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Time Analysis on the Kuningan Eastern Ring Road

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A B S T R A C T

This analysis aims to identify delay factors and reduce the risk of delay in construction projects using the CPM method in the construction project of the East Ring Road Kuningan. The results of the study show that common factors that can have an impact on delays include the provision of materials, workforce readiness, and schedule adjustment to weather conditions. Therefore, supervision and control on critical routes must be carried out intensively to ensure that the project can be completed on time according to plan because delays in one activity alone will have a direct impact on the overall project completion.

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INTRODUCTION

With the condition of rapidly developing infrastructure, as well as the development of transportation facilities, especially highways that are increasingly rapid, the level of difficulty in managing and running a highway project is getting higher. The higher the difficulty, the longer the time needed to complete the project, so time management is needed to prioritize and strive to improve the efficiency of project management in order to achieve maximum results from the available resources. All of this is to achieve the goals of a highway project, namely success that meets the criteria of time (schedule), as well as cost (budget) and quality (quality). (Indra Wati, Nurmiati Z & Nur Adyla S, 2018).

Human resource performance is one of the factors of excellence of a company. So that conditions and environments can be created that allow the company's performance to be better (mochamad Choerul Anam & Ronny Durrotun Nasihien, 2019).

Project planning is the first step in managing the resources, funds and time that have been set to complete the project (I Gusti Ngurah Wiryadharma Verdinata, Ni Komang Armaeni & Ni Made Widya Pratiwi, 2023).

Construction project control is needed in the process of trying to manage all stages in construction project activities so that the project is in accordance with the planning reference and standards that have been determined so that there is a control of conformity between planning and implementation (Ma'rifatul Muniroh, Meidy Kempa & C.G. Buyang, 2021).

LITERATURE REVIEW

Project Time Management

The timing of the project implementation is needed so that the project must be as detailed as it can be completed on time. Time planning is possible so that it can be controlled easily, so that if there is a late work, you can immediately determine the right solution so that the project is handed over to the owner on time in accordance with the contract. (Alfin Ali Kadzafi, Moch. Khamim & Marjono, 2021).

The road construction project will run according to the planned goals both in terms of time, cost, quality, safety and occupational health if the risks that arise follow a series of planning, handling and monitoring of risks. (Fahirah & Tlantan, 2022).

Critical Path Method (CPM)

Critical Path Method is a CPM technique carried out by compiling a network of work that is identified by the activity and using simple time estimates for each activity that shows the implementation period (Ganesstri Padma Arianie, Nia Budi Puspitasari, 2017).

