An Empirical Study on Analyzing Schedule Delays of Construction Project in Indonesia

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Abstract –

Schedule delay is one of the worrying problems in the construction industry. Activity delays might increase project duration, cost and sometimes cause delay claim disputes between parties in construction projects. Some methods have been developed for analyzing and measuring project schedule delays, but most of those methods contain assumptions and subjective assessments. In order to identify the useful methods for projects in Indonesia, this study implements popular schedule delay analysis methods into a real project case in Indonesia which has varied relationships among activities and high frequency of concurrent delays. In this study, collecting and analyzing actual project schedule information, identifying delay events, executing delay analysis and comparing analytical results, have been completed to examine the possibilities of using available methods to provide reasonable or even correct outcomes. This study concludes that some of the available methods are unable to deal with concurrent delay problems and some result in different outcomes to the others. Therefore, choosing suitable methods would be an issue when solving delay analysis problems in Indonesia's construction projects

Keywords –

Construction management; Schedule delay analysis; Concurrent delay; Indonesia.

1 Introduction

Schedule delay is one of the worrying problems in the construction project. Construction projects involve many parties and generally have highly complicated situations during execution. Activity delays in construction project might increase project duration, cost and sometimes cause delay claim disputes between parties involved. A delay caused by a party may not always affect the project completion date and may not always cause damage to another party [1]. Therefore, to distinguish delay responsibility among parties is necessary. Another issue related to delay in construction project is solving concurrent delay. Concurrency in delay sometimes occurs and may impact the total duration of the project. The result of delay caused by concurrent delay may increase the dispute liability claim of the parties. The project parties would be hard to identify their own liability towards project delays if the concurrency occurs and it will lead the parties into a confusing situation. The analysis of the concurrent delay has to consider all aspects of the delay that have occurred in the project [2]. Therefore, dealing with concurrent delay is an important issue to choose the suitable schedule delay methods.

Yang and Kao [3] stated that as-planned and as-built schedule are the basis information for the parties to recognize the delay and solve delay disputes and claims. To demonstrate cause and effect relationships of time-related disputes in construction contract, schedule delay analysis is commonly conducted [1]. There are many delay analysis methods that have been developed for analyzing and measuring project schedule delays, but most of those methods contain assumptions, the application of personal experience and judgments, theoretical projection and subjective assessments [4]. Most of the previous studies might use uncompleted or uncomplicated project information which only consists of limited activities and delay types. Furthermore, previous studies consider the logical relationship of activities limited to Finish to Start (FS) and use the delay type only based on assumptions.

In order to identify the useful methods for projects in Indonesia, this study implements the approaches of those popular methods into a real project case in Indonesia which has varied relationships amongst activities, high frequency of concurrent delays and real delays events. By using a real project in Indonesia as a project case, this study collects as-planned schedule, as-built schedule and delays information from project participants. This research addresses the suitable delay analysis method based on the available documents of the project and examines the suitability of each delay analysis approach when it is applied to the discussed real project.

2 Schedule Delay Analysis Method

Many schedule delay analysis methods have been developed in previous studies [1, 5-10]. The popular schedule delay analysis methods include as-planned vs as-built, impacted as-planned, the collapsed as-built, isolated delay types, window but-for technique, isolated collapsed as-built and critical path effect based delay analysis method [3, 7-9, 11-15].

The as-planned vs as-built is the simplest method that compares two schedules, which is why it is also called "the total time method or net impact method" [16]. By subtracting the total duration of as-built into as-planned schedule, the total delay duration will be obtained.

Impacted as-planned method starts with as-planned schedule and analyzes from two perspectives, owner's and contractor's. As an example, from the owner's perspective, the delay caused by owner inserted into as-planned schedule. The difference between each impacted as-planned critical path(s) and the previous one, is the delay resulting from the delayed event(s) [17].

Collapsed as-built (but-for) method is also called the subtractive as-built or but-for method. For the collapsed as-built (but-for) owner delays, the owner delays are subtracted from as-built schedule and the difference of duration of two schedules is the liability of the owner [18].

