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SCHEDULING ANALYSIS USING THE PRECEDENCE DIAGRAM METHOD (PDM) METHOD IN THE PHASE II BRIDGE CONSTRUCTION PROJECT IN PEJAMBUAN VILLAGE, SUNGAI TABUK DISTRICT, BANJAR REGENCY, SOUTH KALIMANTAN

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ABSTRACT

In its implementation, starting from the planning stage, the implementation of scheduling, to the supervision and implementation of good controls, construction projects need to be well managed in their work. In the process of Building the Phase II Bridge Project in Pejambuan Village, Sungai Tabuk District, there was a slight delay in the eighth week due to equipment damage and delays in the material supply mobilization process. This project only has a time schedule in the form of an S Curve which is not helpful in controlling work in the field.

This study aims to analyze scheduling using the Precedence Diagram Method (PDM) method assisted by the Microsoft Project 2021 application and identify critical and non-critical paths of work so that the implementation of the project can be carried out with an effective duration.

Based on the results of the analysis of this study, the total duration of work is 138 working days with the total duration of work calculated using calendar days for 174 days, and the total duration of project realization is 180 calendar days. CV planning calculation. Al Fatih Karya is scheduled to be completed by September 30, 2024, while scheduling with the PDM method is completed by September 24, 2024. The critical trajectory in the results of this analysis is found in 13 activities starting from ordinary excavation work and ending with the installation of bridge nameplates.

Keywords : Bridge, Microsoft Project 2021, Scheduling, Delay, PDM

1. INTRODUCTION

In the construction process of the Phase II Bridge Project in Pejambuan Village, there are several obstacles, namely equipment damage and delays in the process of mobilizing material supplies. This project only has a simple Time Schedule in the form of a bar chart (S Curve). The researcher added and evaluated with the Precedence Diagram Method (PDM) method because it is more effective and as an evaluation material so that the scheduling of phase II can be carried out properly and on time.

The benefit of this research is that it can be an alternative for researchers and implementers regarding project scheduling because in the PDM method it can find out the relationship of dependency, Early Start, Early Finish, Latest Start, Latest Finish, Lag

and Lead relationship, and critical trajectory in all project work descriptions. With the existence of a critical trajectory, we can find out on the work whether it is too late or not.

2. THEORITICAL STUDY

Construction Projects

In planning a construction project, there is a project schedule, quality, and project cost. These three elements are generally referred to as project objectives, commonly referred to as Triple Constrain (Aulia, 2021).

Project Scheduling

Explain the development/progress of the plan to the implementation of the project realization, which shows whether the implementation of the project is going well and according to plan (Tasha Nadia Mulia et al., 2023).

S Curve

The S-curve depicts the cumulative percentage of all project work that provides information about the project's progress and compares the project realization schedule to the planned schedule (Isnandar et al., 2023).

Microsoft Project

Application to assist in planning, managing, monitoring and reporting data of a construction project (Winata et al., 2021).

Work Breakdown Structure (WBS)

Define and group project tasks into smaller chunks for easier management (Gazalba et al., n.d.).

Precedence Diagram Method (PDM)

Precedence Diagram Method (PDM) is a project scheduling method that has a critical path. Some of the basic terms used are (Oktavia, 2018) :

1. ES (Early Start), the earliest start time of work.
2. EF (Early Finish), the earliest time to finish the work.
3. LS (Late Start), the last time work begins without slowing down the duration of the overall project completion.
4. LF (Late Finish), the last time work is completed without slowing down the duration of the project's completion.
5. D (Acitivity Duration Time), the time required for a job.

If the works that pass through the critical path are delayed, then the implementation of the project as a whole will be delayed. The following are the requirements for the critical path (Virgina, 2019):

1. The longest track.
2. A trajectory that has no grace period between the end of the work stage and the beginning of the next work stage.

In general, there are four types of constraints in the PDM method, including (Syaputra, 2019) :

1. Finish to Start (FS), the relationship between the start of a job and the completion of the previous work.
2. Finish to Finish (FF), the relationship between two works with both works completed at the same time.
3. Start to Start (SS), the relationship between two jobs with both jobs starting at the same time.
4. Start to Finish (SF), the relationship between two jobs and the first job can be completed when the second work starts.

