



Analysis of Project Network Planning Using the Critical Path Method

(Case Study of the Construction of the State Vocational School 1 Bualemo
Building in Banggai Regency)

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Abstract: In the development of the implementation of building construction projects, work is often delayed from the specified time, to overcome this, an implementation method is needed, one of which is using Network Planning with the Critical Path Method (CPM). CPM is a basic method of planning and controlling a work system based on a network or network that can increase efficiency and effectiveness in allocating time and costs. The research method used is the primary research method, conducting observations or direct observations in the field and conducting face-to-face interviews on projects being implemented with a self-management system, carried out by the SMK Negeri 1 Bualemo school by forming a school construction team (P2S). The application of network planning with the CPM method in building construction can accelerate the project implementation schedule compared to the specified time and can increase the cost effectiveness of project implementation. The results of the study using CPM are known to be Critical Paths, namely Activities **A – C – H – L – M – N – T – W – X – Y** with the original project completion time of 175 days to 157 days, optimizing the time by 18 days, with the original Budget of Rp. 2,224,035,000,- to Rp. 2,140,996,000 ,- cost optimization of Rp. 83,038,723.02.

Keywords: Network Planning, CPM Method, Project

INTRODUCTION

The school building construction project work at the Central Sulawesi provincial education office, in the process of implementing the work every year always faces various problems, sometimes the implementation uses a less than perfect system in using work implementation methods and resource management, so that school project buildings are still often found to be late in completing the time that has been determined, this certainly results in hampering the regional government program, especially the Central Sulawesi provincial education office in the process of implementing the planned school building construction.

The project work implementation system used by the work implementer cannot be separated from the use of limited resources, which can be developed to include not only manpower, but also other resources such as costs, time, materials and equipment, and the environment. For this reason, the building construction project implementer who carries out work control needs to pay attention to good initial planning by coordinating and controlling the project work implementation system, so that during implementation there are no obstacles that result in work delays.

Delays in project implementation work sometimes occur when project implementers use methods that are less focused and planned in optimizing their implementation, starting from initial planning, project description planning, project work implementation, project control and project results.

From the problems described, it is necessary to make efforts to speed up the process of implementing project work by using a work method, this method is in the form of a tool used in project implementation called Network Planning (Work Network), with one of the methods being the Critical Path Method (CPM).

The application of network planning in the implementation of a school building construction project is very helpful for project implementers to make decisions in outlining the sequence of project implementation activities, so that it is achieved according to the expected targets and of course this is a success for project implementers in their ability to speed up the work process before the schedule limit that has been determined in the implementation of the work.

Realizing the importance of implementing the school construction process and the magnitude of the problems faced, it is necessary to conduct research concerning the problem of the project work implementation system through Network Planning analysis with the Critical Path Method (CPM) on the building construction project (case study of the construction of the SMK Negeri 1 Bualemo building in Banggai Regency).

Formulation of the problem

Based on the description of the background of the problem above, the formulation of the problem in this discussion is:

1. Can the application of Network Planning with the Critical Path Method (CPM) in the construction of the SMK Negeri 1 Bualemo building accelerate the project implementation schedule compared to the predetermined time?
2. Can the application of Network Planning with the CPM Method increase the cost effectiveness of project implementation?

Research purposes

1. Analyze the effectiveness of implementing Network Planning with the Critical Path Method (CPM) in accelerating the construction schedule for the SMK Negeri 1 Bualemo building compared to the predetermined schedule.
2. Evaluate the extent to which the CPM method can increase cost efficiency in implementing the development project.

THEORETICAL BASIS

History of Network

- a. Networks emerged and were discovered in 1957, initially arising from various studies, especially on user dissatisfaction in comparing the implementation of work process stages with a previously created chart regarding the provisions of the results that should be achieved, called a Gantt chart. (The Liang Gie 1981: 217)
- b. In 1957, the network was implemented in a US Navy project called "Runner," a guided missile project. Originally planned to take five years, a team of experts revised the plan to allow for a three-year project completion time. (Ali , 1992: 01).

Methods in Network

In networks, two methods are known, namely CPM and PERT. These methods are depicted graphically, supplemented with quantitative data, so that they form a network diagram. To find out more about CPM and PERT, according to Ali (2992: 02), first the differences and similarities as well as the benefits of the CPM and PERT methods are explained as follows:

The difference between PERT and CPM lies in the assumptions about the project. PERT considers

a project to consist of events that follow one another, whereas according to CPM, a project consists of activities that form a path or several paths.

