PREPARING EVALUATION OF TOLL CONSTRUCTION PROJECT PLANS USING CRITICAL PATH METHOD (CPM) FOR TRANS SUMATERA TOLL SECTION

Yusuf Luqman[1], Meilita Tryana Sembiring[2], Iskandarini[3]
[1,2,3]Master Management Program, Postgraduate School, Universitas Sumatera Utara
Corresponding E-mail: [1)]Yusuf.lq31@gmail.com, [2)]meilita_tryans@yahoo.co.id, [3)]rini_soetadi@yahoo.com

Abstract

The rapid development of technology drives competition and efficiency in Information Technology projects. Toll road projects in Indonesia, such as the Trans Sumatra Toll Road and inner-city toll roads in Jakarta, face challenges of delays. The Critical Path Method (CPM) is used to plan and evaluate these projects for improved efficiency. Evaluation of project plans is necessary to complete pending tasks. This descriptive research utilizes Job and Activity Analysis to collect quantitative data on time, cost, and resources from construction activities on the Sumatra Toll Road. The collected data is then processed using CPM to create a schedule, identify critical paths, and evaluate float times. The research provides efficient project scheduling recommendations to complete the remaining tasks on the Sumatra Toll Road project. The study concludes that by adhering to the schedule, the project can be completed on time. Delays in previous projects were primarily caused by land acquisition issues. To prevent further schedule delays, preventive strategies and resource augmentation should be considered. In summary, this research contributes efficient project scheduling recommendations to complete the remaining tasks on the Sumatra Toll Road project.

Keywords: ***Evaluation, Project Plan, Toll Road Construction, Critical Path Method (CPM)***

1. INTRODUCTION

The rapid development of world technology provides competition in an increasingly competitive environment, companies are expected that companies need to complete projects providing Information Technology services that need to be carried out with efficient use of time and resources (Mazlum (2015), Kholil (2018)), as well as increased productivity company and customer satisfaction (Taghipour, 2020). Inefficient project realization causes the use of company time and resources to exceed plans (Kholil, 2018). Realizing the project according to the plan will help the company ensure the profits and costs incurred during the project. This also happens in road construction projects. Presidential Regulation Number 117 of 2015 concerning the Acceleration of Toll Road Development in Sumatra was enacted on October 22, 2015. The Trans Sumatra Toll Road is one of the National Strategic Projects so it has a clear target for completion. However, in its implementation there are certainly many parties involved. Therefore, project planning must involve all parties, including the local government in charge of land acquisition. The completion project for one of the Trans Sumatra toll roads, which should have been completed within a target time of 2 years, has in fact been delayed until the 4th year. Over the past 2 years, human, material and capital resources have been prepared, resulting in a cost increase of 11%. from the original plan. Therefore, in this study a comprehensive project plan will be prepared using the Critical Path Method (CPM) for the remaining stages of the work. Using this method can also increase the accuracy of cost and time use (Habibi, 2018). Project duration can also be ensured with this approach, according to research conducted by Burgelman (2018). The use of this method can also

be carried out in medium-sized companies and can obtain good results on project scheduling and measurable completion times (Karabulut, 2017).

Delays in toll road projects in Indonesia do not only occur in Sumatra. The same thing also happened in Jakarta in the construction of inner-city toll roads. The main problems that caused the delay included: the stages of work that were not according to schedule, delays in the delivery of materials, the influence of traffic in the area around the project, and rising fuel prices (Maddeppungeng, 2019). As for the things that cause delays in the start of construction projects due to pre-design problems, delays in contractor payments to suppliers and labor, contractor financial administration, to the influence of weather (rainy season) on project implementation (Alaydrus, 2018). To overcome delays that have occurred in project implementation, it is necessary to evaluate the project plan that has been prepared and plan a schedule for efficient completion of project activities in the future. In this research, project scheduling will be used using the CPM method to evaluate the condition of the project over the last 4 years and provide recommendations regarding what needs to be done to complete the remaining project work.

Figure 1. Project S-Curve

2. LITERATURE REVIEW

2.1 Project management

A project is a series of activities carried out only once, its implementation is limited to a certain time (Tampubolon, 2004). Projects can also be part of an organization's temporary work program to achieve organizational goals (Munawaroh, 2003). A project can also be defined as a set of organized activities to convert resources into value-added products in one cycle, with the provisions according to the agreed agreement so that implementers must be able to manage them effectively and efficiently (Malik, 2010).

