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ANALYSIS OF SCHEDULING USING CPM AND PDM METHODS WITH MICROSOFT PROJECT 2019 IN THE REPLACEMENT PROJECT OF SALIM RIVER BRIDGE MATARAMAN

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ABSTRACT

The success of an emergency response project is that it can be completed quickly and on time because of the urgency of the situation so that timely management of implementation is needed by making a schedule. This research was conducted to determine the appropriate scheduling method according to the character of the emergency response construction project. Scheduling methods are used in the form of Critical Path Method (CPM) and Precedence Diagram Method (PDM). The analysis was carried out on the duration and dependencies for each work item which was then scheduled with the help of Microsoft Project 2019 to get the results in the form of network diagrams and critical paths. Based on the results of the scheduling analysis the Replacement Project of Salim River Bridge Mataraman, it was found that for the CPM method the project could be carried out for 129 days starting from January 20, 2021 and ending on May 29, 2021 and for the PDM method the project was carried out for 120 days starting from January 20, 2020 and ends on May 20, 2021 earlier than the CPM method. Each method has two critical paths due to the traffic safety and management work required throughout the project.

Keywords : Critical Path Method (CPM), Precedence Diagram Method (PDM), Microsoft Project 2019

1. INTRODUCTION

Emergency response construction projects are projects based on circumstances caused by natural disasters in accordance with legislation. Which results in damage to infrastructure that interferes with public service activities and/or endangers the community. This project is called an emergency response project because it is one of the main bridges located on the national road connecting the provinces of East Kalimantan and South Kalimantan where on January 17, 2021, there was a landslide and caused the bridge to break due to the flood disaster. As a result of this incident, the route which is the national road cannot be passed so that community activities are hampered, therefore this project is said to be an emergency response because of the urgency of the situation so that it cannot be delayed in handling so that timely management of implementation is needed, in this case it can be done by create a project schedule. A scheduling method that is easy to understand and fast to work on is needed to avoid delays in project work. The CPM and PDM methods were chosen because so far the scheduling used in the project only uses the S curve which in its use is difficult to control the course of the project so that scheduling is made with the CPM and PDM methods which can analyze the relationship of activities according to needs, namely by making work diagrams and knowing critical path. In addition, these two methods were also chosen because of the use of *Microsoft Project* 2019 which has the facility to schedule the two methods. This research was conducted to be able to perform scheduling using the CPM and PDM methods with *Microsoft Project* 2019 and to compare the duration and critical path of the two methods.

2. LITERATURE REVIEW

Emergency Response Project

The emergency response project is one of the handling of emergency situations that are motivated by the need for construction work with a priority level of speed and accuracy of work that is urgent due to infrastructure damage that can interfere with activities and concerns the safety of the community. According to Institutional Regulation Number 13 of 2018 concerning the Procurement of Goods/Services in Handling Emergency Situations, a situation can be said to be an emergency in the event of a disaster or search and rescue operations.

Analysis Pareto

Analysis Pareto is done by selecting several tasks from many problems. Based on Pareto's law, 80% of the total costs are selected as 20% of the causes.

Project Scheduling

According to Husen (2010), scheduling is one element of the planning results, which can provide some information in the project such as costs, labor, tools, materials, as well as knowing the duration of the project and the progress of time to complete the project. So that scheduling can be used efficiently, in its manufacture, it uses technical methods or methods that have been used.

Critical Path Method (CPM)

The CPM method is a method whose activity lies on the arrow line, namely Activity On Arrow (AOA). There dummy which means a pseudo activity that does not require time and money. The CPM method is also known as the critical path, which is a path with a series of each component of its activities having the longest total amount of time and the fastest project completion period (Soeharto, 1999). The following is a framework for the CPM method:

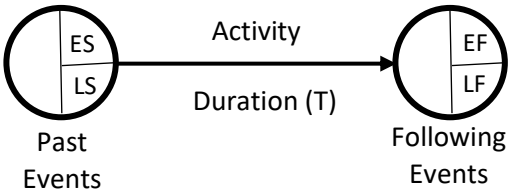


Figure 1. CPM Framework

In a CPM schedule, the factors that are determined are:

1. ES (Earliest Activity Start Time), the earliest time to start an activity.
2. EF (Earliest Activity Finish Time) is the earliest finish timefor an activity.
3. LS (Latest activity start time), the latest time allowed to start an activity.
4. LF (Latest activity finish time), the slowest time to be able to complete an activity.
5. T, the required duration of an activity.