The similarity between CPM and PERT lies in the project visualization, project visualization according to CPM and PERT is in the form of a diagram, both types of diagrams have the same form and structure based on the same principles.

The difference in views on projects according to CPM and PERT is not a fundamental difference because, although events are different from activities, activities and events are inseparable. Every activity must begin with a starting event and must be completed with a final event.

The real difference lies in the method of estimating the time for each activity in the network. CPM uses more precise times, where each activity is assigned a time period that is closest to reality, while PERT uses more probabilistic estimates based on a series of possible activity times.

Benefits of Networking

The benefits of networks in project implementation according to Badri (1992) are as follows:

- 1). Planning (scheduling) and monitoring the project logically.
- 2). Think comprehensively, but also in detail about the project implementation.
- 3). Document and communicate the scheduling plan (time), and other alternatives for completing the project with additional costs.
- 4). Monitor projects more efficiently

From the description of the benefits of the network will help complete project implementation including:

- a. Time scheduling efficient work sequence
- b. Equal distribution of labor time and costs
- c. Rescheduling if there are delays in project completion
- d. Determining the trade- off or exchange of time with efficient costs
- e. Determine the probability or other possibilities of project completion.
- f. Planning complex projects.

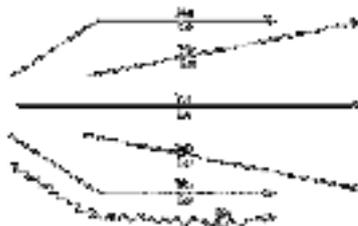
Network

Network planning is essentially the interdependence of work components depicted or visualized in a network diagram. This allows us to identify which tasks should be prioritized, which can serve as a basis for subsequent tasks, and it can also be seen that a task cannot begin if the previous activity is not completed.

According to Ali (1992), the CPM method uses a network diagram in the work network process, which first identifies the symbols of arrows and circles, then the relationship between activities. The earliest time of activity (SPA) and the latest time of activity (SPL), including:

Arrow and circle symbol

- a. Arrow, its shape is an arrow which means activity or action, there are six alternative ways of depicting an arrow, namely:
 1. Horizontal
 2. Tilted up
 3. Slanted down
 4. Broken line up
 5. Broken line down
 6. Curved Line.



b. Round circle



Node/event is shaped like a round circle which means when an event or incident occurs.

c. Dummy



The dummy is in the form of a broken arrow which means a pseudo activity or pseudo activity.

d. Double arrow



Double arrow parallel arrows represent critical path activities.

The logic of the dependency of these activities can be explained as follows:

- a. Activity A must be completed before activity B can begin, and activity C can begin after activity B is completed. The relationship between these activities is shown in Figure 1.

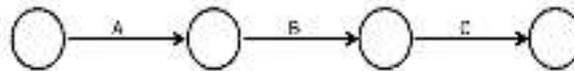


Figure 1. Network (source: Arif Rakhmat, 2016)

- b. Activities A and B must be completed before activity C can begin. The relationship between these activities is shown in Figure 2.

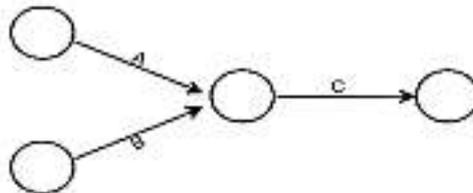


Figure 2. Network (source: Arif Rakhmat, 2016)

- c. If activities A and B must start before activities C and D. The relationship between these activities can be seen in Figure 3.

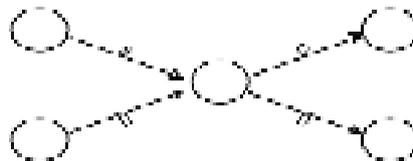


Figure 3. Network (source: Arif Rakhmat, 2016)

- d. Activities A and B must be completed before C can begin, but D can begin once activity B has completed. The relationship between these activities is shown in Figure 4.

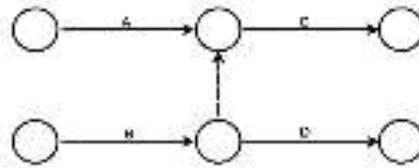


Figure 4. Network (source: Arif Rakhmat, 2016)

- e. If activities A, B, and C start and finish on the same event cycle, the relationship between these activities can be seen in Figure 5.