In the PDM method, there are forward calculations, backward calculations, Lag and Lead, and Float including:

1. Forward Calculation, calculated to get Early Start and Early Finish scores.
2. Countdown calculation, calculated to get Late Start and Late Finish.
3. Lag is the waiting time of J's work period against the work I that has begun, which is found in the relationship between SS and SF. Lead is the preceding time for the period of work J after the commencement of work I before the end of work I, which is found between FS and FF (Winata et al., 2021).
4. Float, which is the time available to allow for work delays, either intentional or accidental, but the delay does not result in project delays (Situmorang, 2017).

3. METHOD

Research Location

This research was carried out on a bridge construction project located in Pejambuan Village, Sungai Tabuk District, Banjar Regency, South Kalimantan.

Picture 1. Project Location

Research Procedure

Compile a Work Breakdown Structure (WBS) based on Curve S. Data Then conduct an interview with Mr. M. Rosyadi Razak as the Site Manager of this bridge project to find out the order of work, duration, Lag Time, Lead Time, and the relationship of dependencies between works during implementation in the field. Analyze the dependency relationship, namely Start to Start, Start to Finish, Finish to Finish, Finish to Start, and Lag and Lead in all job descriptions.

Create scheduling with Input work items, work duration, and dependency relationships into Microsoft Project 2021, with data processing outputs in the form of Network Diagrams. Create the Early Start and Latest Start S curves from the scheduling results using the PDM method and compare them with the realization S curve.

4. RESULTS AND DISCUSSION

Work Breakdown Structure (WBS)

The steps in the preparation of the WBS in this bridge construction project include:

1. Level 1, namely the Construction of the Pejambuan Village Bridge, Sungai Tabuk District (Continued).
2. Level 2, describes the project and divides it into sub-work parts of the project, namely earthworks and geosynthetics, granular pavement and cement concrete pavement, structures, bridge rehabilitation, and daily work & miscellaneous work.
3. Level 3, A more detailed breakdown of the work in the previous level.
4. Numbering or code, numbering system based on Project level.

Duration of Work and Dependency Relationships

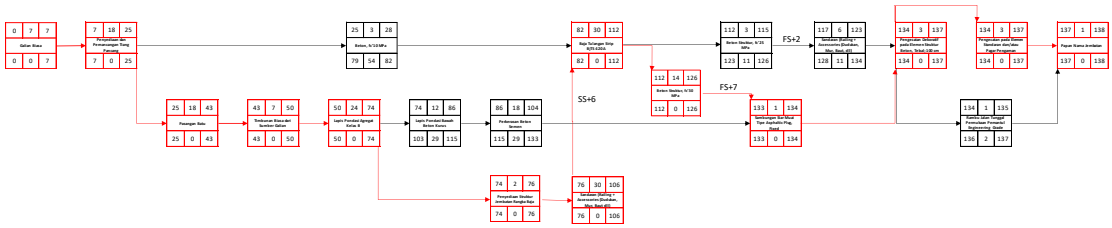
The following is a table of the results of the analysis of the duration of work and the relationship of job dependence:

Table 1. Duration of Work and Dependency Relationship between Jobs

ID	Job Description	Dependency	Duration (Days)	Relationship	Lag Time	Lead Time
Earthworks and Geosynthetics						
3	Common Mines	-	7	-	-	-
4	Ordinary Heaps from Mineral Sources	17	7	FS	-	-
Grained Pavement and Cement Concrete Pavement						
6	Class B Aggregate Foundation Layer	4	24	FS	-	-
7	Cement Concrete Pavement	8	18	FS	-	-
8	Skinny Concrete Bottom Foundation Layer	6	12	FS	-	-
Structure						
10	Structural Concrete, fc'30 MPa	13	14	FS	-	-
11	Concrete Structure, fc'25 MPa	13	3	FS	-	-
12	Concrete, fc'10 MPa	16	3	FS	-	-
13	BjTS 420A Fin Reinforcement Steel	12	30	FS	-	-
		15		SS	-	6
14	Provision of Standard Steel Frame Bridge Structure Type C Span 55 m	6	2	FS	-	-
15	Installation of 55m Length Standard Steel Frame Bridge	14	30	FS	-	-
16	Preparation and Erection of Ironwood Piles Size 10x10 cm	3	18	FS	-	-
17	Stone Pair	16	18	FS	-	-
18	Asphaltic Plug Type Asphaltic Plug Broadcast Connection, Fixed	7	1	FS	-	-
		10		FS	7	-
19	Railing + Accessories (Mounts, Nuts, Bolts, etc)	11	6	FS	2	-
20	Bridge Nameplate	23	1	FS	-	-
		25		FS	-	-
Bridge Rehabilitation						
22	Decorative Painting on Concrete Structural Elements, Thick; 100 cm	18	3	FS	-	-
		19		FS	-	-
23	Painting on Standard Elements and/or Safety Rails (Gruard Rail) 80 mic	22	3	SS	-	-
Day Jobs and Miscellaneous Jobs						
25	Single Road Signs with Engineering Grade Reflective Surfaces	22	1	SS	-	-

In the implementation of this bridge project, the lag and lead times are found in the work of BjTS 420A (13) fin reinforcement steel, Asphaltic Plug, Fixed (18) type expansion joints, and railing + accessories (Mounts, nuts, bolts, etc.) (19). Lag and Lead time analysis refers to the results of interviews with main contractors and refers to previous research using similar methods as an additional reference in determining the duration of work that experiences Lag Time and Lead Time.

PDM NETWORK DIAGRAM (PRECEDENCE DIAGRAM METHOD)



Forward and Backward Calculation

The calculation table for the forward and backward calculation of the scheduling of the bridge project is shown in the table below:

Table 2. Forward and Backward Calculation

ID	Duration (Day)	Forward Calculation		Countdown	
		ES	EF	LS	LF
	138				
3	7	0	7	0	7
4	7	43	50	43	50
6	24	50	74	50	74
7	18	86	104	115	133
8	12	74	86	103	115
10	14	112	126	112	126
11	3	112	115	123	126
12	3	25	28	79	82
13	30	82	112	82	112
14	2	74	76	74	76
15	30	76	106	76	106
16	18	7	25	7	25
17	18	25	43	25	43
18	1	133	134	133	134

ID	Duration (Day)	Forward Calculation		Countdown	
		ES	EF	LS	LF
19	6	117	123	128	134
20	1	137	138	137	138
22	3	134	137	134	137
23	3	134	137	134	137
25	1	134	135	136	137

Critical and Non-Critical Paths

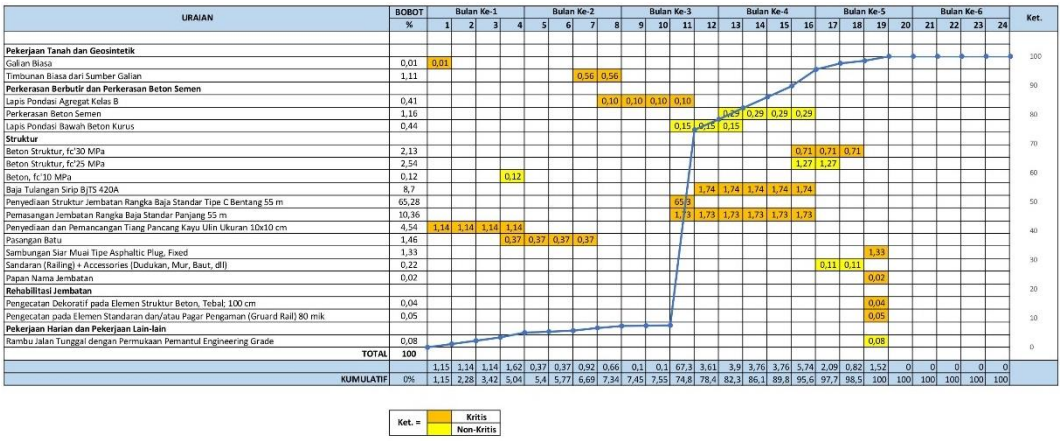
The following is a table of critical and non-critical paths for each work item in the Phase II Bridge Construction Project in Pejambuan Village:

Table 3. Work on a Critical Path

Code	Job Description	Duration	ICE	EF	LS	LF	Total Float	Critical
	Pejambuan Village Bridge Construction Project Phase II	**138 days**						
I.	**Earthworks and Geosynthetics**							
3	Common Mines	7 days	0	7	0	7	0	Yes
4	Ordinary Heaps from Mineral Sources	7 days	43	50	43	50	0	Yes
II.	**Grained Pavement and Cement Concrete Pavement**							
6	Class B Aggregate Foundation Layer	24 days	50	74	50	74	0	Yes
7	Cement Concrete Pavement	18 days	86	104	115	133	29	Not
8	Skinny Concrete Bottom Foundation Layer	12 days	74	86	103	115	29	Not
III.	**Structure**							
10	Structural Concrete, fc'30 MPa	14 days	112	126	112	126	0	Yes
11	Concrete Structure, fc'25 MPa	3 days	112	115	123	126	11	Not
12	Concrete, fc'10 MPa	3 days	25	28	79	82	54	Not
13	BjTS 420A Fin Reinforcement Steel	30 days	82	112	82	112	0	Yes
14	Provision of Standard Steel Frame Bridge Structure Type C Span 55 m	2 days	74	76	74	76	0	Yes
15	Installation of 55m Length Standard Steel Frame Bridge	30 days	76	106	76	106	0	Yes
16	Preparation and Erection of Ironwood Piles Size 10x10 cm	18 days	7	25	7	25	0	Yes
17	Stone Pair	18 days	25	43	25	43	0	Yes
18	Asphaltic Plug Type Asphaltic Plug Broadcast Connection, Fixed	1 day	133	134	133	134	0	Yes
19	Railing + Accessories (Mounts, Nuts, Bolts, etc)	6 days	117	123	128	134	11	Not
20	Bridge Nameplate	1 day	137	138	137	138	0	Yes
IV.	**Bridge Rehabilitation**							
22	Decorative Painting on Concrete Structural Elements, Thick; 100 cm	3 days	134	137	134	137	0	Yes
23	Painting on Standard Elements and/or Safety Rails (Gruard Rail) 80 mic	3 days	134	137	134	137	0	Yes
V.	**Day Jobs and Miscellaneous Jobs**							
25	Single Road Signs with Engineering Grade Reflective Surfaces	1 day	134	135	136	137	2	Not

Early Start and Latest Start Curves Based on the PDM Method

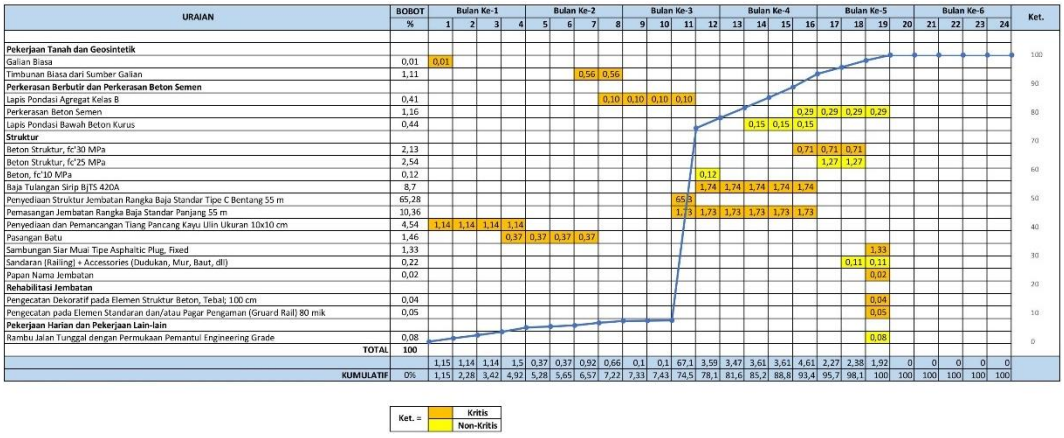
The Early Start S curve and the Latest Start S curve refer to the Early Start and Latest Start data from the scheduling results using the PDM method. This S curve provides insight and is a reference for the project to find out when to start the earliest, start the latest, finish the fastest, and finish the latest on work on critical and non-critical tracks so that it can make an estimate of the time of work while in the field which if there is a delay in the work on the critical track, the construction of the construction project can be delayed from schedule. The following are the Early Start S Curve and the Latest Start S Curve :