2.2 Critical Path Method (CPM)

Critical path method Critical path method (CPM) according to Levin and Kirkpatrick (1972), namely a method for planning and supervising projects, is the most widely used system among all other systems that use the principle of network formation. The CPM method is widely used by industry or construction projects. This method can be used if the duration of the work is known and does not fluctuate too much. Meanwhile, Siswanto (2007) defines CPM as a project management model that prioritizes costs as the object being analyzed. CPM is a network analysis that seeks to optimize total project costs by reducing total project completion time. Using the CPM method can save time in completing various stages of a project.

3. RESEARCH METHODS

3.1 Types of research

The type of research used is descriptive research with the type of Job and Activity Analysis. This type of research focuses on the activities and work of a person or group of people to get critical path recommendations in project planning (Sinulingga, 2011). The activities that are the focus of this research are project activities that have not been completed (on progress or due). In this study a schedule will be prepared containing critical paths, slack time, and resource requirements that can serve as a tool for monitoring the progress of project work going forward.

3.2 Research Objects and Time

Because this research is based on work and activity analysis, the object of this research is the work and activities carried out in the project. This study uses past data from project activities carried out. The project studied is a construction project for one of the toll road sections in Sumatra. This aims to be able to arrange a schedule for the implementation of activities that have been delayed, and what strategies can be taken in the future to prevent further delays than planned. The method used as an analytical approach is the Critical Path Method (CPM). This method uses activities, time, relationships between activities, resources used to achieve activity targets. From the preparation of the Network Diagram it will also show the path of activities that should be considered so that the completion of project activities is not late (Mazlum and Guneri, 2015).

3.3 Data Types and Sources

The data that needs to be obtained in this study are as follows:

1) Activities carried out
2) The time needed to complete these activities
3) Costs incurred in each activity
4) Resources used in each activity (labor, machinery/tools)
5) Relationship between activities

All of the data collected is quantitative in nature except for the relationship between activities whose data is qualitative. The entire data is taken based on the company's historical data and includes secondary data because it is taken based on company records.

3.4 Analysis Method

Data analysis is used based on the relationship between activity sequence, critical path, and float. When there is still free float available, project activities can be advanced or reversed for the function of efficiency (utility) and effectiveness (usage) of existing resources. The CPM method focuses on activities that can be carried out without disrupting the overall project schedule and can be carried out within the estimated timeframe. Process crashing may be necessary in several overlapping activities that require the same resources (labor). Scheduling the project will also ensure that the project will not be late all the time the critical path is met and non-critical activities are still carried out within the estimated timeframe. In this way, a comparison of scheduling between actual and these two methods can be obtained.

4. RESULTS AND DISCUSSION

4.1 Description of Existing Conditions

This Sumatra toll road section project is a project that should have been completed. As a typical cross-sectional illustration of this work, it can be seen in Figure 4.1 below:

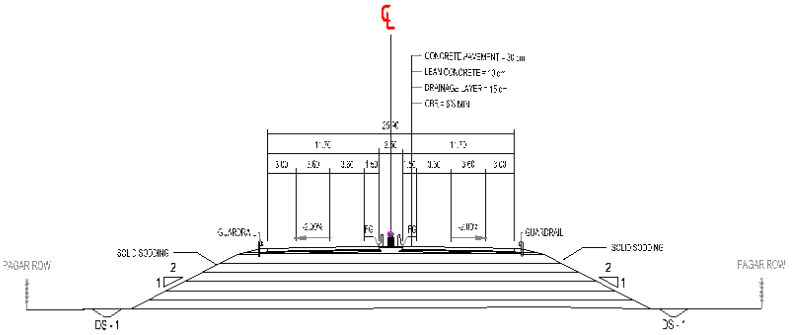

Figure 2 Typical cross section

4.2 Critical Activity Determination

Critical activities can be determined after inputting activities and the relationship between activities in them. The way to determine critical activities using Microsoft Project is done by: view >> Data >> Group by: Critical. This is done to be able to obtain critical activities in order to obtain critical activities as shown in Table 1.