METHODOLOGY

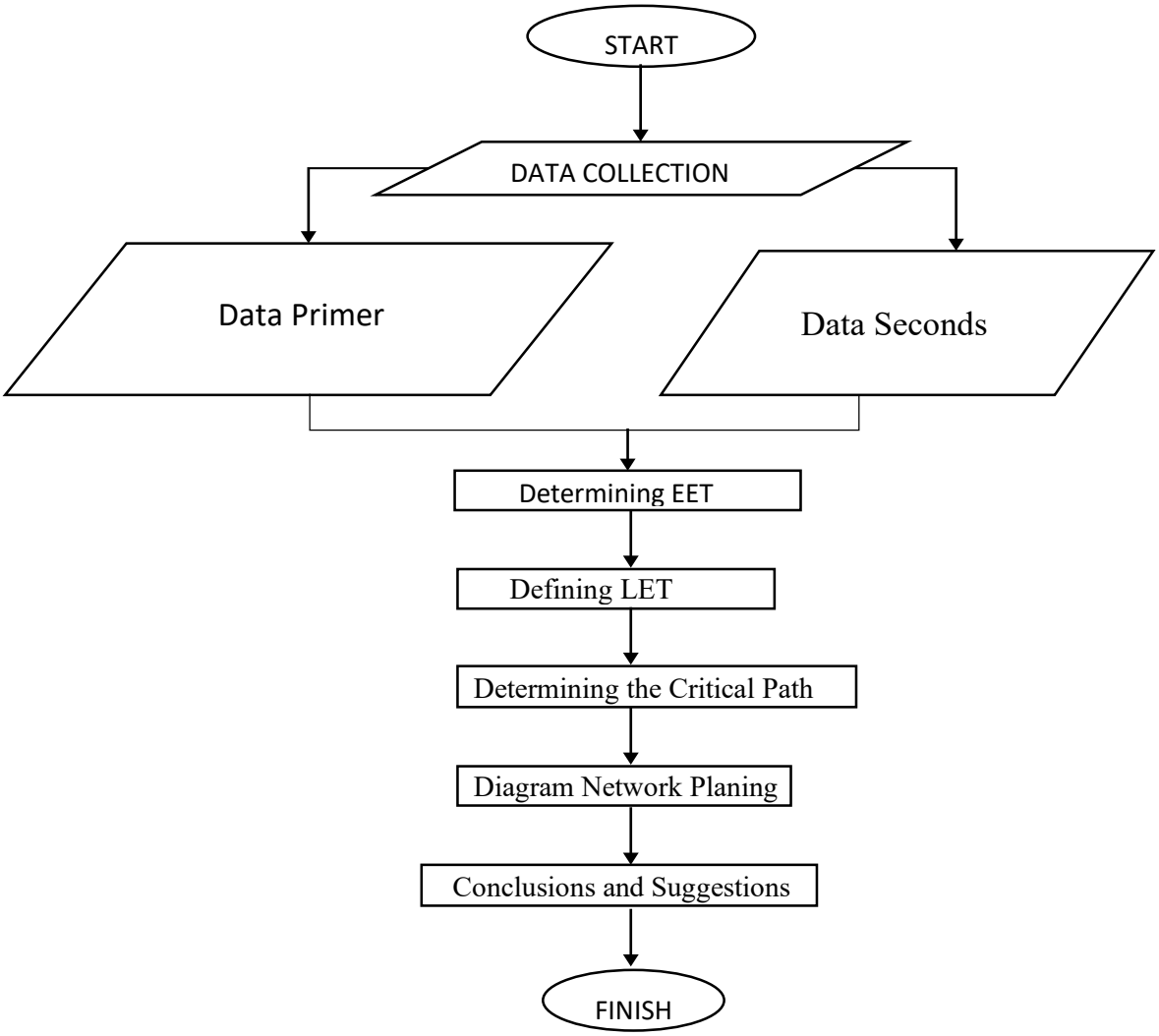


Figure 1. flowchart

This study uses a quantitative approach that aims to identify the schedule of project activities The sampling technique is carried out with the calculation of appropriate techniques. Quantitative data collection aims to test the hypothesis that has been determined. The collection of primary data was obtained directly from the authorities using explicit procedures and the collection of secondary data was obtained from several parties related to the object of research, data was obtained, including time schedules and weekly progress reports. Critical Path Method (CPM) is the method used in this study.

The Critical Path Method, in its implementation, the CPM method is able to classify work based on its type of critical and non-critical, a work can be classified as critical if its implementation cannot be delayed, the delay of work will have an impact on increasing the total project completion time (Danang Hadicara, Abdul Rochim & Praktikso, 2023)

RESULT AND DISCUSSION

The results of the primary data analysis show that the work volume data is the unit size of the work volume according to each work item. To produce a good volume calculation, the estimator must understand the definitive design picture (Suwarni & Anondho, 2021) the volume calculation is compiled systematically with the grouping of preparatory work, channel work and road pavement work.