Isolated delay type method is derived from snapshot analysis (SA) method to overcome drawbacks in previous methods. In this method, the project duration is divided into several time frames or scenarios. Analyzing at least twice from owner's perspective and contractor's perspective, this method examines only the non-excusable (NE) delay events and ignores the excusable-compensable (EC) and excusable-non-compensable (EN) delays while analyzing from the contractor's perspective [5].

In window but-for technique, the project duration is divided into several time frames [5]. This technique is a combination of window and but-for technique. In this method, the owner and contractor caused delay analysis are used continuously. One scenario will consist of actual progress and all delay types of the parties involved with one-by-one inserting delay types into the scenario. It means the scenario will begin with the first type of delays and then continue with others. It is different from the other methods above that analyze the owner's and contractor's perspective separately.

Isolated collapsed as-built (but-for) method uses the concept of isolated delay type method, but start with an as-built schedule because it reflects actual start and finish dates and actual duration. In this method, the owner and contractor caused delays are used continuously. One scenario will consist of all delay types of the parties involved with one-by-one subtracting delay types from the scenario. Therefore, this method can be regarded as a combination of the collapsed but-for method and isolated delay type method [15].

Critical path effect based delay analysis method (EDAM) has a systematic window extraction method for performing delay analysis stable and adopts a process-based analysis approach to resolving concurrent delays and liability distribution problems accurately [3]. The project duration in this method is also divided into several time frames or scenarios. The analyst has to calculate using some equations represent baseline duration, duration caused by owner's delay and contractor's delay, and duty of owner and contractor for each window and each activity. The critical path changes in each window have to be analyzed comprehensively. When delays occur in the critical path, equations to find out the liability of each party has to be calculated.

Methods which are chosen in this research cover three levels of schedule delay analysis. First is the simplest one: the as-planned vs. as-built method. Impacted as-planned and collapsed as-built method which involve the owner's and contractor's perspective, even those perspectives used separately are in the second level. Isolated delay type, window but-for technique, isolated collapsed as-built (but-for) and critical path effect based delay are in the third level. Above four methods in third level use project schedule, delays information, involve owner's and contractor's perspectives and several time frames based on the project schedules. For the last three methods, owner's and contractor's perspectives are used continuously, which means those two perspectives are considered at the time.

3 Project Case in Indonesia

This study implements popular schedule delay analysis methods into a real project case in Indonesia. The case is a building project with the contract price of Rp.81.124.159.736,00 (about US$ 6.084.921,00) and has been delayed for several days. The project has to be finished on September 25 but the real completion date is October 23. The reason for choosing this project is that all the related data and information like as-planned and as-built schedule of the project, weekly project reports, and delays information including causes and time are recorded and can be obtained. Furthermore, this project suffered many delays caused by owner and contractor, as well as by the project architects, sub-contractor and consultant. This project is uncomplicated and fulfills the requirement of examining different delay types. The information of as-planned and as-built schedules are presented in Table 1.

Table 1. The as-planned and as-built schedule information

Task Name	As-planned Information			As-Built Information		
	Duration	Start	Finish	Duration	Start	Finish
Master Schedule	294 days	11/30/2015	9/25/2016	322 days	11/30/2015	10/23/2016
Main Building	272 days	12/21/2015	9/24/2016	308 days	12/14/2015	10/23/2016
Structure	142 days	12/21/2015	5/10/2016	252 days	12/21/2015	9/4/2016
Architecture	213 days	1/28/2016	9/3/2016	186 days	1/28/2016	8/7/2016
Finishing	199 days	2/11/2016	9/3/2016	189 days	4/11/2016	10/23/2016
Interior	192 days	2/11/2016	8/27/2016	181 days	4/11/2016	10/15/2016
Facade	165 days	4/6/2016	9/24/2016	187 days	4/11/2016	10/21/2016
Supporting Building	286 days	11/30/2015	9/17/2016	322 days	11/30/2015	10/23/2016
Landscape	171 days	4/1/2016	9/25/2016	203 days	3/28/2016	10/23/2016

4 Project Case Delay Analysis

To complete project delay analysis, this study follows a series of processes proposed by previous studies [11, 19]. The steps completed are organized as following phases [20].