Table 1 Critical Activities

Activity	Duration	Start	Finished
Critical: Yes	**191 d**	**Fri 03/23/23**	**Tue 09/30/23**
Common Borrow Material 5 - 10 km	126 days	Thu 03/23/23	Sun 06/08/23
Basic Soil Preparation	154 days	Thu 03/23/23	Sun 03/09/23
Drainage Layer	159 days	Thu 03/23/23	Fri 08/09/23
Lean Concrete (t = 10 cm)	163 days	Thu 03/23/23	Tue 12/09/23
Concrete Pavement	172 days	Thu 03/23/23	Thu 09/21/23
Concrete Barrier Single Face	181 days	Thu 03/23/23	Sat 09/30/23

In addition to critical activities, this plan will also obtain non-critical activities. These critical activities are activities that can still be postponed at certain intervals without disrupting the final project activity. The activities can be seen in Table 2.

Table 2. Non-Critical Activities

Activity	Duration	Start	Finished
Critical: No	**188d**	**Fri 03/23/23**	**Sat 09/28/23**
Start	1 day	Fri 03/24/23	Fri 03/24/23
GENERAL	180 days	Thu 03/23/23	Fri 29/09/23
Traffic Management and Safety	179 days	Thu 03/23/23	Mon 28/09/23
Mobilization	179 days	Thu 03/23/23	Mon 28/09/23
Work and Handling of Existing Water Streams	179 days	Thu 03/23/23	Mon 28/09/23
Environmental Handling	179 days	Thu 03/23/23	Mon 28/09/23

Table 2. Non-Critical Activities

Activity	Duration	Start	Finished
Quality management	180 days	Thu 03/23/23	Fri 29/09/23
Workplace Cleaning	21 days	Thu 03/23/23	Wed 12/04/23
Tree Cutting, he. > 30 cm - 50 cm	0.28 days	Sun 26/03/23	Sun 26/03/23
Tree Cutting, he. > 50 cm - 75 cm	7 days	Sun 26/03/23	Sat 01/04/23
Tree felling > 75 cm	7 days	Sun 26/03/23	Sat 01/04/23
Demolition of Concrete Structures	0.07 days	Thu 03/23/23	Thu 03/23/23
House Demolition	21 days	Thu 06/04/23	Sun 07/05/23
Demolition of Asphalt or Concrete Pavement	0.14 days	Thu 03/23/23	Thu 03/23/23
Normal Excavation for Stockpiles Max 5 km	84 days	Thu 03/23/23	Sun 25/06/23
Ordinary excavation for disposal (waste) max 5 km	49 days	Thu 03/23/23	Sun 05/21/23
Ordinary excavation for disposal (waste) max 5 km	49 days	Thu 03/23/23	Sun 05/21/23
Common Borrow Material 10 - 15 km	116 days	Thu 03/23/23	Thu 07/27/23
Common Borrow Material 15 - 20 km	116 days	Thu 03/23/23	Thu 07/27/23
Common Borrow Materials 20 - 25 km	70 days	Thu 03/23/23	Sun 11/06/23
Free Drain Granular Material	75 days	Tue 04/04/23	Wed 06/28/23
Granular Backfill	75 days	Wed 03/05/23	Sun 07/16/23
Geotextile Separator (Class 1)	75 days	Thu 03/30/23	Fri 23/06/23
Plastic Filter Woven (Geotextile Stabilizer)	21 days	Thu 06/04/23	Sun 07/05/23
Piled Land For Preloading	60 days	Fri 23/06/23	Mon 08/21/23
Vertical Drop Monitoring	60 days	Fri 23/06/23	Mon 08/21/23
Borlog Test	21 days	Fri 03/31/23	Mon 01/05/23
CPTu Test	21 days	Fri 03/31/23	Mon 01/05/23
Structure Excavation Depth 0 - 2 m	28 days	Mon 27/03/23	Thu 04/05/23
Structure Excavation Depth 2 - 4 m	35 days	Sat 01/04/23	Tue 05/16/23
Blank Stone Pair (Blinding Stone)	28 days	Sat 20/05/23	Fri 16/06/23
Reinforced Concrete Culvert Pipe, Ø 60 cm, Type B	133 days	Thu 06/04/23	Sun 08/27/23
Reinforced Concrete Culvert Pipe, Ø 120 cm, Type B	84 days	Sun 02/04/23	Wed 05/07/23
Ground channel, type DS-1	164 days	Thu 03/23/23	Wed 13/09/23
DS-3 channel	133 days	Thu 06/04/23	Sun 08/27/23
Concrete channel, type DS-3a	133 days	Thu 06/04/23	Sun 08/27/23