Analysis of the Volume of Road Works

Results of Liquid Asphalt Volume Research

Figure 2. Liquid Asphalt Volume Details

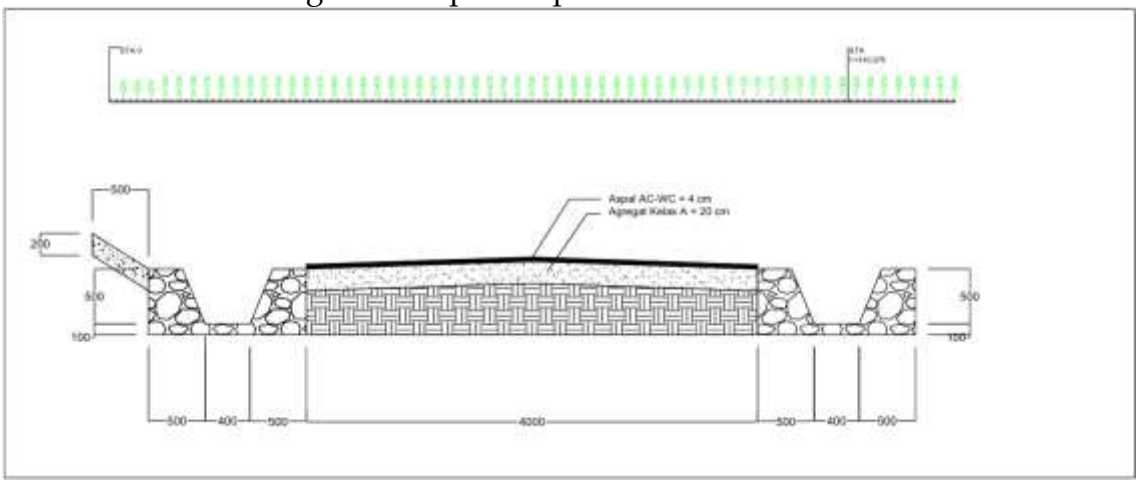


Table 1. Volume of Liquid Asphalt

JOB ITEMS	P (m)	L (m)	Work Area Area (m2)	Asphalt needs (litres/m2)	Volume (liter)
Absorbent layer - Liquid asphalt/Emulsion (Prime Coat)	1310.075	4	5240.3	0.4	2096.12
Adhesive Layer – Liquid Asphalt/Emulsion (Thanks Coat)	803.13	4	3212.52	0.15	481.88

Based on the analysis of figure 2 in the road length data, the volume of liquid asphalt mixture is estimated with the formula : Volume Calculation in Liters with the formula:

Area = length x width (1)

Liter Volume = Area x asphalt requirement (2)

A prime *coat* is used to bond the top foundation layer (grade A aggregate) with AC-BC or AC-Base hotmix. Meanwhile, the adhesive layer (*tack coat*) functions as an adhesive between new asphalt and old asphalt (Tiurma Elita Saragi, Nurvita Insani Simanjuntak & Aprilta Tarigan, 2023)

Hot Asphalt Volume

Figure 3. Hot Asphalt Volume Details

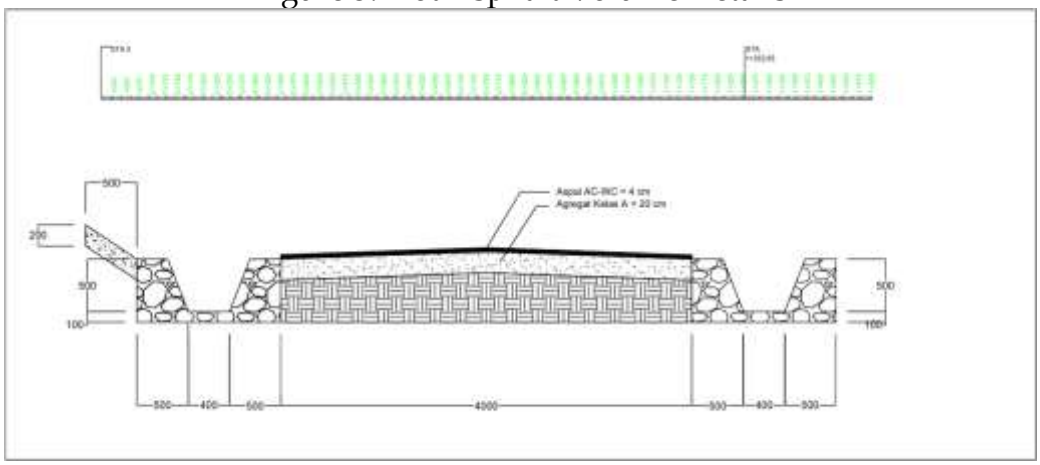


Table 2. Hot Asphalt Volume

CALCULATION OF HOT ASPHALT ASPHALT VOLUME						
JOB ITEMS	p (m)	l (m)	t (m)	Volume (m3)	Specific Gravity	Weight (tone)
Laston Lapis AUS (AC-WC)	1252.65	4	0.04	200.4	2.35	471.00

