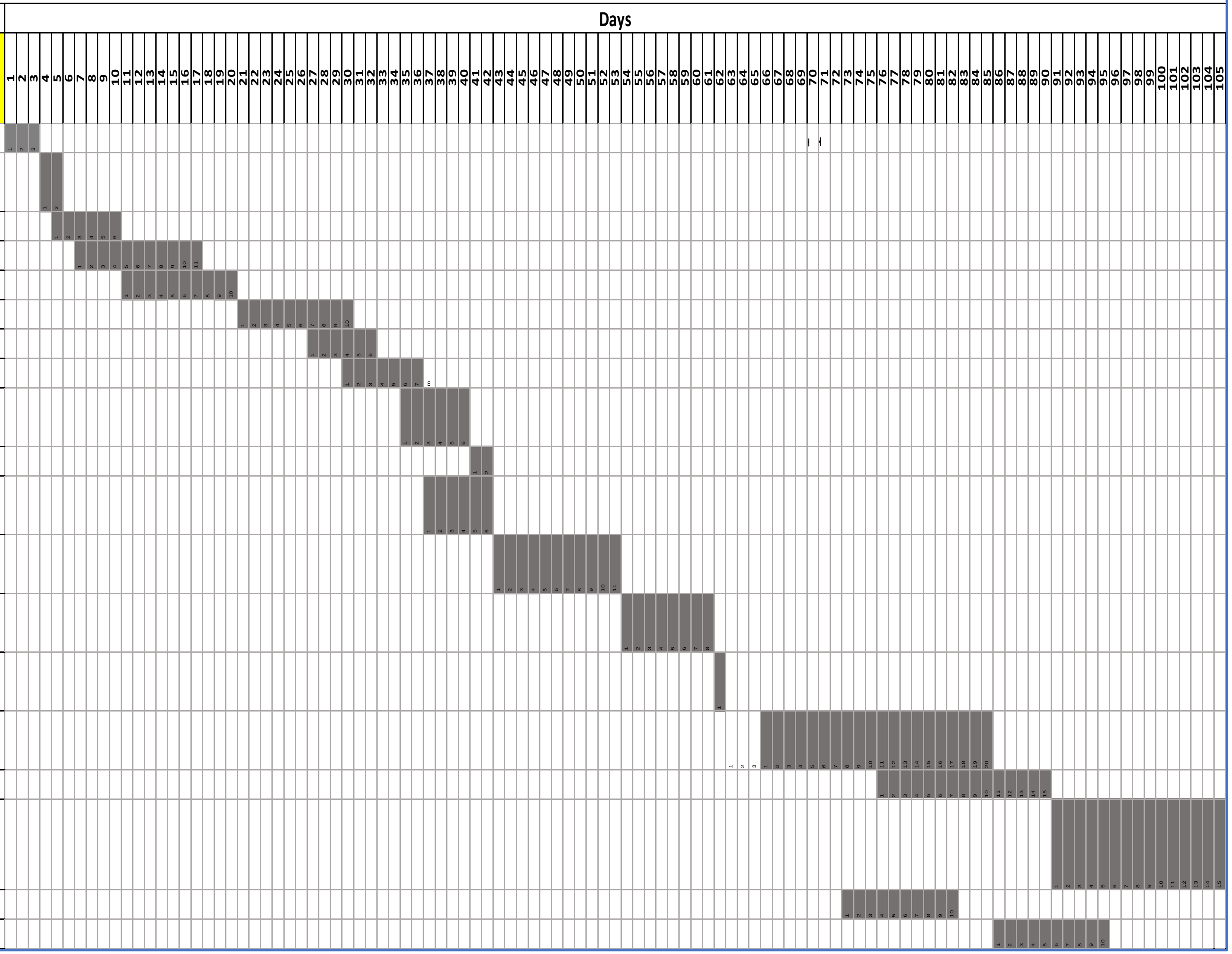

Fig 2 As Planned Schedule

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As-Build Schedule

Activity no.	Task Name	Original Duration	After Delay Duration	Project delay	Predecessors
1	GENRAL EXCAVATION	3 days	3 days	0	
2	FOUNDATION EXCAVATION	2 days	3	1	1
3	FOUNDATION PCC	6 days	6	0	2Fs-1 day
4	FOUNDATION RCC	11 days	14	3	3SS+2 days
5	PEDESTAL	10 days	15	5	4FS-7day
6	BACK FILLING	10 days	10	0	5
7	PLINTH BEAM PCC	6 days	6	0	6FS-4 days
8	PLINTH BEAM RCC	7 days	9	2	7SS+3 days
9	GRADE SLAB PREPARATION	6 days	6	0	8FF+4 days
10	GRADE SLAB PCC	2 days	3	1	9
11	COLUMN UPTO FLOOR SLAB	6 days	7	1	8
12	GROUND FLOOR SLAB PREPARATION	11 days	11	0	11,10
13	GROUND FLOOR ROOF SLAB STEEL BINDING	8 days	8	0	12
14	GROUND FLOOR SLAB RCC	1 day	3	2	13
15	GROUND FLOOR BRICK WORK	20 days	20	0	14fs +3day
16	PLASTER WORK	15 days	15	0	15fs-10 days
17	GROUND FLOOR TILE Work	15 days	19	4	16
18	ROOF WATER PROOFING	10 days	10	0	14FS+10 days
19	TOILET PLUMBING WORK	10 days	15	4	15