Table 2. Non-Critical Activities

Activity	Duration	Start	Finished
Channel DS-3 U - Ditch	133 days	Thu 06/04/23	Sun 08/27/23
Stone Masonry Channel, type DS-5A	133 days	Wed 12/04/23	Sat 02/09/23
Channel DS-5	150 days	Fri 07/04/23	Mon 14/09/23
Semicircular Channel, type DS-8	150 days	Wed 12/04/23	Tue 09/19/23
Channel , type DS-10	84 days	Tue 04/07/23	Mon 25/09/23
Catchbasin, Type DC-1	133 days	Thu 06/04/23	Sun 08/27/23
Inlet Drain, Type DI-5	14 days	Thu 06/04/23	Sun 30/04/23
Outlet Drain, Type DO-1	14 days	Thu 06/04/23	Sun 30/04/23
Outlet Drain, Type DO-5	14 days	Thu 06/04/23	Sun 30/04/23
Porous materials for backfill or filter materials	133 days	Sun 02/04/23	Wed 08/23/23
Perforated Pipe for Subsurface Drainage Dia. 6 Inch	133 days	Sun 02/04/23	Wed 08/23/23
Class A Aggregate Underlay	105 days	Sat 03/25/23	Tue 07/18/23
Bitumen Coated Absorb Binder (Prime Coat)	30 days	Sun 08/27/23	Mon 25/09/23
Adhesive Coated Bitumen (Tack Coat)	30 days	Sun 08/27/23	Mon 25/09/23
Asphalt Concrete Binder Course	30 days	Mon 08/28/23	Tue 09/26/23
Asphalt Concrete Wearing Course	30 days	Wed 08/30/23	Mon 28/09/23
Asphalt Pen.60/70	30 days	Mon 08/28/23	Tue 09/26/23
Concrete Pavement, Double Wire Mesh	105 days	Fri 07/04/23	Mon 07/31/23
Concrete Pavement, Single Wire Mesh	105 days	Fri 07/04/23	Mon 07/31/23
Capping Layer	56 days	Sat 03/25/23	Tue 30/05/23
Structural Concrete Class B-1-1a (Reinforced Concrete Floors of U/I Prestressed Concrete Girders)	28 days	Sun 30/07/23	Sat 26/08/23
Class B Concrete - 1-1a (Slab) using 1mm thick Bondeks Plate	21 days	Sun 09/07/23	Sat 29/07/23
Class B-1-2 Structural Concrete (Diaphragm From U/I Prestressed Concrete Girder)	42 days	Sun 09/07/23	Sat 08/19/23
Class B-1-3 Structural Concrete (Reinforced Concrete Pier Head)	48 days	Mon 08/05/23	Sat 06/24/23
Structural Concrete Class B-1-4 (Reinforced Concrete Column from Pier)	42 days	Fri 05/05/23	Mon 15/06/23
Class B-1-6 Structural Concrete (Barrier Concrete)	42 days	Sun 06/08/23	Sat 09/16/23
Class B -1 Concrete (Pile Cap, Abutment, Step Plate, Ret. Wall & Plant Box)	28 days	Sun 08/27/23	Sat 09/23/23
Class C-1 Structural Concrete (Abutments, Pier Footings, Retaining Walls, Footing Plates)	100 days	Mon 01/05/23	Tue 08/08/23
Class C-2 Structural Concrete (Culverts - Box Culverts)	84 days	Wed	Sat 07/15/23