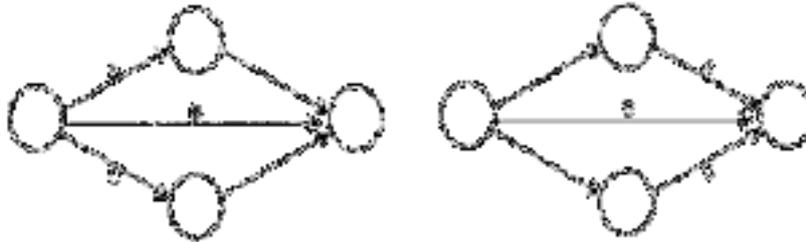


Figure 5. Network (source: Arif Rakhmat, 2016).

The earliest moment (SPA)

What is meant by SPA is the earliest possible time an event can occur, and it is impossible for it to occur earlier. The benefit of determining SPA is to determine the earliest possible time to carry out activities arising from the event in question. According to Ali (1992:54-56).

Slowest Time (SPL)

What is meant by SPL is the latest time an event can occur, and it cannot be as easy as possible (although it is possible) so that the project can be completed at the planned time. The benefit of determining SPL is to know the latest time to complete all activities leading up to the event in question, so that the project can still be completed at the planned time. Ali (1992: 58-59).

Critical Path

According to Render and Jay (2006) in Arif (2016: 18), the critical path is a series of project activities whose implementation cannot be postponed and whose activities show a mutual relationship. The more critical paths in a project, the more things that must be monitored. The accumulated longest duration of time on the critical path will be used to estimate the overall project completion time.

In order to find out the critical path, we calculate the two start and end times for each activity, as follows:

Forward Calculation

1. Earliest start (ES), which is the earliest time an activity can start, assuming all predecessors have finished.
2. Earliest finish (EF), namely the earliest time an activity can be completed.

The forward countdown begins at the start point and ends at the finish point, and has ES (fastest time to start an activity) and EF (fastest time to complete an activity) components. The following are the rules for forward countdown:

- a) The initial activity starts when the previous activity has been completed (except the earliest activity).

- b) The earliest finish time is the same as the earliest start time after adding the duration of the previous activity.
- c) If an activity has two or more predecessor activities that are joined, then the earliest start time (ES) of the activity is the same as the earliest finish time (EF) of the largest of the predecessor activities.

Countdown

1. Latest start (LS), which is the latest time an activity can be started so as not to delay the completion time of the entire project.
2. Latest finish (LF), which is the latest time an activity can be completed so as not to delay the completion time of the entire project.

Project Duration

Project duration is the amount of time required to complete all project work (Maharany and Fajarwati, 2006) explains that the factors that influence the duration of work are the volume of work, work method (construction method), field conditions, and the skills of the workforce carrying out the project work. The formula used to calculate the duration of activities is (Soeharto, 1999):

$$D = \frac{V}{Pr.N}$$

Description:

- D = Duration of activity
- V = Volume of activity
- Pr = Average work productivity
- N = Number of workers and equipment

METHODOLOGY

Data Collection

The research location was conducted at State Vocational School 1 Bualemo, located in Mayayap Village, Bualemo District, Banggai Regency, Central Sulawesi Province.

There are several reasons for choosing the research location, as follows:

1. The location is 86 km from Luwuk City, Banggai Regency with fairly good road conditions.
2. Access to the location is quite safe and vehicle access is quite smooth.
3. The new school building was built in 2024.

Researchers conducted initial exploration directly to the location to determine the focus or problem to be studied to make the research more effective and efficient by conducting the project and requesting initial information from the school before collecting data. In the construction project of SMK Negeri 1 Bualemo, which was carried out independently or the school was the one who carried out the work on the project, the research subjects were divided into two, namely the facilitator coordinator, facilitator/planner, field supervisor and school construction committee (P2S), namely the principal, committee chairman, secretary, treasurer, school committee. Central Sulawesi Provincial Education Office, and Regional Office Branch V of Banggai Regency, Banggai Islands, Banggai Laut.

The strategy used in this research is a qualitative method strategy with a descriptive approach, which is carried out in the form of a case study of the construction of the SMK Negeri 1 Bualemo building, a case study is research conducted by further investigating the causes of certain aspects of an activity, then the data can be developed or proven to solve the problems in the research.