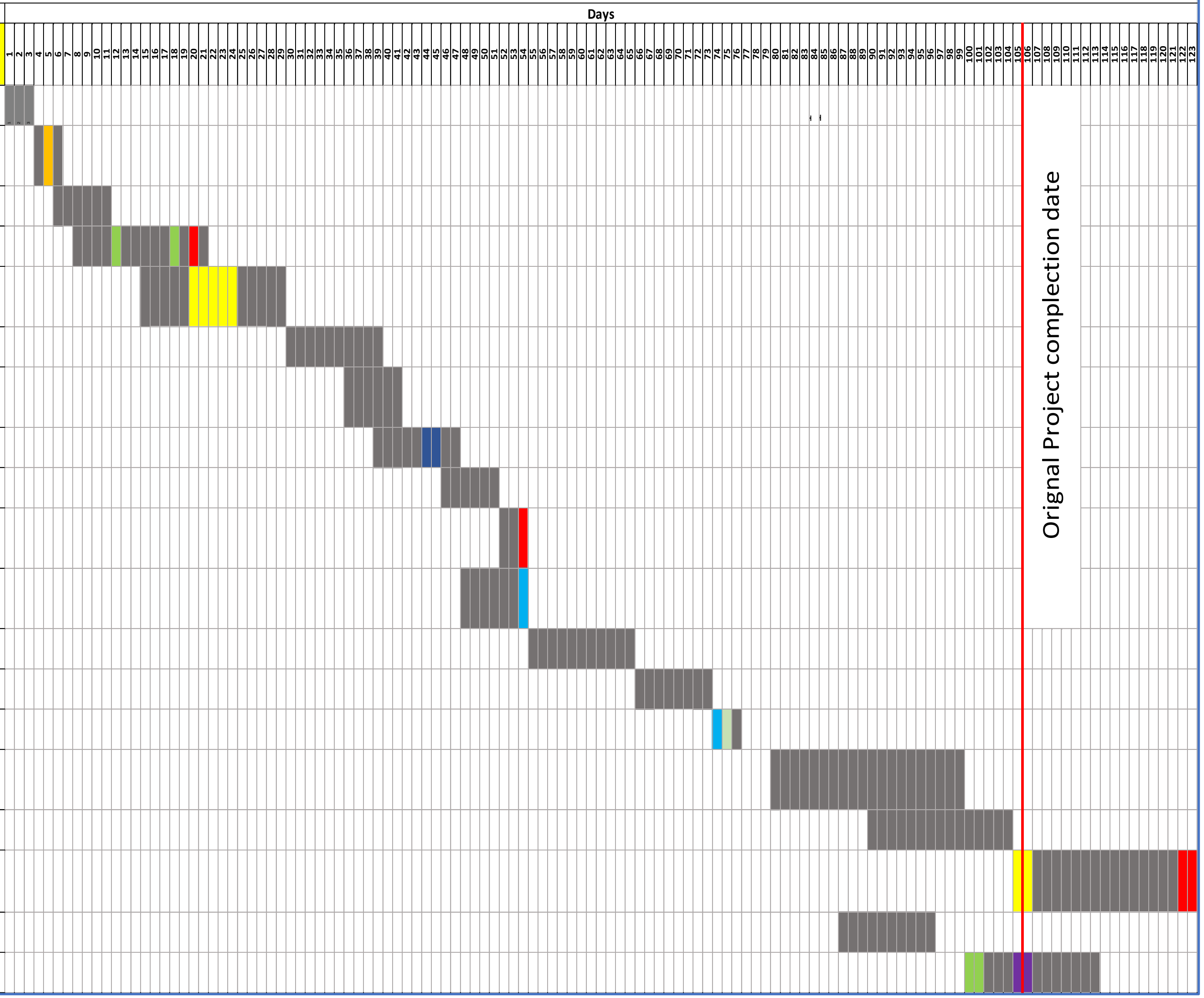

Fig .3 As Build Schulde

Project Delay Causes

Activity no.	**Activity Name**	**original Duration**	**Delay**		**Types of delay**	**Causes of delay**
2	FOUNDATION EXCAVATION	2 days	1		NE	Shortage of equipment
4	FOUNDATION RCC	11 days	2		NE	Material Shortage
			1		NE	Labor Shortage
5	PEDESTAL	10 days	5		EC	Unclear Details and Specification of plinth beam Level]
8	PLINTH BEAM RCC	7 days	2		EN	Due to weather
10	GRADE SLAB PCC	2 days	1		NE	labour shortage
11	COLUMN UPTO FLOOR SLAB	6 days	1		EC	Client checking
14	GROUND FLOOR SLAB RCC	1 day	2		EC	Client checking
					NE	batching Plant Backdown
17	GROUND FLOOR GRADE SLAB	15 days	4		EC	
					NE	labour Shortage
19	TOILET PLUMBING WORK	10 days	2		NE	Material Shortage
			2		EC	Drawing Error
		Total Delay	**23**			

Table1: Summary of delay in Project

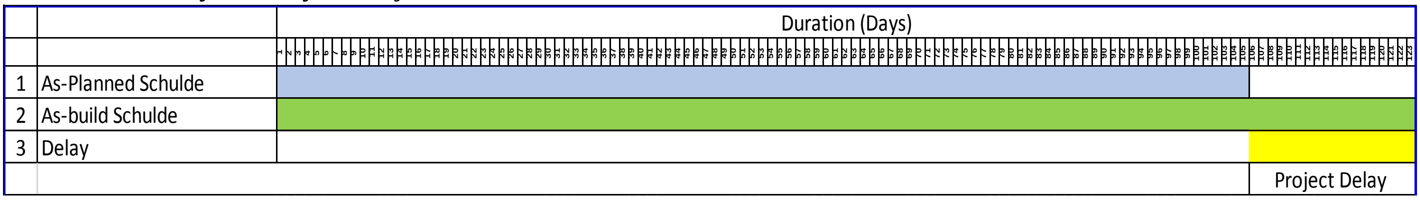

Fig.3 Compare B/w As Planned Schedule Vs As- Build Schedule

4.1Global Impact Technique

The simplest method for analysing claims of building delays is the Global Impact Technique.(Alkass et al., 1996b)The global impact technique can be applied without taking the project schedule into account since it assumes that every delay event has an equal impact on the project's delay, which is not practical. It not a CPM Based Techniques.(khalid s, n.d.) In table no.2 shown the result of global impact technique. Draw Back the Global Impact may not be appropriate for all construction projects, particularly those with complex schedules or multiple concurrent activities.it not based on CPM its difficult to find out the real project delay causes. Table 2 Show the Result of this techniques

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Table no. 2 Result of Global Impact technique

Global Impact Technique	
Responsible	**Project Delay**
Owner	11
Contractor	10
Neither Party	2
Total Delay	**23**

4.2 As-Planned Technique

The as-planned technique, sometimes known as the "What If" technique, is a CPM-based approach that bases the analysis on the as-planned timetable. (Schumacher, 1995). Determining the owner's damages can be accomplished by affecting the original timetable and accounting for only delays caused by the contractor. Contractor damages, on the other hand, are determined by considering only delays induced by the owner and affecting the original timetable. Using this method, the difference between the completion dates before to and following the impact is used to calculate each party's damages. It determines each party's obligation for prolonging the project's overall duration using the time-effect.(Michael T. Callahan, 1992)(Barry B. Bramble, 2010)Tables 3 and 4 present the findings of the analysis using Gross of Measure and Unit of Measure, respectively.