The constraint used in AOA is that FS (Finish to Start) is equal to 0, which means that the next job can only start after the previous job is finished. The critical path can be obtained by the following steps:

1. Forward pass

$$EF(ij) = ES(ij) + T(ij)$$

For all activities (ij) defined, information:

EFi =erliest start time to all activities originating from the event i.

T(ij) = time duration of the activity from event i to j

Where for the initial ESi is always 0.

2. Backward pass

$$LS(ij) = LF(ij) – T(ij)$$

For all activities (i, j) defined, information:

LFi =latest completion timefor all activities originating from event i.

An activity (i, j) is on a critical path if the activity satisfies the following three conditions:

$$ES = LS$$

$$EF = LF$$

$$EF – ES = LF – LS = T$$

Precedence Diagram Method (PDM)

PDM method is a method whose activities are written with nodes and arrows to show the dependencies of each activity, so it is also called Activity On Node (AON).According Hendriputri (2018) in PDM there are overlapping activities. The following is an example node of a PDM activity :

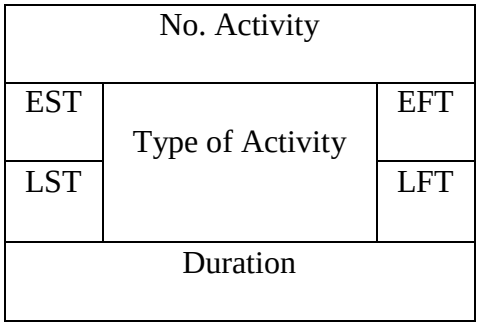


Figure 2. Node PDM Activity

Description:

ES = Earliest Start, the earliest activity start time

EF = Earliest Finish, the earliest activity completion time

LS = Latest Start, slowest activity start time

LF = latest Finish, activity completion time at the latest

PDM has a logical dependency relationship that varies. There are 4 types of relationship between two activities in PDM, namely:

1. FS (Finish to Start), is a relationship where an activity can be started after the previous activity is completed.

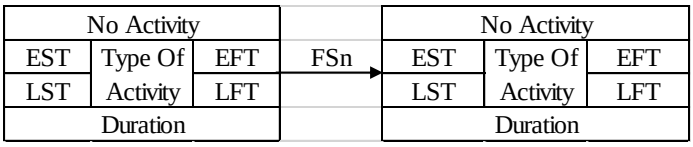


Figure 3. Finish to Start (FSn)

2. SS (Start to Start) relationship, is a relationship where an activity can be started when the previous activity started.

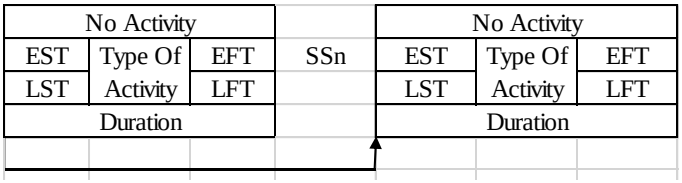


Figure 4. Start to Start (SSn)

3. FF (Finish to Finish) relationship, is a relationship where an activity is completed after the previous activity is completed.

Figure 5. Finish to Finish (FFn)

4. SF (Start to Finish) relationship, is a relationship where an activity is finished when the previous activity started.

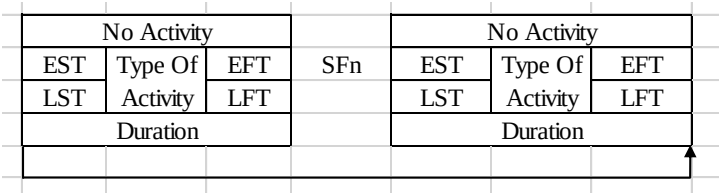


Figure 6. Relationship Start to Finish (SFn)

In scheduling using PDM calculations can also be based on 2 types, namely:

1. Forward pass

This calculation results in ES, and EF within the project completion period, if there is more than one activity combined then it is selected The biggest ES. For the notation (i) is the previous activity (predecessor) and (j) the activity being reviewed.