Data Collection Techniques

Data collection and analysis for qualitative case study research. A qualitative approach aims to gain a deeper understanding of a particular phenomenon or problem, one that cannot be measured solely with numbers or statistics. Therefore, data collection is conducted in ways that allow researchers to explore information in depth through various techniques. The typical steps in data collection and analysis for qualitative case studies are as follows:

Data in qualitative research can be divided into two main types: **primary data** and **secondary data**.

- **Primary data:** data obtained directly from original sources through data collection techniques such as interviews, observation, and documentation. Primary data is crucial in qualitative case studies because it provides information directly from the experiences or perspectives of the research subjects.
- **Secondary data:** data that already exists and is obtained from other sources, such as previous research reports, books, articles, or other documents relevant to the research topic.

Research Flowchart

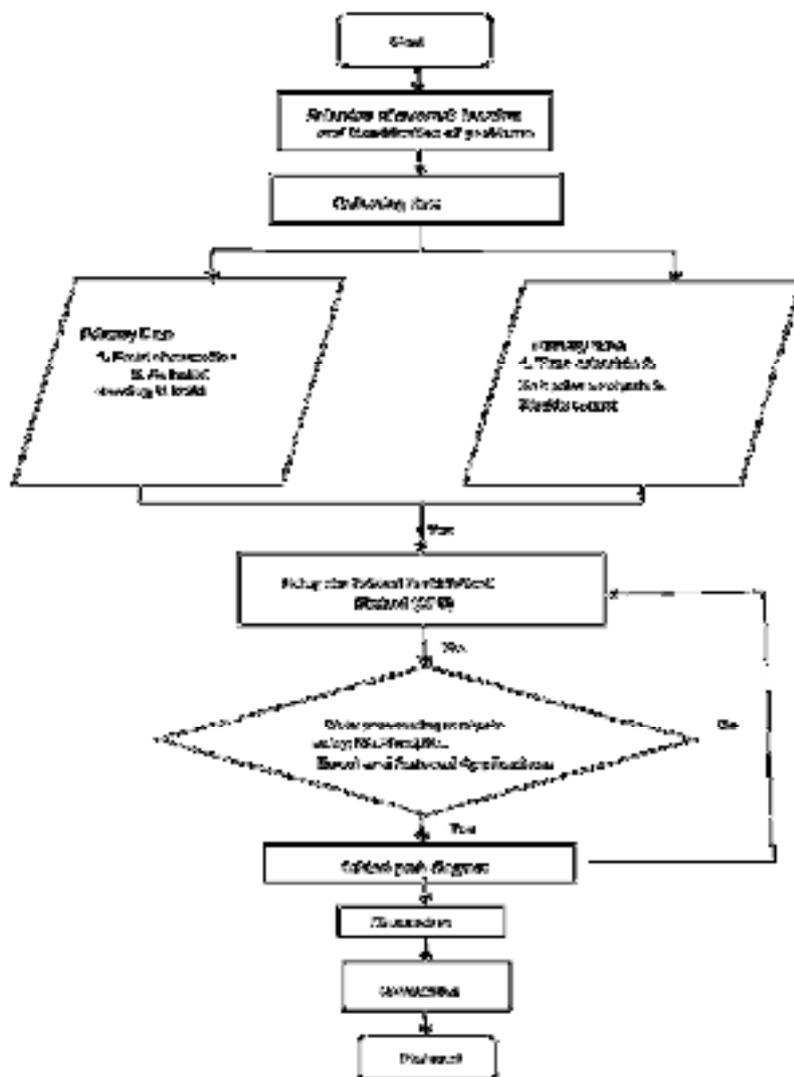


Figure 6. Research Flowchart

RESULTS AND DISCUSSION

Table 1. Relationships between Activities

NO.	JOB DESCRIPTION	CODE ACTIVITY	ACTIVITIES PREVIOUSLY	DURATION (DAY)
1.	Preparation Field / Site Work	A	-	14
2.	Implementation of EMBB Earthworks and Road	B	-	167
3.	Floor Plate Foundation 70 x 70 cm	C	A	1
4.	Foundation River abut	D	C	1
5.	Abutment RI Pier	E	D	5
6.	Construction of Filled Soil Using a Screper	F	E	4
7.	embankment sand Lower Pier	G	F	2
	Work Foundation And Concrete			
8.	Floor Plate Foundation 70 x 70 cm	H	D	4
9.	Pile Cap 24 x 30 cm	I	A	2
10.	Pt. Abutment Pier	J	H	2
11.	Pt. Pier Abutment Pt : 5 Pier	K	J	12
	Work Structure Concrete			
12.	Column Pedestal	L	HJ	21
13.	Abut	M	KL	49
14.	Column	N	M	25
15.	Pier Abut.	O	N	17
16.	Beam	P	O	7