Preparation phase is to collect required project information. The as-planned schedule, as-built schedule, delays information and weekly progress reports are the basic required information of this research.

Diagnosis phase consists of some works including analyzing the relationships among the activities, categorizing delay types based on causes of delays and developing an analysis of self-made as-built schedule based on weekly progress report to ensure the generated as-built schedule is the same with obtained report. In this phase, the as-planned schedule, the as-built schedule, and delay types will be presented in one table named as schedule delay information table. The schedule delay information table is the starting point to accomplish the schedule delay analysis.

Analysis phase is to analyze project construction delays using some popular methods. Starting with schedule delays information table which consists of as-planned schedule, as-built schedule and delay types, the schedule delay analysis can be performed.

The last phase is summation phase. This phase is to identify the most suitable schedule delay analysis approaches for Indonesian project case.

4.1 As-planned vs. As-built Method

The concept of this method is to compare the duration of as-planned and as-built schedules. As-planned schedule of the project has 294 days and the as-built schedule has 322 days. Based on the calculation using the as-planned vs. as-built method, the total duration of the delay is 28 days. The as-planned vs. as-built method is very simple to prepare and perform, but the liability for each party in the project is unable to be calculated.

4.2 Impacted As-Planned Method

This method begins with as-planned schedule and then inserts the owner or contractor delays. The impacted as-planned method presents the delay liability based on owner's perspective is 21 days [the contractor has 7 days (28-21=7)] and the liability of the contractor is 21 days [the contractor has 7 days (28-21=7)] based on contractor's perspective. Table 2 presents the result of impacted as-planned method calculation.

4.3 The Collapsed As-Built (But-For) Method

Starting with as-built schedule, this method removes the contractor-caused-delay events from owner's perspective. The difference of duration between two given schedules is the liability of contractor. The contractor must be responsible for that delay and vice versa.

The collapsed as-built (but for) method presents the delay liability of the contractor based on owner's perspective is 21 days and from the contractor's perspective, the owner has the responsibility of 7-day delay. The results are presented in Table 3.

4.4 Isolated Delay Type

This method selects several time periods (frames, windows) to analyze the as-planned schedule and delay activities. After analyzing the schedule delay of a window, the next step is to repeat the process for the next window. In this method, the as-planned schedule is divided into six periods. From owner's and contractor's perspectives, the results of the calculation using this method are shown in Table 4.

Table 2. Results of impacted as-planned method

Perspective of	As-Planned Duration	Date Completion		Delay Liability	
		with Owner's delay	with Contractor's delay	Owner	Contractor
Owner	294	315		21	7
Contractor			315	7	21

Table 3. Result of collapsed as-built (but-for) method

Perspective of	As-Built Duration	Date Completion		Delay Liability	
		without Contractor's delay	without Owner's delay	Owner	Contractor
Owner	322	301		7	21
Contractor			315	7	21

Table 4. Results of isolated delay type method

Scenario	Analysis Period (week)	Delay Liability (days)	
		Owner	Contractor
1	0 - 8	0	0
2	9 - 16	0	0
3	17 - 24	0	0
4	25 - 32	0	7
5	33 - 40	0	0
6	41 - 47	21	14
Sum		**21**	**21**

4.5 Window But-For Technique

Starting with as-planned schedule, this method selects several periods (frames) to analyze delay liability. After inserting the actual progress and delay activity in one scenario, the process has to be repeated for the next window. In one scenario, actual progress and delays caused by owner are inserted first into as-planned schedule and duration changes have to be calculated as the completion date with owner's delays. This as-planned schedule with owner's delays is used as a baseline to calculate the completion date with contractor's delays. After the delays caused by owner and contractor are finished to be calculated, the schedule becomes the new baseline for subsequent scenario.