Initial time is considered zero. According to H. Kurzner (1976), to find ES and EF applies:

Activity relationship finish to finish

EFj = EFi + FFij ES j = EFj – Dj

Relationship activity finish to start

ES j = EFi + FSij EFj = ES j + Dj

Activity relationship start to start

ES j = ESi + SSij Efj = ES j + Dj

Relationship of activities start to finish

EFj = ESi + SFij ES j = EFj – Dj

2. Backward Pass

This calculation produces LS, LF and float period, if any more than one activity is combined then select the smallest LS. For the notation (i) is the activity being reviewed and (j) the next activity. To find LS and LF then apply:

Relation of finish to finish

activities Lfi = LFj – FFij LSi = LFi – Di

Relationship of activities finish to start

Lfi = LSj – FSij LSi = LFi – Di

Relationship of start to start activities

LSi = LSj – SSij LFi = LSi + Di

Relationship start to finish activities

LSi = LFj – SFij LFi = LSi + Di

Microsoft Project 2019

Microsoft Project is software that can be used in project management to provide convenience and help in planning and controlling. Its versatility helps in managing projects more effectively and efficiently.

3. RESEARCH METHODOLOGY

In the research, preparations were made in the form of a literature study on the topic of discussion. For further identification and limitation of problems and collecting data, where the data obtained in the form of primary and secondary data will be processed data with the following stages:

1. Determining activities based on Pareto law where for each activity it is necessary to know the percentage of costs. Then a ranking is made from the largest to the smallest, the number of activities containing a cost of 80%. It is checked that the number of selected activities must be 20% of the total number of activities.
2. Determining the duration for each work item is obtained from the S-curve or volume comparison (RAB) and work productivity, where productivity can be obtained through field observations, implementation methods, and also interviews.
3. Analyze dependency relationship:
   - For Precedence Diagram Method (PDM), namely start to startt (SS), start to finish (SF), finish to finish (FF), and finish to start (FS) based on interviews.
   - The Critical Path Method (CPM) is finish to start (FS).
4. Processing the data so that project scheduling is obtained in the form of a Network Diagram using the Critical Path Method and Precedence Diagram Method with the help of Microsoft Project 2019
5. Obtaining the critical path to the total project duration from both methods.

The flow of the research carried out can be seen in Figure 7 below:

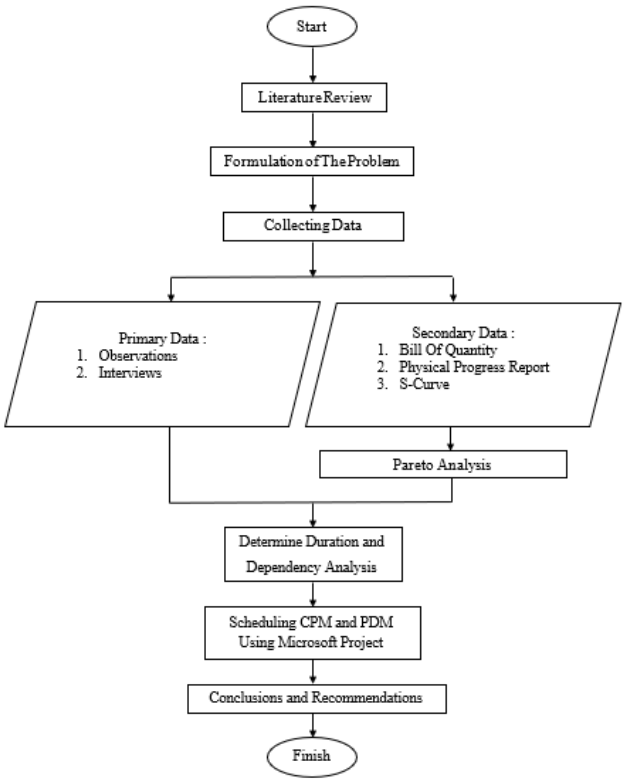


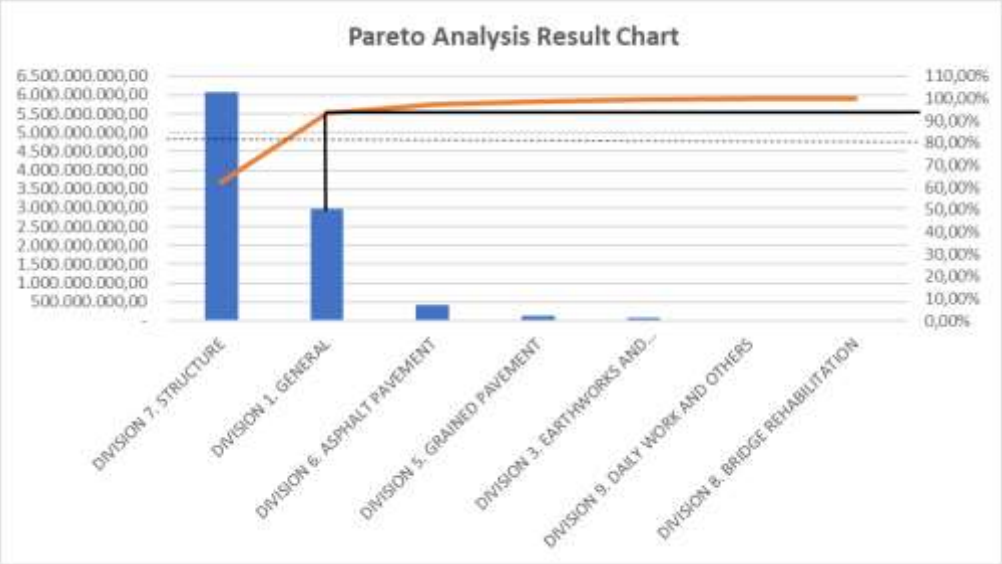
Figure 7. Flow Chart of Research Methods

4. RESULTS AND DISCUSSION

Perform a pareto analysis of the recapitulation data of the list of quantities and prices of project work based on the Bill of Quantity (BoQ). The data will be ranked from the largest to the smallest as in Table 1 and then a graph is made to find out activities that contain costs of 80%. So that the results of the analysis of activities used are division 7 structure and division 1 general

Table 1. Job Ranking Based on Pareto Analysis

No Division	Job Description	Weight (%)	Price Each Division (Rupiah)	Cumulative Weight (%)
1	DIVISION 7. STRUCTURE	62,54%	6.082.226.146,65	62,54%
2	DIVISION 1. GENERAL	30,63%	2.978.571.209,69	93,17%
3	DIVISION 6. ASPHALT PAVEMENT	4,29%	417.514.838,81	97,46%
4	DIVISION 5. GRAINED PAVEMENT	1,22%	119.112.126,57	98,68%
5	DIVISION 3. EARTHWORKS AND GEOSYNTHETICS	0,85%	82.321.959,47	99,53%
6	DIVISION 9. DAILY WORK AND OTHERS	0,40%	39.159.561,87	99,93%
7	DIVISION 8. BRIDGE REHABILITATION	0,07%	6.599.974,91	100,00%



Graph 1. Pareto Analysis

Determining the duration of each work item based on the reference to the S-Curve and analyzing the dependency relationship to get the sequence of activities from the start of project work to completion of both methods. The duration and dependency relationship can be seen in Table 2:

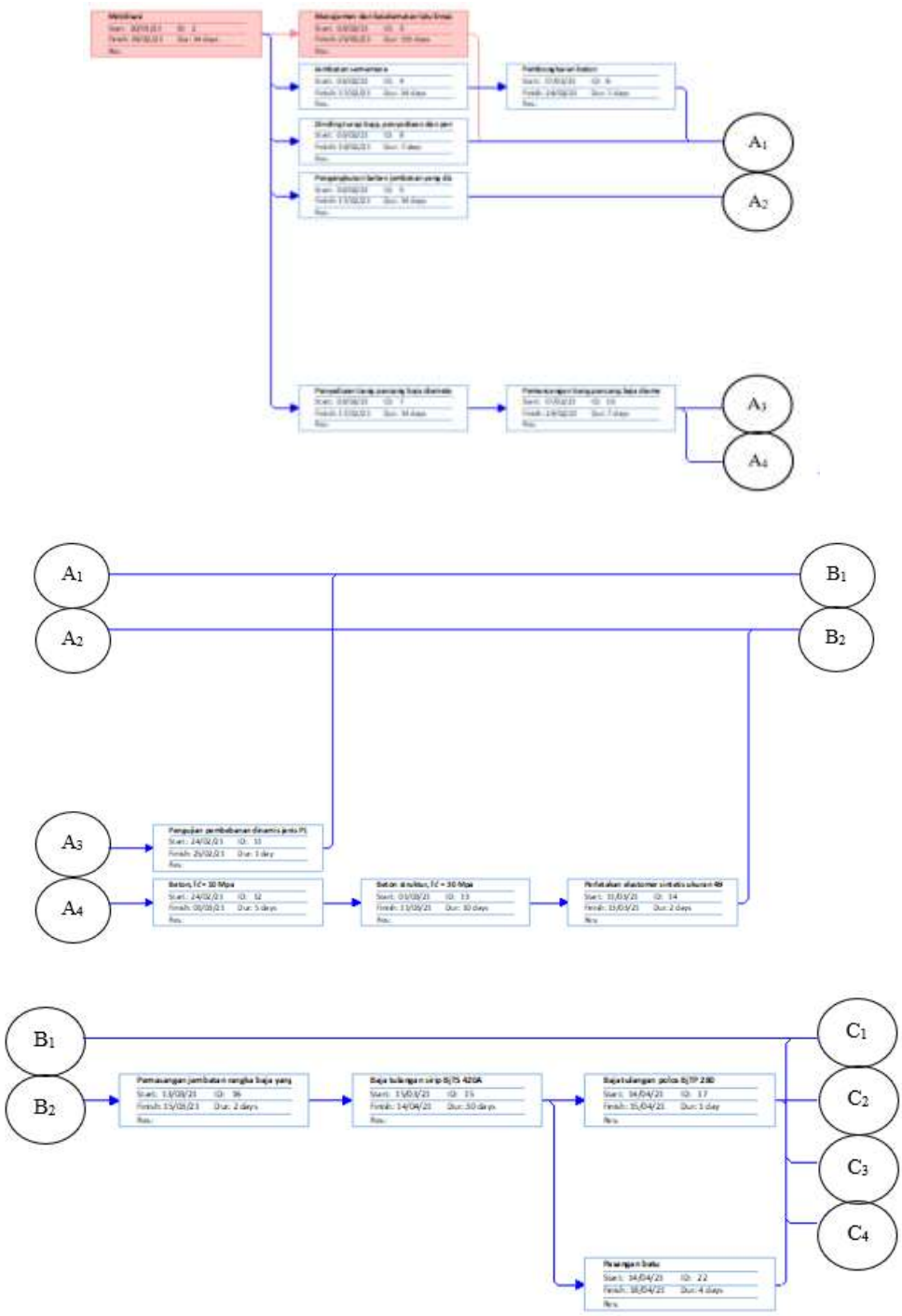
Table 2. Duration and Dependency Analysis of the CPM and PDM Methods

No.	Job Name		Code	Volume	Unit	Duration (day)	Predecessor	Connection
	No.	Job						
		Division 1. General						
1	1.1	Mobilization	A1	1,00	Ls	14	Start	FS0
2	1.2	Traffic Management and Safety	A2	1,00	Ls	115	A1	SS+5
3	1.3	Temporary Bridge	A3	1,00	Ls	14	A1	FS0
		Division 7. Structure						
4	7.1	Demolition of Concrete	B1	48,60	M2	7	A3	FS0
5	7.2	Provision of steel piles diameter 500 mm thick 12 mm	B2	386,50	M'	14	A1	FS0
6	7.3	Steel sheet piles, provision and erection	B3	547,20	M2	7	A1	FS0
7	7.4	Transportation of bridge materials provided by service users	B4	106897,60	Kg	14	A1	FS+4
8	7.5	Erection of steel piles diameter 500 mm	B5	386,50	M'	7	B2	SS+7 FF+4
9	7.6	PDLT (Pile Dynamic Load Testing) type dynamic loading testing on poles of size / diameter 500 mm	B6	2,00	Unit	1	B5	FS+1
10	7.7	Concrete, fc'= 10 Mpa	B7	66,87	M3	5	B5	FS+3
11	7.8	Concrete structure, fc' = 30 Mpa	B8	317,39	M3	10	B7	FS+4
12	7.9	Synthetic elastomeric placement size 460 mm x 410 mm x 112mm	B9	4,00	Unit	2	B8	FS+4
13	7.10	Reinforcing steel fins BjTS 420A	B10	47843,07	Kg	30	B11	FS0
14	7.11	Installation of steel truss bridges provided by service users	B11	104491,60	Kg	2	B4 B9	FS+10 FS0
15	7.12	Plain reinforcing steel BjTP 280	B12	2623,98	Kg	7	B10	FS0
16	7.13	Plain reinforcing steel BjTP 280	B13	93,60	M'	1	B12	FS0
17	7.14	Steel drainage pipe diameter 3 Inch	B14	18,00	M'	1	B13	SS1
18	7.15	Foundation of Piles, provision and erection	B15	400,00	M'	2	B12	FS0
19	7.16	Masonry demolition	B16	14,06	M2	4	B10	FS0
20	7.17	Masonry	B17	62,78	M3	10	B15	FS0
21	7.18	Bridge nameplate	B18	2,00	Unit	1	B17	FS0