URAIAN	BOBOT	Bulan Ke-1				Bulan Ke-2				Bulan Ke-3				Bulan Ke-4				Bulan Ke-5				Bulan Ke-6				Ket.
	%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Pekerjaan Tanah dan Geosintetik																										
Galian Biasa	0,01	0,01																								
Timbunan Biasa dari Sumber Galian	1,11							0,56	0,56																	
Perkerasan Berbutir dan Perkerasan Beton Semen																										
Lapis Pondasi Agregat Kelas B	0,41							0,10	0,10	0,10	0,10	0,10														
Perkerasan Beton Semen	1,16													0,29	0,29	0,29	0,29									
Lapis Pondasi Bawah Beton Kurus	0,44											0,15	0,15	0,15												
Struktur																										
Beton Struktur, fc'30 MPa	2,13																0,71	0,71	0,71							
Beton Struktur, fc'25 MPa	2,54																1,27	1,27								
Beton, fc'10 MPa	0,12				0,12																					
Baja Tulangan Sirip BjTS 420A	8,7												1,74	1,74	1,74	1,74	1,74									
Penyediaan Struktur Jembatan Rangka Baja Standar Tipe C Bentang 55 m	65,28											65,3														
Pemasangan Jembatan Rangka Baja Standar Panjang 55 m	10,36											1,73	1,73	1,73	1,73	1,73	1,73									
Penyediaan dan Pemancangan Tiang Pancang Kayu Ulin Ukuran 10x10 cm	4,54	1,14	1,14	1,14	1,14																					
Pasangan Batu	1,46				0,37	0,37	0,37	0,37																		
Sambungan Siar Muai Tipe Asphaltic Plug, Fixed	1,33																			1,33						
Sandaran (Railing) + Accessories (Dudukan, Mur, Baut, dll)	0,22																	0,11	0,11							
Papan Nama Jembatan	0,02																			0,02						
Rehabilitasi Jembatan																										
Pengecatan Dekoratif pada Elemen Struktur Beton, Tebal; 100 cm	0,04																			0,04						
Pengecatan pada Elemen Standaran dan/atau Pagar Pengaman (Gruard Rail) 80 mik	0,05																			0,05						
Pekerjaan Harian dan Pekerjaan Lain-lain																										
Rambu Jalan Tunggal dengan Permukaan Pemantul Engineering Grade	0,08																			0,08						
TOTAL	**100**																									
		1,15	1,14	1,14	1,62	0,37	0,37	0,92	0,66	0,1	0,1	67,3	3,61	3,9	3,76	3,76	5,74	2,09	0,82	1,52	0	0	0	0	0	
KUMULATIF	0%	1,15	2,28	3,42	5,04	5,4	5,77	6,69	7,34	7,45	7,55	74,8	78,4	82,3	86,1	89,8	95,6	97,7	98,5	100	100	100	100	100	100	