Based on the data in table 2. The coating work uses Laston Layer AUS (AC-WC), the volume of hot asphalt can be calculated by the formula:

Volume = length x width x thickness (3)

Berat = volume x BJ (4)

Laston (AC-WC) is the top surface of the highway pavement structure that is directly related to the wheels of the vehicle, has a smoother texture and is able to contribute a measurable carrying capacity and function as a waterproof layer to protect the construction below it (Asrola, Sofyan M. Saleh & Muhammad Isya, 2018)

Volume of Work

Figure 4. Details of Work Volume

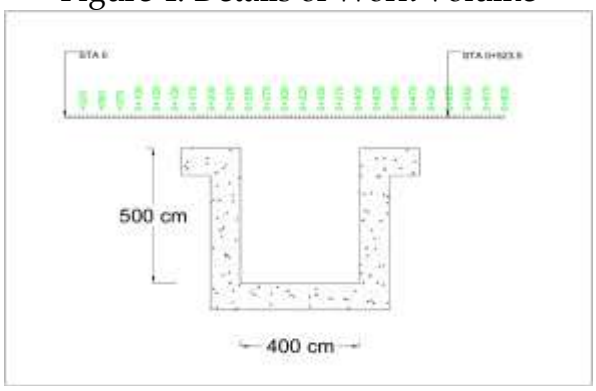


Table 3. Volume of work

VOLUME OF WORK					
JOB ITEMS	p (m)	l (m)	t (m)	Wide (m2)	Volume (m3)
Excavation For Drainage Sewers and Waterways	523.5	0.4	0.5	209.4	104.700
Rock Excavation	300	0.10585	0.5	31.755	15.88
Excavation of structures with a depth of 0-2 meters	4.272	3.3	1.5	14.0976	21.15
Organic Deposits From Excavated Products	81	0.5	0.5	40.5	20.25
Stone Pairs	285.15	0.5	0.5	142.575	71.29
Class A Aggregate Foundation Layer Repair	75	4	0.2	300	60
Pairing Stone With Mortar	269.85	0.5	0.5	134.925	67.46
Excavation on channels or slopes for maintenance	134.3	0.5	0.2	67.15	13.43
Hot Asphalt Mix Repair	301.2	0.5	0.2	150.6	30.12

Based on table 3. The volume of work results is carried out along the work area. So the cross-sectional area of the excavation can be calculated as follows:
Volume Calculation with m3 units with the formula :

Area = Length x Width (5)

Volume m3 = Area x Height (6)

Wide

Table 4. Wide

AREA			
JOB ITEMS	P (m)	L (m)	AREA (m2)
Thermoplastic Road Markings	770.9	0.5	385.45

Based on the calculations in table 4., marking work is carried out along the work area. Then the total area of marking work can be calculated as follows:
Area Calculation With m2 units with the formula :

Area = Length x Width (7)

This area is the total area of the road surface that will be coated with thermoplastic paint, both for the curbside, the center line, and other marking symbols. Good road markings provide good visibility for traffic, while poor road markings can affect traffic operations on the road. Driving safely at night requires road signs that must be reflected to help drivers navigate in low visibility conditions. The reflectivity of road markings is a property that measures the

ability of signs to reflect light from lights to the driver's eyes (Yogi Oktopianto & Rukman, 2021).

Determination of Area Length

Table 5. Area Length

JOB ITEMS	Meter
Reinforced Concrete Box Culvert, 40 cm x 40 cm deep size	19
Gutter Reinforced Concrete Box, 50 cm x 50 cm deep size	8
Gutter Reinforced Concrete Box, inner size 80 cm x 80 cm	8
Reinforced Concrete Box Culvert, inner size 100 cm x 100 cm	7
Perforated Pipe for Below Surface Drainage Works, 4 inch diameter	6
Concrete Tube 1/2 Round (Graft) Diameter 30 cm	267

Based on the table above, this work item uses a culvert with a specific dimension of the work expressed in units of meters of length, since each culvert unit already has fixed dimensions (prefabricated). Then the total volume calculated is the total area requirement for the application of the above work

Determination of Duration of Work

The determination of the duration of construction work that is not based on technical analysis will cause potential problems because the duration of the work and the stages of work are not yet known but the time of completion of the work has been determined so that not a few construction work implementers have to bear losses and even bear legal sanctions due to delays in construction work (Junaedi Manto, 2016).