17.	Roof Plate Concrete	Q	P	5
18.	Cap Pier Concrete = 3 cm, R.100	R	Q	5
19.	Concrete Bridge Slabing Work Architecture	S	R	2
20.	Work Paving Foot Flooring	T	S	40
21.	Work Frame , Doors , Windows & Installation	U	T	10
22.	Work Roof and Ceiling	V	U	40
23.	Work Painting	W	V	7
24.	Work Finishing And Sanitation	X	W	2
25.	Work Electrical	Y	X	10

Source : Results Data analysis

Table 2. Determining the Critical Path with the Critical Path Method

No.	Code Activity	Duration	ICE	EF	LS	LF	Float	Critical / No
1.	A	14	14	28	14	28	0	Yes
2.	B	157	-	-	-	-	Dummy	-
3.	C	1	15	16	15	16	0	Yes
4.	D	1	-	-	-	-	Dummy	-
5.	E	6	-	-	-	-	Dummy	-
6.	F	4	-	-	-	-	Dummy	-
7.	G	2	-	-	-	-	Dummy	-
8.	H	4	14	23	14	23	0	Yes
9.	I	2	19	21	19	21	0	No
10.	J	3	-	-	-	-	Dummy	-
11.	K	12	40	52	40	52	0	No
12.	L	21	40	61	40	61	0	Yes
13.	M	10	50	60	50	60	0	Yes
14.	N	25	75	100	75	100	0	Yes
15.	O	22	97	119	97	119	0	No
16.	P	7	-	-	-	-	Dummy	-
17.	Q	8	147	155	14	155	0	No
18.	R	6	-	-	-	-	Dummy	-
19.	S	2	147	149	14	149	0	No
20.	T	60	135	195	13	195	0	Yes
21.	U	12	147	159	14	159	0	No
22.	V	50	147	197	14	197	0	No
23.	W	7	142	149	14	149	0	Yes

Table 3. Activities on the Critical Path

NO.	Uraian Kegiatan	Waktu Kegiatan	ES	EF
1	Preparasi Data / Survei	A	0	14
2	Pengumpulan Data / Pengukuran	B	14	15
3	Pengolahan Data / Pengolahan	C	15	16
4	Detail Pekerjaan	D	14	23
5	Detail	E	14	23
6	Detail	F	14	23
7	Detail Pekerjaan	G	14	23
8	Detail Pekerjaan	H	14	23
9	Detail Pekerjaan	I	14	23
10	Detail Pekerjaan	J	14	23
11	Detail Pekerjaan	K	14	23
12	Detail Pekerjaan	L	14	23
13	Detail Pekerjaan	M	14	23
14	Detail Pekerjaan	N	14	23
15	Detail Pekerjaan	O	14	23
16	Detail Pekerjaan	P	14	23
17	Detail Pekerjaan	Q	14	23
18	Detail Pekerjaan	R	14	23
19	Detail Pekerjaan	S	14	23
20	Detail Pekerjaan	T	14	23
21	Detail Pekerjaan	U	14	23
22	Detail Pekerjaan	V	14	23
23	Detail Pekerjaan	W	14	23
Total Durasi				149

SOURCE: Hasil Data Analisis

Network Diagram (CPM)