Table 5 presents the results of this method. From the owner's perspective, the owner has the responsibility of 0-day delay liability and the contractor has 22 days based on the contractor's perspective. Based on this calculation, the concurrent delay has 6 days, it is obtained from total duration of project delay minus 22 days.

4.6 Isolated Collapsed But-For Analysis

This method selects several periods (frames) of as-built schedule as the starting point to complete the analysis. Based on calculation in Table 6, the owner causes 0-day delay [the contractor has responsibility of 28-day delay (28-0=28)] and the contractor causes 22-day delay [the owner has the responsibility of 6-day delay (28-22=6)]. The summation value of delay responsibilities caused by the contractor (28 days) and the owner (6 days) is 34 days. The concurrent delay (6 days) can be calculated by using the summation value (34 days) minus total delay days (28 days). At the end, the owner causes 0-day delay and the contractor has responsibility of 28-day delay, with 6 days of concurrent delay.

Table 5. Results of window but-for technique

Scenario	Analysis Period	Project Completion	Completion Date		Delay Liability	
			Owner Delay	Contractor Delay	Owner Delay	Contractor Delay
1	0 - 8	294	294	294	0	0
2	9 - 16	294	294	294	0	0
3	17 - 24	294	294	294	0	0
4	25 - 32	307	300	307	0	7
5	33 - 40	307	307	307	0	0
6	41 - 47	322	307	322	0	15
Sum:					0	22

Table 6. Results of isolated collapsed but-for analysis

Scenario	Analysis Period (week)	Target date for comparison	Without Contractor Delay		Without Owner Delay	
			Completed Date	Delayed Date	Completed Date	Delayed Date
1	41 - 47	307	307	0	322	15
2	33 - 40	307	307	0	307	0
3	25 - 32	294	294	0	301	7
4	17 - 24	294	294	0	294	0
5	16 - 9	294	294	0	294	0
6	0 - 8	294	294	0	294	0
Sum:				0		22

4.7 Critical Effect Based Delay Analysis Method (EDAM)

The EDAM uses as-planned schedule as a starting point and requires clearly delays information. This method applies the critical path method before delay impact calculation to determine a comparison baseline. In this method, the schedule is divided into several time frames and uses equations to calculate the delay liability of each party.

Critical path changes have to be analyzed as a part of this method. By using critical path changes analysis, at week 30, the total duration becomes 300 days from its initial duration 294 days (Figure 1-2). It means the project has 6 days of delay (300-294=6). At this week, the owner and the contractor cause delays on the critical path and the EDAM provides equations for calculating the delay liability of the project parties.

Because of both project parties cause delay in the same week, one concurrent delay exists. By using the equation proposed in EDAM, the concurrent delay of 6 days is distributed as the owner has 4.38 days and the contractor has 1.62 days (Figure 3). From week 31 until week 47, only the contractor causes the delays.

After analyzing all of the critical path changes, the final summation has to be calculated. In the project, total project delay duration is 28 days with 6-day of concurrent delay and 22-day delay caused by the contractor. Using the equation, the liability of the contractor and the owner can be calculated. At the end, the owner caused 4.38-day and the contractor caused 23.62-day of delay from 28-day in total.

4.8 Comparison Result of Each Method

Table 7 presents the comparison results of all methods. As explained earlier, the methods which are chosen in this research cover three levels of schedule delay analysis. In the first level, as-planned vs. as-built method only shows 28 days of the total delay in the project. This method is unable to address the liability of the project parties.