Table 6. Determination of Duration of Work

JOB ITEMS	VOLUME OF WORK	PRODUCTIVITY PER DAY	NUMBER OF EMPLOYEES	DURATION
Field Engineering	1	0.150	1	7
Reinforced Concrete Box Culvert, inner size 80 cm x 80 cm	6	0.214	4	7
Reinforced Concrete Box Culvert, 50 cm x 50 cm deep size	8	0.286	4	7
Excavation for Drainage Sewers and Waterways	104.7	1.870	2	28
Perforated Pipe for Below Surface Drainage Works, 4 inch diameter	6	0.214	4	7
Reinforced Concrete Box Culvert, 40 cm x 40 cm deep size	19	0.339	4	14
Rock Excavation	15.88	0.756	1	21
Reinforced Concrete Box Culvert, inner size 100 cm x 100 cm	7	0.250	4	7

Concrete Tube 1/2 Round (Graft) Diameter 30 cm	267	2.543	5	21
pair of stones with mortar	67.46	0.642	3	35
Excavation on Waterways or Slopes for Maintenance	13.43	0.959	1	14
Structure Excavation with a depth of 0-2 meters	21.15	0.755	1	28
Stone Pairs	71.29	0.424	6	28
Class A Aggregate Foundation Layer Repair	60	1.429	2	21
Ordinary Deposits from excavated products	20.25	0.964	1	21
Liquid Asphalt/Emulsion Binder Seep Coating	2096.12	33.272	3	21
Hot Asphalt Mix Repair	30.12	0.359	4	21
Laston Lapis Off (AC WC)	464.98	6.643	10	7
Thermoplastic Road Markings	385.45	11.013	5	7
Adhesive Coating - Molten Asphalt/Emulsion	481.88	34.420	2	7

Calculation to determine the duration of the adhesive layer – liquid asphalt/emulsion $Duration = \frac{Volume\ of\ work}{daily\ productivity\ x\ number\ of\ workers}$ (8)

From the table above, workers are able to accomplish more than normatively expected. Work of the Stone Pair:

1. Takes place sequentially (large volumes → work without much pause)
2. Not too dependent on the weather and special tools
3. Can be fully worked on by 3 people on a regular basis every day.
4. Stone pair work is ideal and efficient because the actual > standards → labor resources are optimally utilized

CPM Method (Critical Path Method)

Based on the results of the data analysis obtained to make it easier to determine the critical path by coding each work item, it can be seen in the table below:

Table 7. Job Item Code

NO	JOB ITEMS	DURATION (Day)	CODE	PREDECESSOR
1.	Field Engineering	7	A	-
2.	Reinforced Concrete Box Culvert, inner size 80 cm x 80 cm	7	B	A
3.	Reinforced Concrete Box Culvert, 50 cm x 50 cm deep size	7	C	B

4.	Excavation for Drainage Sewers and Waterways	28	D	A
5.	Perforated Pipe for Below Surface Drainage Works, 4 inch diameter	7	And	A
6.	Reinforced Concrete Box Culvert, 40 cm x 40 cm deep size	14	F	C
7.	Rock Excavation	21	G	And
8.	Reinforced Concrete Box Culvert, inner size 100 cm x 100 cm	7	H	D,F
9.	Concrete Tube 1/2 Round (Graft) Diameter 30 cm	21	I	D
10.	pair of stones with mortar	35	J	D
11.	Excavation on Waterways or Slopes for Maintenance	14	K	H
12.	Structure Excavation with a depth of 0-2 meters	28	L	G
13.	Stone Pairs	28	M	J
14.	Class A Aggregate Foundation Layer Repair	21	N	L
15.	Ordinary Deposits from excavated products	21	Or	L
16.	Liquid Asphalt/Emulsion Binder Seep Coating	21	P	M
17.	Hot Asphalt Mix Repair	21	Q	N
18.	Laston Lapis Off (AC WC)	7	R	P
19.	Thermoplastic Road Markings	7	S	Q
20.	Adhesive Coating - Molten Asphalt/Emulsion	7	T	R,S