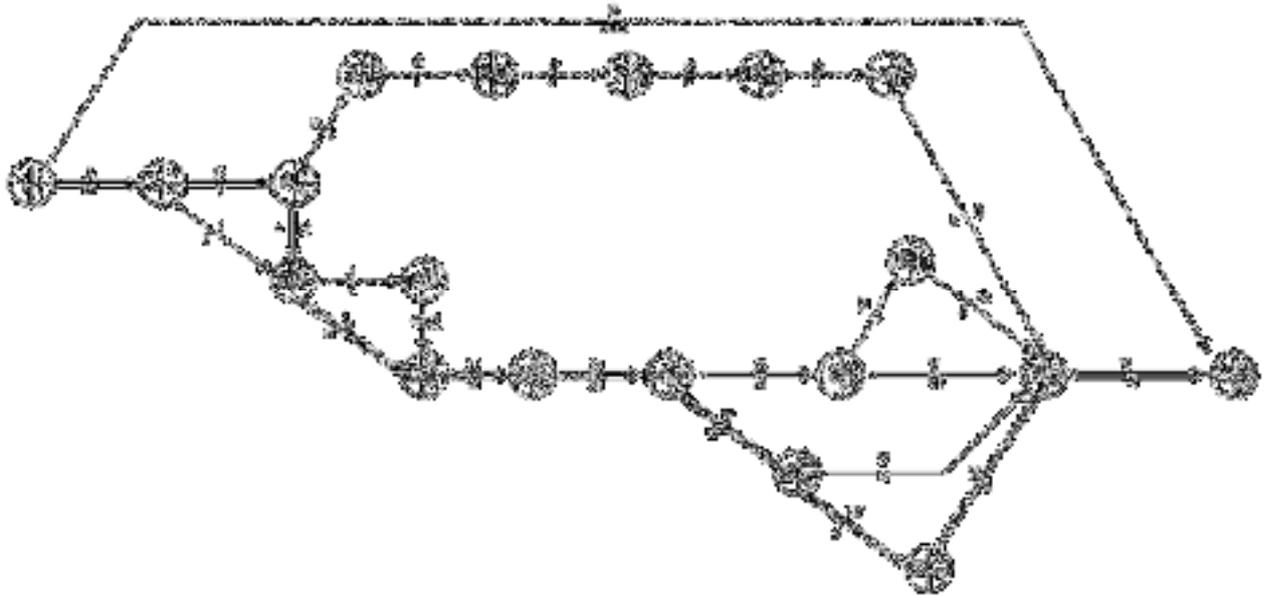


Figure 7. Network Diagram (CPM)

The network planning diagram and table above show the critical path of the estimated time as follows: **A – C – H – L – M – N – T – W – X – Y**. Using the Critical Path Method (CPM), the duration obtained is = $14 - 1 - 4 - 21 - 10 - 25 - 60 - 7 - 5 - 10 = 157$ days.

Efficiency Analysis of the SMKN 1 Bualemo Building Construction Project

In preparing the Cost Budget Plan (RAB), by referring to the unit price list for wages, materials, and equipment, labor costs are calculated by excluding the cost components of materials and equipment. From this calculation, the labor wage cost is obtained at Rp 807,320,900.00.-

Time Efficiency and Impact on Cost

Time and cost efficiency analysis using the critical path method shows a reduction in project duration from 175 days to 157 days, resulting in a time efficiency of 18 days. The cost savings obtained from this time efficiency are calculated as follows: Rp 4,613,262.39 (variable cost per day) × 18 days (time efficiency) = Rp 83,038,723.02.

Thus, the cost efficiency of the SMKN 1 Bualemo building construction project for 18 days is Rp 83,038,723.02. This reduces the total project cost to Rp 2,140,996,294.64.

Details of the Cost Budget Plan (RAB)

Table 7. The following is a breakdown of costs in the Cost Budget Plan (RAB) for the data management project:

No.	Uraian Pekerjaan	Cost
1.	Pekerja	Rp. 721.312.933,33
2.	Materiale	Rp. 1.399.893.599,49
3.	Prosesing Administrasi	Rp. 22.800.000,00
Jumlah		Rp. 2.140.996.294,64

Sumber : RAB Data Manajemen

CONCLUSION

The results of the research that has been carried out related to Network Planning analysis The project uses the Critical Path Method (CPM) in the case study of the construction of the SMK Negeri 1 Bualemo building in Banggai Regency, it can be concluded:

1. The application of Network Planning with the Critical Path Method (CPM) method successfully accelerated the implementation schedule for the SMK Negeri 1 Bualemo building construction project compared to the S-Curve Schedule. Optimizing the project duration from 175 days to 157 days, resulting in a time efficiency of 18 days (10.286%).
2. The implementation of CPM also increases the cost-effectiveness of project implementation. The total estimated initial project cost of Rp. 2,224,035,000.00 can be optimized to Rp. 2,140,996,294.64 The time efficiency of 18 days resulted in cost savings of Rp. 83,038,723.02.

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