After determining the duration and dependency relationship, then the existing data is processed into a schedule using Microsoft Project 2019 where the steps are as followsfollowing:

1. Activate the software then select Blank Project to start a new job
2. Set the total working hours and total working days, click the File menu > Options > Schedules
3. Enter the project start date by clicking the Project menu > Project Information > Project Information Dialog > Schedule From > Project Date
4. Compile work calendar, click Project > Change Working Time > Works Week > Details > Select working day > Determine working hours each day
5. Enter work items in the Task Name and set indents and outdents
6. Enter Predecessors
7. Displays Network Diagram as shown in Figure 8 and Figure 9, click View > Other View > More View > Ne twork Diagram

8. Displaying the critical path, click Gantt Chart > Bar Styles > Critical Tasks



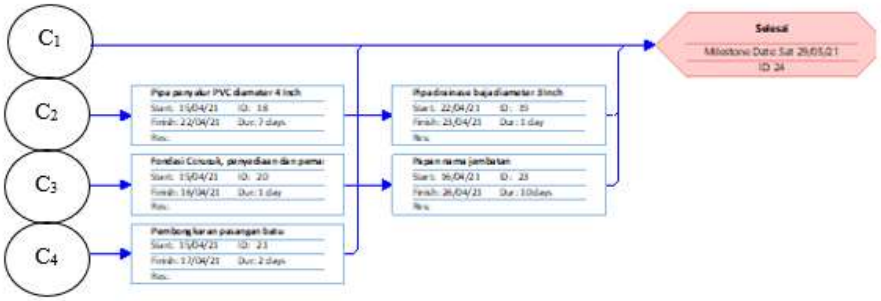
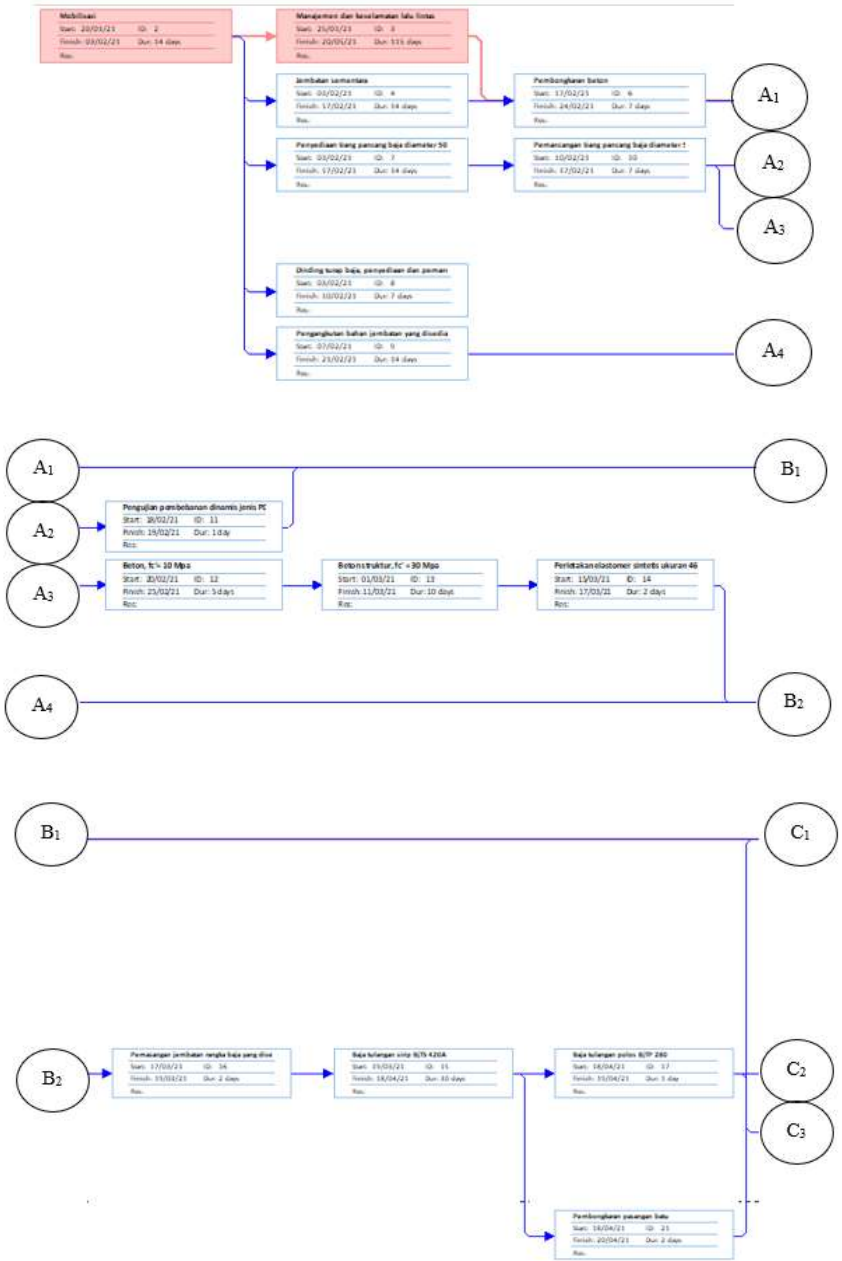