Results of Forward Calculation of the CPM (Critical Path Method) EET

Table 8. EET Calculation Table

ACTIVITY CODE	PREDECESSOR	DURATION	FORWARD CALCULATIONS	
			ES	EF
START		0	0	0

A	0	7	0	7
B	A	7	7	14
C	B	7	14	21
D	A	28	7	35
E	A	7	7	14
F	C	14	21	35
G	E	21	14	35
H	D,F	7	35	42
I	D	21	35	56
J	D	35	35	70
K	H	14	42	56
L	G	28	35	63
M	J	28	70	98
N	L	21	63	84
O	L	21	63	84
P	M	21	98	119
Q	N	21	84	105
R	P	7	119	126
S	Q	7	105	112
T	R,S	7	126	133

For EST, the highest score is chosen if the predecessor is more than 1 in order to get the maximum score, starting from start to finish with the following calculation:

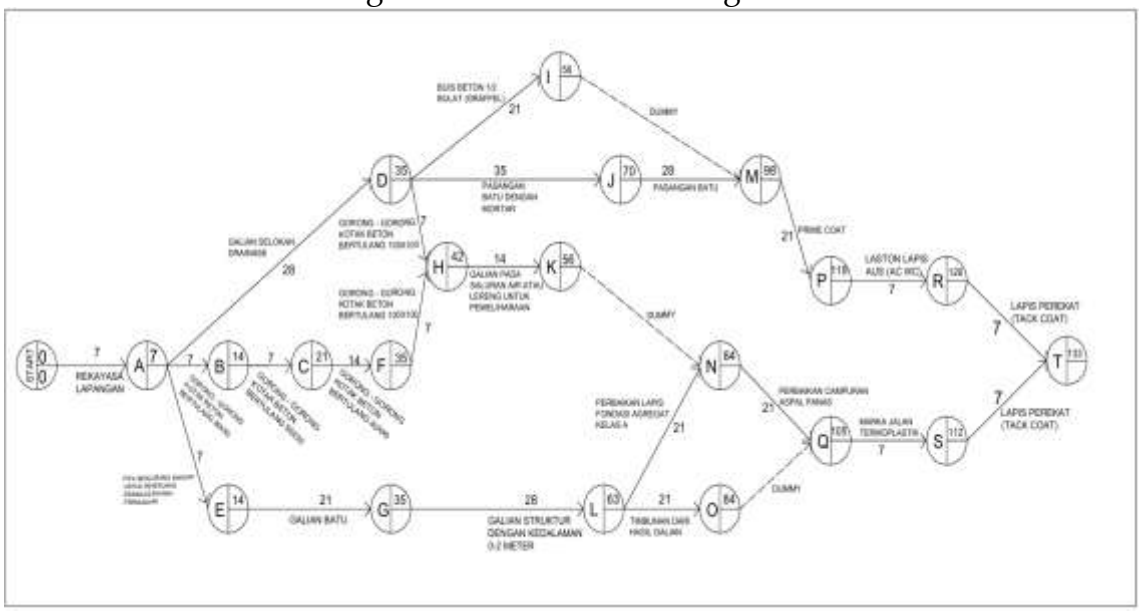
EFT = EST + Activity Duration (9)

Conditions:

EFT = *Earliest Finish Time*

EST = *Earliest Start Time*

Figure 5. EET Network Diagram



Countdown Results of the CPM (Critical Path Method) LET Method

Table 9. LET Calculation Table

ACTIVITY CODE	PREDECESSOR	DURATION	COUNTDOWN	
			LS	LF
START	A	0	7	0
A	B,D,E	7	35	7
B	C	7	63	56
C	F	7	77	63
D	J	28	70	35
E	G	7	49	28
F	H	14	84	77
G	L	21	77	49
H	K	7	98	84
I	DUMMY	21	98	98
J	M	35	98	70
K	DUMMY	14	98	98
L	O,N	28	98	77
M	P	28	119	98