Ket. =	Kritis
	Non-Kritis

Figure 2. Curve Realization Based on Early Start



URAIAN	BOBOT	Bulan Ke-1				Bulan Ke-2				Bulan Ke-3				Bulan Ke-4				Bulan Ke-5				Bulan Ke-6				Ket.
	%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Pekerjaan Tanah dan Geosintetik																										
Galian Biasa	0,01	0,01																								
Timbunan Biasa dari Sumber Galian	1,11							0,56	0,56																	
Perkerasan Berbutir dan Perkerasan Beton Semen																										
Lapis Pondasi Agregat Kelas B	0,41							0,10	0,10	0,10	0,10	0,10														
Perkerasan Beton Semen	1,16																0,29	0,29	0,29	0,29						
Lapis Pondasi Bawah Beton Kurus	0,44													0,15	0,15	0,15										
Struktur																										
Beton Struktur, fc'30 MPa	2,13																0,71	0,71	0,71							
Beton Struktur, fc'25 MPa	2,54																	1,27	1,27							
Beton, fc'10 MPa	0,12												0,12													
Baja Tulangan Sirip BjTS 420A	8,7												1,74	1,74	1,74	1,74	1,74									
Penyediaan Struktur Jembatan Rangka Baja Standar Tipe C Bentang 55 m	65,28											65,3														
Pemasangan Jembatan Rangka Baja Standar Panjang 55 m	10,36											1,73	1,73	1,73	1,73	1,73	1,73									
Penyediaan dan Pemancangan Tiang Pancang Kayu Ulin Ukuran 10x10 cm	4,54	1,14	1,14	1,14	1,14																					
Pasangan Batu	1,46				0,37	0,37	0,37	0,37																		
Sambungan Siar Muai Tipe Asphaltic Plug, Fixed	1,33																			1,33						
Sandaran (Railing) + Accessories (Dudukan, Mur, Baut, dll)	0,22																	0,11	0,11							
Papan Nama Jembatan	0,02																			0,02						
Rehabilitasi Jembatan																										
Pengecatan Dekoratif pada Elemen Struktur Beton, Tebal; 100 cm	0,04																			0,04						
Pengecatan pada Elemen Standaran dan/atau Pagar Pengaman (Gruard Rail) 80 mik	0,05																			0,05						
Pekerjaan Harian dan Pekerjaan Lain-lain																										
Rambu Jalan Tunggal dengan Permukaan Pemantul Engineering Grade	0,08																			0,08						
TOTAL	**100**																									
		1,15	1,14	1,14	1,5	0,37	0,37	0,92	0,66	0,1	0,1	67,1	3,59	3,47	3,61	3,61	4,61	2,27	2,38	1,92	0	0	0	0	0	
KUMULATIF	0%	1,15	2,28	3,42	4,92	5,28	5,65	6,57	7,22	7,33	7,43	74,5	78,1	81,6	85,2	88,8	93,4	95,7	98,1	100	100	100	100	100	100	

Ket. =	Kritis
	Non-Kritis

Figure 3 Curve Realization Based on Latest Start

The S curve of project realization, duration or weight is from the result of calculating the cost of each work divided by the total cost of work. Meanwhile, in the Early Start S Curve and the Latest Start S Curve, the Early Start duration and the Latest Start duration were obtained from the scheduling results using the PDM method. For example, the implementation of the work of Supplying the 55 m Type C Standard Steel Frame Bridge Structure on the S Early Start Curve can start in the fourth week, while the implementation of the 55 m Type C Span Standard Steel Frame Bridge Structure Provision work on the S Latest Start Curve starts in the twelfth week.

5. CONCLUSION

Based on the results of research conducted on the Phase II Bridge Construction Project in Pejambuan Village, Sungai Tabuk District, Banjar Regency, South Kalimantan, it can be concluded:

1. In the implementation of this bridge project work, there is a dependency relationship Finish to Start = 0; Finish to Start = 2 ; Finish to Start = 7 ; Start to Start = 0; and Start to Start = 6. The Finish to Start (FS = 2) and (FS = 7) dependency relationships are included in the Lag Time category and the Start to Start dependency relationship (SS = 6) is included in the Lead Time category.
2. Analysis of the scheduling of the Bridge Advanced Construction Project in Pejambuan Village, Sungai Tabuk District using the PDM method assisted by the Microsoft Project 2021 application, namely the project was carried out for 138 working days with a total duration of work calculated using 174 calendar days starting on April 1, 2024 and ending on September 24, 2024 with a comparison at the time of project realization was 180 calendar days. The critical trajectory in the results of this analysis is found in 13 activities.
3. The difference between the S curve of project realization with the Early Start S Curve and the Latest Start S Curve lies in the duration or weight of the work entered. The duration of the S curve of project realization is obtained from the results of calculating the cost of each work divided by the total cost of work. Meanwhile, the duration of the Early Start S Curve and the Latest Start S Curve was obtained from the results of scheduling using the PDM method. This S curve can also be a reference for implementers to determine when to start the earliest and the latest to start the implementation of a work so that the project can run smoothly.

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