The impacted as-planned and collapsed as-built (but-for) methods start with different type of project schedule. Those methods in the second level of schedule delay analysis, consider the owner's and contractor's perspectives into the calculation separately and presents the different results of the parties' liability. However, the

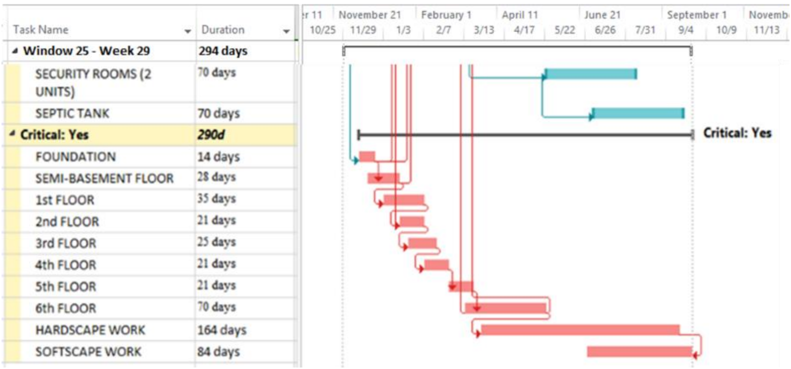


Figure 1. Critical path on week 29

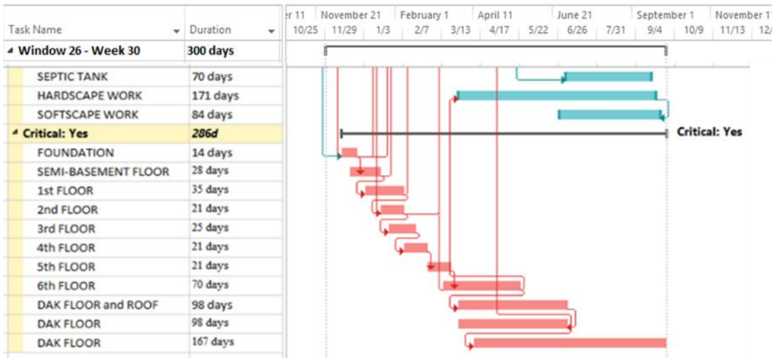
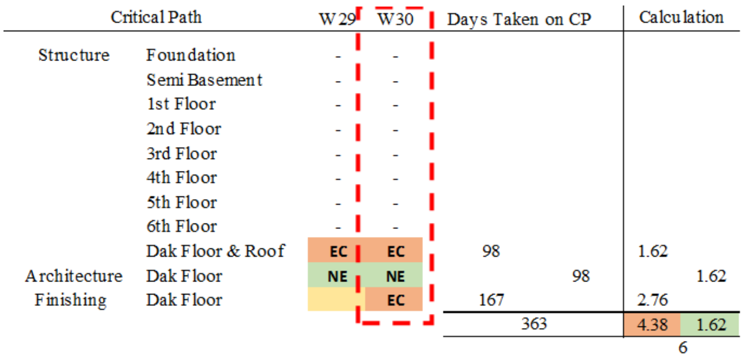


Figure 2. Critical path on week 30



Critical Path		W29	W30	Days Taken on CP		Calculation	
Structure	Foundation	-	-				
	Semi Basement	-	-				
	1st Floor	-	-				
	2nd Floor	-	-				
	3rd Floor	-	-				
	4th Floor	-	-				
	5th Floor	-	-				
	6th Floor	-	-				
	Dak Floor & Roof	EC	EC	98		1.62	
Architecture	Dak Floor	NE	NE		98		1.62
Finishing	Dak Floor		EC	167		2.76	
				363		4.38	1.62
						6	

Figure 3. Calculation of delays in the critical path on week 30

impacted as-planned and collapsed as-built (but-for) methods are unable to address the concurrent delay in the project.

The isolated delay type, window but-for, isolated collapsed but-for and EDAM are in the third level. These methods divide the schedule into several time frames and consider owner's and contractor's perspectives. The isolated delay type uses owner's and contractor's perspectives separately to its calculation. This method is unable to address the concurrent delay in the project case.