N	Q	21	119	98
O	DUMMY	21	119	119
P	R	21	126	119
Q	S	21	126	119
R	T	7	133	126
S	T	7	133	126
T	0	7	133	133

For ESG, the smallest value is chosen if the predecessor is more than 1 so that the minimum score is obtained, starting from the finish to the start with the following calculations:

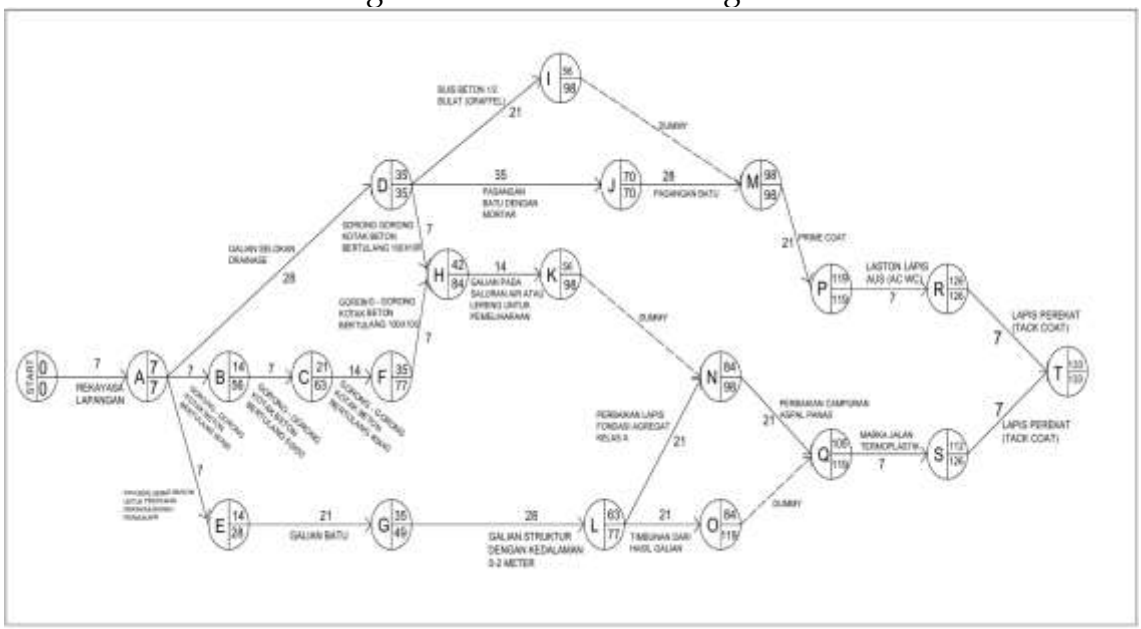
LFT = LST - Duration of Activities (10)

Conditions:

LFT = *Latest Finish Time*

LST = *Latest Start Time*

Figure 6. LET Network Diagram



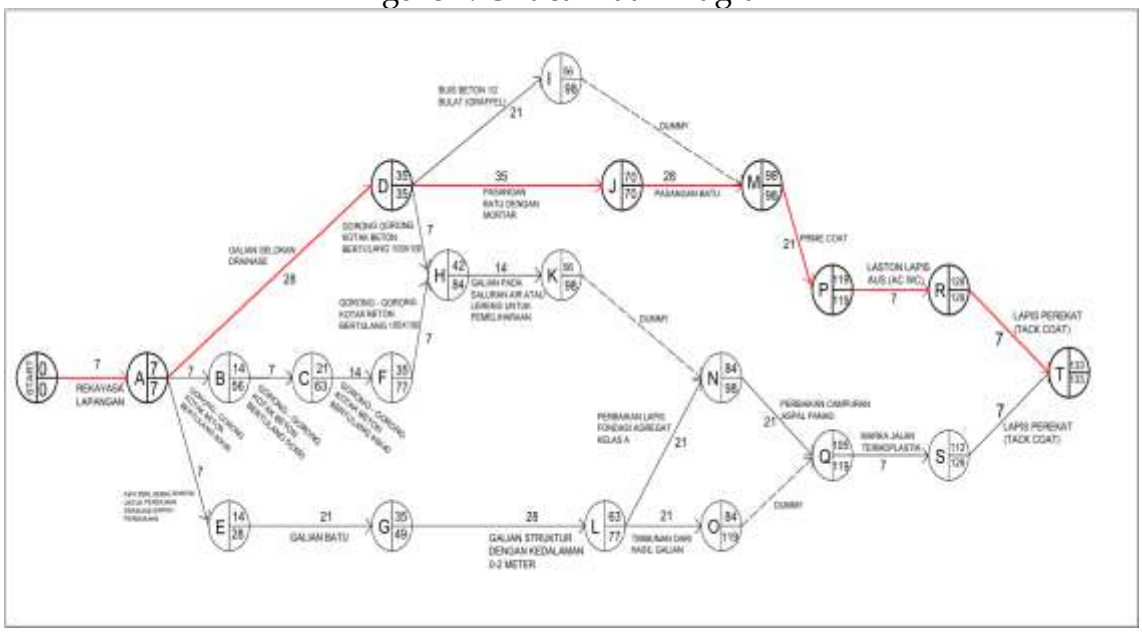
Determining the Critical Path

Critical routes consist of a sequence of critical project activities, from the initial activity to the last activity. The critical path goes through the most time-consuming process. As a result, the important path has the greatest impact on the overall project completion time represented by the bold arrow (Mar'aini, Y Rahmat Akbar, 2022) as in the following data:

Table 10. Critical Path

ACTIVITY CODE	DURATION	CALCULATION ADVANCED		COUNTDOWN		TOTAL
		EN	EF	LS	LF	
START	0	0	0	7	0	0
A	7	0	7	35	7	0
B	7	7	14	63	56	42
C	7	14	21	77	63	42
D	28	7	35	70	35	0
A	7	7	14	49	28	14
F	14	21	35	84	77	42
G	21	14	35	77	49	14
H	7	35	42	98	84	42
I	21	35	56	98	98	42
J	35	35	70	98	70	0
K	14	42	56	98	98	42
L	28	35	63	98	77	14
M	28	70	98	119	98	0
N	21	63	84	119	98	14
O	21	63	84	119	119	35
P	21	98	119	126	119	0
Q	21	84	105	126	119	14
R	7	119	126	133	126	0
S	7	105	112	133	126	14
T	7	126	133	133	133	0

Figure 7. Critical Path Diagram



From the results of the analysis of the planning and scheduling of the ring road project in the Kuningan area, it was found that the duration of the project work was 133 days. It is found in field engineering work, drainage ditch excavation work, stone pairing work with mortar, stone pairing work, liquid asphalt/emulsion binder coating work, wear layer laston (AC-WC) and liquid asphalt/emulsion adhesive layer as a critical trajectory, the work has a longer work duration than other jobs.

CONCLUSIONS AND RECOMMENDATIONS

This critical path shows a series of activities that do not have a time allowance (float), so a delay in one of the activities in this path will directly cause a delay in the entire project. Activities such as concrete culvert work, stone pairing, and asphalt pavement are important points that greatly affect the completion time.

Key factors that could potentially affect project delays on critical lines include:

- Delays in the provision of materials and tools due to site conditions that can affect the mobility of material transport vehicles
- Technical obstacles in the field due to extreme weather and field conditions that are not detected during planning
- Manual jobs that require a lot of labor

Therefore, supervision and control of activities on critical lines must be carried out intensively, to ensure that projects can be completed on time according to plan. All activities on this line do not have a time allowance (float = 0), so delays in one activity alone will have a direct impact on the delay in the completion of the project as a whole. These factors are generally related to field management, material logistics, as well as external conditions such as weather and regulations. Especially in terms of material provision, workforce readiness, and schedule adjustment to weather conditions. Measures such as crashing, fast

tracking, and daily monitoring of critical activities are highly recommended to minimize the risk of delays and ensure projects can be completed on time as planned.

ADVANCED RESEARCH

This study has limitations in the number of respondents and the implementation time of these factors affect the data that can be obtained and analyzed. Therefore, it is suggested that further studies involve various more diverse parties in order to obtain more representative results.

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