Table3: The outcomes of the Gross of measure approach's as-planned technique

Responsibility	Completion Date		Project Delay
	Before Delay	After Delay	
Owner (EC)	105	114	9
Contractor (NE)	105	113	8
Neither Party	105	107	2

Table4 :The outcomes of the unit of measure approach's as-planned technique

Activity	Completion Date		Project Delay
	Before	After	
2	105	106	1
4	105	108	3
10	105	106	1
14	105	106	1
17	105	107	2
19	105	105	0
Total Delay (Contractor Responsibility)			**8**
Activity	**Completion Date**		**Project Delay**
	Before	**After**	
5	105	110	5
11	105	106	1

14	105	106	1
17	105	107	2
19	105	105	0
Total Delay (OwnerResponsibility)			**9**

Activity	Completion Date		Project Delay
	Before	After	
8	105	107	2
Total Delay (NeitherResponsibility)			**2**

It fail in adressing several issues of DAIs. The evaluation of this technique confirmed the following:

The project-level amount of responsibility is more than the 18-day overall amount of delay (from day 105 to day 123). As show in table 3 technique's duty indicates 19 days using a gross measure and 19 days using a unit of measure (owner + Contractor + Neither Party). Thus, this technique does not properly address who is responsible for the real-time of the delayed period. This problem of disregarding real-time occurred as a result of the analysis methodology's failure to consider every event in the analysis at once.

4.3As-Built Technique

As-built approach, also known as the "Net Impact" technique, is another CPM-based strategy that bases the analysis on the as-built timetable.(Alkass et al., 1996). Using this method, the analysis begins by contrasting the as-planned schedule's total float with the schedule events that are affected for each activity. When the As-Built' TF has a negative value, it means that the event has impacted the project's total completion by a number of days equivalent to that negative value. (Khalid S. Al-Gahtani& Satish B. Mohan, 2011)

Table5: The result of the as-built technique:

Activity	As Planned			As built			EVENT			Project Delay
	Early Start	Early Finish	Total Float	Early Start	Early Finish	Total Float	Day	type	Total Float	
1	0	3	0	0	3	0	0	0	0	0
2	3	5	0	3	6	0	1	NE	-1	1
3	4	10	0	5	11	0	0	0	0	0
4	6	17	0	7	21	0	3	NE	-3	3
5	11	21	0	14	29	0	5	ec	-5	5
6	21	31	0	29	39	0	0	0	0	0
7	27	33	0	35	41	0	0	0	0	0
8	30	37	0	38	47	0	2	c	-2	2
9	31	41	0	45	51	0	0	0	0	0
10	41	43	0	51	54	0	1	NE	-1	1
11	37	43	0	47	54	1	1	EC	0	0
12	43	54	0	54	65	0	0	0	0	0
13	54	62	0	65	73	0	0	0	0	0
14	62	63	0	73	76	0	1	EC	-1	1
							1	NE	-1	1
15	65	85	0	79	99	0	0	0	0	0
16	75	90	0	89	104	0	0	0	0	0

	90	105	0	104	123	0	2	EC	-2	2
17							2	NE	-2	2
18	73	83	24	86	96	27	0			
19	85	95	10	99	114	9	2	EC	9	0
							3	NE	9	
								TOTAL DELAY		**18**

Table:6The total responsibility using the as-built technique

Activity	Delay type	Project Delay
5	EC	5
14	EC	1
11	EC	0
17	EC	2
Owner Responsibilities		8

Activity	Delay type	Project Delay
2	NE	1
4	NE	3
10	NE	1
14	NE	1
17	NE	2
Contractor Responsibilities		8

Activity	Delay type	Project Delay
8	EN	2
Neither Party		2

The real-time duration of the delayed period is ignored by this method. This method considers the problem of an acceleration event, but it ignores the problems of acceleration, pacing delay analysis, concurrent delays, and concurrent effects. This means that at the project level, it is impossible to pinpoint the cause of the delay damages through an accurate and comprehensive assessment.

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4.4 But-For Technique

But-for Known by the name "Collapsed As-Built" technique, it is a CPM-based approach that bases the analysis on the as-built timetable Essentially, this approach is a variation on the "but for" strategy, using the as-built schedule (also known as the "as-built but for" methodology) in place of the as-planned schedule as a baseline. In order for the resulting schedule to provide the project completion date while accounting for the other party's delays, it entails subtracting each party's delays from the as-built network.(Keith Pickavance, 2010)

Table7 : The outcomes of the gross of measure approach' but -for technique

Activity	Project Completion Days		Project Delay	
	Before Collapsed	After Collapsed		
Owner	123	115	8	
Contractor	123	115	8	
Other	123	121	2	
		Project Delay	**18**	

Table8: The outcomes of the gross of measure approach' but -for technique

Activity	**Project Completion Days**		**Project Delay**
	Before Collapsed	**After Collapsed**	
5	123	118	5
11	118	118	0
12	118	117	1
17	117	115	2
Total Owner Responsibilities			**8**

But for technique

Activity	**Project Completion Days**		**Project Delay**
	Before Collapsed	**After Collapsed**	
2	123	122	1
4	122	119	3
10	119	119	0
14	119	117	2
17	117	115	2
Total Contractor Responsibilities			**8**