Table 2. Non-Critical Activities

Activity	Duration	Start	Finished
		12/04/23	
Class C-4 Structural Concrete (Precast Slabs for Bridge Floors)	42 days	Fri 04/28/23	Thy 08/06/23
Class D Structural Concrete	84 days	Wed 05/17/23	Tue 08/08/23
Class E Structural Concrete	84 days	Sat 04/15/23	Tue 07/18/23
BJTD-40 Threaded Reinforcing Steel Bar	112 days	Thu 03/23/23	Sun 07/23/23
Anchors and Accessories (Fix)	56 days	Thu 05/18/23	Wed 12/07/23
Anchors and Accessories (Move)	56 days	Thu 05/18/23	Wed 12/07/23
PC-I Girder Nominal Span 15.10m to 17.0m, H=1.40m, Installation	14 days	Sun 25/06/23	Sat 08/07/23
PC-I Girder Nominal Span 17.00m to 20.0m, H=1.40m, Installation	14 days	Sun 25/06/23	Sat 08/07/23
PC-I Girder Nominal Span 25.00m to 27.0m, H=1.60m, Mounting	14 days	Sun 25/06/23	Sat 08/07/23
PC-I Girder Nominal Span 30.00m to 32.0m, H=1.70m, Installation	14 days	Sun 25/06/23	Sat 08/07/23
PC-I Girder Nominal Span 39.00m to 41.0m, H=2.10m, Provision	14 days	Fri 05/26/23	Thy 08/06/23
PC-I Girder Nominal Span 39.00m to 41.0m, H=2.10m, Mounting	14 days	Sun 25/06/23	Sat 08/07/23
PC-I Girder Nominal Span 44.00m to 46.0m, H=2.10m, Installation	14 days	Sun 25/06/23	Sat 08/07/23
Provision of pretensioned round concrete piles, dia. 60 cm (Type B)	84 days	Mon 27/03/23	Mon 29/06/23
Provision of Pretensioned Square Concrete Piles, 25 x 25 cm (Type A)	56 days	Mon 27/03/23	Thy 01/06/23
Installation of pretensioned circular concrete piles, dia. 60cm (Type B)	84 days	Mon 10/04/23	Mon 13/07/23
Installation of Pretensioned Box Concrete Piles, 25 x 25 cm (Type A)	56 days	Mon 10/04/23	Mon 15/06/23
Additional Fees for Payment Item 10.05 (2) if carried out in the River Flow	14 days	Fri 05/05/23	Thu 05/18/23
Pre Boring	14 days	Fri 04/14/23	Mon 08/05/23
Dynamic Loading Test for Round Concrete Piles D=60 cm	14 days	Tue 04/07/23	Mon 07/17/23
Expansion Joint Strip Seal Joint Type Heavy Duty (≤80 mm)	30 days	Sun 08/13/23	Mon 09/11/23
Expansion Joint Strip Seal Joint Type Light Duty (≤50 mm)	30 days	Sun 08/13/23	Mon 09/11/23
Elastomeric Bearing Pad 450 x 550 x 83 (Mov)	14 days	Sun 25/06/23	Sat 08/07/23
Elastomeric Bearing Pad 600 x 600 x 83 (Mov)	14 days	Sun 25/06/23	Sat 08/07/23
Elastomeric Bearing Pad 350 x 400 x 40 (Mov)	14 days	Sun 25/06/23	Sat 08/07/23
Elastomeric Bearing Pad 450 x 500 x 60 (Mov)	14 days	Sun 25/06/23	Sat 08/07/23
Elastomeric Bearing Pad 350 x 400 x 40 (Fix)	14 days	Sun 25/06/23	Sat 08/07/23
Elastomeric Bearing Pad 450 x 500 x 60 (Fix)	14 days	Sun 25/06/23	Sat 08/07/23
Ruber Sheet	14 days	Sun 25/06/23	Sat 08/07/23