Figure 8. *Network Diagram* CPM



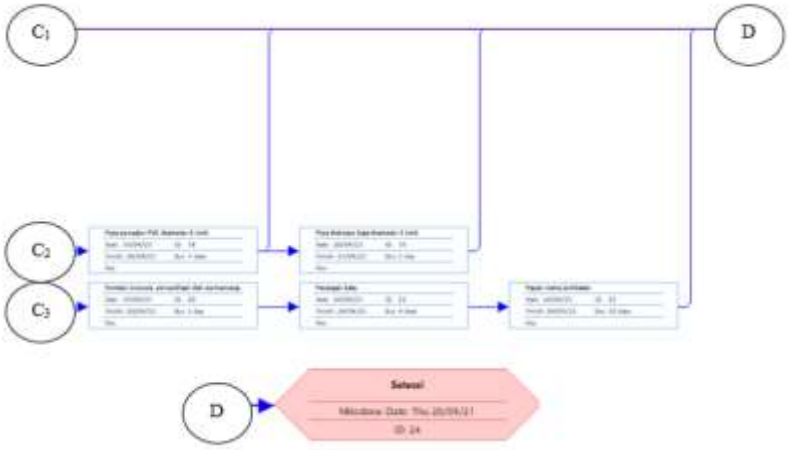


Figure 9. *Network Diagram* PDM

Based on the results of scheduling analysis on the Salim Mataraman River Bridge Replacement Project with the help of *Microsoft Project* 2019 it was found that the CPM method can carried out for 129 days starting from January 20, 2021 and ending on May 29, 2021, the same results are also obtained from manual calculations. As for the PDM method, the project can be carried out for 120 days starting from January 20, 2021 and ending on May 20, 2021 with the same results obtained from manual calculations. After scheduling the two methods, it can be seen that they do not have much difference in duration. This can happen because the differences in the constraints on the CPM and PDM methods are only for some jobs.

The use of Microsoft Project 2019 in this schedule is very helpful in the manufacturing process but also has some limitations, namely not being able to change the work code according to the data, for the network diagram display the CPM method does not use arrows but in the form of nodes. Then for the PDM method it does not show start and finish activities whose duration is zero, this is what makes the critical path difference between the use of Microsoft Project which only displays some critical activities compared to manual calculations on the PDM method. On the critical trajectory, it is also seen that traffic management and safety work is always in the critical trajectory of the two methods, because this work lasts until the end of the project work. Therefore, the duration of the work can be determined at the end following the entire duration of the project by calculating backwards (backward pass), so that later 2 critical paths will be obtained.

5. CONCLUSION

Based on the problems and discussions, the following conclusions were drawn:

1. The results of the scheduling analysis on the Salim Mataraman River Bridge Replacement Project assisted by *Microsoft Project* 2019 found that the project CPM method can be done for 129 days and the project PDM method can be done for as long as 129 days. 120 days so that the PDM method of total duration of work is faster and suitable for scheduling construction projects.
2. There are two critical paths in each method due to traffic management and safety work working throughout the Salim Mataraman River Bridge Replacement Project.

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