But for technique

Activity	**Project Completion Days**		**Project Delay**
	Before Collapsed	**After Collapsed**	
8	123	121	2
Total Neither party responsibilities			**2**

Among the things it ignores are pacing delay analysis, acceleration credit, concurrent delays analysis, and concurrent effects analysis.. Because of this, it is impossible to determine with precision and thoroughness who is responsible for the project-level delay damages.. This technique does not address the cost of delay damages and losses. For instance, the project-level definition of recoverable day and delay damages is

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insufficient. Furthermore, this technique has no way of measuring the losses and damages at the activity-level that cause more harm to the innocent party.

4.5 Window Analysis

Using this method, the entire project time frame of the as-planned schedule is split up into multiple periods (also known as snapshots or windows). These divisions are typically made in response to notable changes in the project's planning, particular kinds of delays, or important project milestones. The schedule's remaining duration is adhered to, but the schedule is affected by the events that took place during this period to represent the real lengths in each window. The completion dates prior to and following the impact can be used to compare the effects of the events in each window. Each party's obligation is calculated according to the events that have an impact on each timeframe.(Alkass et al., 1996; Chih-Kuei Kao a, n.d.)This method, which is additive modelling, compares each window's completion date before and after the occurrences that have an impact.. The most accurate analysis method among the window procedures is the daily window analysis(Braimah, 2013; Hegazy et al., 2005)The impact on the project is ascertained by a week window analysis, which compares the completion dates prior to and subsequent to the impact. Table 9displays the Week window analysis technique's analysis result.

Table no.9

Window	Schudle Update	Completion Date	EC	NE	EN	concurrent Delay
1	105	106		1		
2	106	107		1		
3	107	110	1	2		
4	110	114	4			
5						
6						
7	114	115			2	
8	116	117				1
9						
10						
11	117	119		2		
12						
13						
14						
15	120	121	1			
16	119	120	1			
17						
18	120	122		2		
	total		**7**	**8**	**2**	**1**
					project Delay	18

Benefits: Although this method consider both the contemporaneous delay and the delayed period in real time Summary of Result Shown in the table10

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Table 10 Result Summary

Summary of Delay anlysis Techniques							
S.no.	**Dealy Analysis Techniques**		**EC**	**NE**	**EN**	**concurrent delay**	**Toal Delay**
1	Global impact Technique		11	10	2		23
2	As -Planned Technique	Gross of measure	9	8	2		19
		unit of measue	9	8	2		19
3	As -Build Technique		8	8	2		18
4	But -for technique	Gross of measure	8	8	2		18
		unit of measure	8	8	2		18
5	Window Delay Analysis		7	8	2	1	18

Table :12 comparsion of delay analysis Techniques

Camparsion b/w delay analysis techniques					
S.no.	**Delay Analysis Techniques**		**Real Time**	**Concurrent Delay**	**Cost of delay**
1	Global impact Technique		×	×	×
2	As -Planned Technique	Gross of measure	×	×	×
		unit of measure	×	×	×
3	As -Build Technique		×	×	×
4	But -for technique	Gross of measure	×	×	×
		unit of measure	×	×	×
5	Window Delay Analysis		√	√	×

The table 12 a comparison between various delay analysis techniques.The Window Analysis technique uniquely accounts for concurrent delays in its evaluation. However, a significant drawback of both techniques is that neither provides data on the cost of delays. Consequently, there is no current technique that offers comprehensive information on the financial impact of project delays.

Conclusion:

This research article presents the results of a thorough assessment of the effectiveness of different delay analysis methodologies using a case study of an actual construction project. The goal of the study was to determine the best method for analysing delays while considering elements like concurrent delay collection and real-time data integration.

After applying several delay analysis techniques, such as the As-Built technique, Time Impact technique, Global Impact technique, CPM-Based As-Planned technique, and Window Analysis methodology, it was discovered that the Window Analysis technique worked well in the particular project environment.

Window Analysis proved to be advantageous due to its ability to consider real-time data and simultaneously account for concurrent delays occurring within different segments of the project. This granular approach provided a comprehensive understanding of delay impacts, facilitating more informed decision-making and proactive delay management strategies.

The study emphasises how crucial it is to choose delay analysis methods that are suitable for the unique features and complexity of building projects. Although every technique has its own benefits, Window Analysis was shown to be the most effective at capturing concurrent events and real-time delays, which improved project schedule accuracy and reduced possible disruptions.

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