Window but-for, isolated collapsed but-for and EDAM consider the owner's and contractor's perspectives to the calculation and use it continuously for each period. These three methods are able to address the concurrent delay in the project even those methods start with different type of project schedule. Window but-for and isolated collapsed but-for method provide not only the same results of each project party's liability but also the number of concurrent delay. However, these methods are unable to address the liability of each party in concurrent delay. The EDAM not only provide the same result of concurrent delay as window but-for and isolated collapsed but-for method but also can calculate the liability portion of the project parties in the concurrent -

Table 7. Comparison result of each method

No	Method	Used Data	Delay Liability	
			Owner	Contractor
1	As-Planned vs. As-Built	As-Planned Schedule, As-Built Schedule		
	- Total duration project delay		28	
2	Impacted As-planned	As-Planned Schedule, Delay Information		
	Owner's viewpoint		21	7
	Contractor's viewpoint		7	21
3	The Collapsed As-built (But-For)	As-Built Schedule, Delay Information		
	Owner's viewpoint		7	21
	Contractor's viewpoint		7	21
4	Isolated Delay Type	As-Planned Schedule, Delay Information		
	Owner's viewpoint		21	7
	Contractor's viewpoint		7	21
5	Window But-For Technique	As-Planned Schedule, Delay Information	0	22
	- Concurrent Delay		6	
6	Isolated Collapsed But-For	As-Built Schedule, Delay Information	0	22
	- Concurrent Delay		6	
7	CP Effect Based Delay Analysis Method (EDAM)	As-Planned Schedule, Delay Information	0	22
	- Concurrent Delay		6	
			4.38	23.62

delay. At the end, this method is able to calculate the total liability of each party in this project case including the liability of concurrent delay.

5 Conclusion

Schedule delay in projects is a common yet worrying problem. Activity delays might increase project duration, cost and sometimes cause delay claim disputes between parties in construction projects. Another issue related to delay in construction project is to deal with concurrent delay problems. Concurrency in delay sometimes occurs and may impact the total duration of the project. The result of delay caused by concurrent delay may increase the dispute liability claim of the parties. Therefore, identifying the suitable schedule delay analysis methods is an important issue to help the construction project practitioner solving the problems above.

Some methods have been developed for analyzing and measuring project schedule delays, but most of those methods contain assumptions and subjective assessments. Most of previous studies might use uncomplicated project information which only consists of limited activities and delay types in the schedules. Since this study provides a real project in Indonesia as a case study, it decreases the limitation above.

Before starting to implement some popular methods into a real case project, some works including collecting and analyzing actual schedule information and identifying delay events have been completed in advance. As-planned schedules, as-built schedules and delay information which are already categorized into different delay types will be presented in one table named as schedule delay information table.

This study examines seven schedule delay analysis methods which are divided into three levels. First is the simplest one, as-planned vs. as-built method. Impacted as-planned and collapsed as-built method which involve the owner’s and contractor’s perspectives, even those perspectives used separately are in the second level. Isolated delay type, window but-for technique, isolated collapsed as-built (but-for) and EDAM are in the third level. Above four methods use project schedule, delays information, owner’s and contractor’s perspectives and several time frames based on the project schedules.

In order to find the most suitable schedule delay analysis method for Indonesia construction project, some criteria have to be considered. The methods have to able to solve concurrent delay and calculate the project parties’ liability accurately. Based on this research, the methods which divide the project schedule into several time frames and use owner’s and contractor’s perspective continuously produce the most stable and accurate results. If the parties only have limited information about project schedule, these two characteristics can be used as a basic way to choose and examine the schedule delay analysis methods. To track liability of each party in concurrent delays, the further calculation is needed. One method which discussed above uses some equations to calculate it.

Schedule delay analysis method is a reliable way to identify and calculate delays in construction projects. The project parties can use the methods to solve the dispute related to schedule delay in the project. To implement the schedule delay analysis method, some information must be provided including as-planned schedule as an initial plan schedule of the project, as-built schedule as the actual schedule, delay information based on the real situation in the project and detailed progress reports. Since the concurrent delay is one of the important issues to complete the schedule delay analysis, the agreement about this issue should be considered by the project parties and could be written clearly in the contract. If the parties have a clear clause/agreement about this issue, the schedule delay analysis results would be more factual.

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