Table 2. Non-Critical Activities

Activity	Duration	Start	Finished
Elastomeric Bearing Pad 600 x 600 x 83 (Fix)	14 days	Sun 25/06/23	Sat 08/07/23
Elastomeric Bearing Pad 450 x 550 x 83 (Fix)	14 days	Sun 25/06/23	Sat 08/07/23
Drainage Pipe D=20 cm with Fittings and Supports	42 days	Fri 04/08/23	Mon 14/09/23
Drainage Pipe D=15 cm with Fittings and Supports	42 days	Fri 04/08/23	Mon 14/09/23
Deck Drain Type 1 with Accessories	21 days	Sun 30/07/23	Sat 08/19/23
Solid Sodding	180 days	Thu 03/23/23	Fri 29/09/23
Gabion With Wire Coated Galvanized	91 days	Thu 03/23/23	Sun 02/07/23
Kali Stone Couple	105 days	Thu 03/23/23	Sun 07/16/23
Slope Protection with Concrete Blocks	105 days	Thu 03/23/23	Sun 07/16/23
Vehicle Guardrail Type A	175 days	Thu 03/23/23	Sun 09/24/23
Guardrail End Section	14 days	Fri 09/15/23	Mon 28/09/23
End Beam Guardrail 3 Waves	14 days	Fri 09/15/23	Mon 28/09/23
Crash Cushion 100 Km/Hour	14 days	Fri 09/15/23	Mon 28/09/23
Chainlink Fence	60 days	Sun 30/07/23	Wed 27/09/23
Regulatory and Warning Signs Type - A1	81 days	Sun 09/07/23	Wed 27/09/23
Regulatory and Warning Signs Type - A2	81 days	Sun 09/07/23	Wed 27/09/23
Regulatory and Warning Signs B-1	81 days	Sun 09/07/23	Wed 27/09/23
Regulatory and Warning Signs B-2	81 days	Sun 09/07/23	Wed 27/09/23
Type C Regulatory and Warning Signs	81 days	Sun 09/07/23	Wed 27/09/23
Height and Width Limit Warning Signs	81 days	Sun 09/07/23	Wed 27/09/23
Left Lane Width Warning Sign	81 days	Sun 09/07/23	Wed 27/09/23
Guidance Sign Type A-2	81 days	Sun 09/07/23	Wed 27/09/23
Guidance Sign Type A-3	81 days	Sun 09/07/23	Wed 27/09/23
Directional Signs Type A-4	81 days	Sun 09/07/23	Wed 27/09/23
Directional Signs Type B-1	81 days	Sun 09/07/23	Wed 27/09/23
Type C Direction Signs	81 days	Sun 09/07/23	Wed 27/09/23
Type D Direction Signs	81 days	Sun 09/07/23	Wed 27/09/23
Direction Signs Type D-2	81 days	Sun 09/07/23	Wed 27/09/23
PUPR Logo Ornament	84 days	Fri 23/06/23	Mon 14/09/23

Table 2. Non-Critical Activities

Activity	Duration	Start	Finished
"HK Logo Ornament (""Innovation For Solutions"")"	84 days	Fri 23/06/23	Mon 14/09/23
"Logo Ornament (""Advanced Indonesia")"	84 days	Fri 23/06/23	Mon 14/09/23
"Logo Ornament (""Indrapura - Kisaran Toll Road"")"	84 days	Fri 23/06/23	Mon 14/09/23
Road Markings, Type A (General Application)	86 days	Tue 04/07/23	Wed 27/09/23
Rumble Strip	14 days	Thy 07/09/23	Wed 20/09/23
Concrete Kerbs, Type A	91 days	Fri 02/06/23	Mon 31/08/23
DS-Kerb	140 days	Sun 02/04/23	Wed 08/30/23
Single Barrier (Type B height 115 cm)	147 days	Thu 06/04/23	Sun 10/09/23
Nyamplung (Calophylum Inophylium)	112 days	Thu 05/18/23	Wed 06/09/23
Bungur (Largersiroemia Indica)	112 days	Thu 05/18/23	Wed 06/09/23
Bintaro (Cerbera Oddia)	112 days	Thu 05/18/23	Wed 06/09/23
Fruit Butterflies	112 days	Thu 05/18/23	Wed 06/09/23
Jati Mas	112 days	Thu 05/18/23	Wed 06/09/23
Bamboo Tree 2.5 m high	112 days	Thu 05/18/23	Wed 06/09/23
Sea Fir Tree 2 m high	112 days	Thu 05/18/23	Wed 06/09/23
Umbrella Sunshade Tree 2 m high	112 days	Thu 05/18/23	Wed 06/09/23
Ketapang Kencana tree 2 m high	112 days	Thu 05/18/23	Wed 06/09/23
Spatodhea tree 2 m high	112 days	Thu 05/18/23	Wed 06/09/23
Steering Bench, Type B	56 days	Fri 07/28/23	Thu 09/21/23
Patok Rumija, Type A	56 days	Fri 07/28/23	Thu 09/21/23
RUMIJA Fence, Type 1 (Concrete Panel)	140 days	Thu 04/13/23	Sun 10/09/23
RUMIJA Fence, Type 2 (Barbed Wire)	140 days	Thu 04/13/23	Sun 10/09/23
RUMIJA Fence, Type 3 (BRC)	28 days	Mon 08/28/23	Sun 09/24/23
PJU lamp, Height 13 m, Type A (1 x 150 Watt), LED Type, Smart System	28 days	Mon 17/08/23	Wed 13/09/23
PJU lamp, Height 13 m, Type B (2 x 150 Watt), LED Type, Smart System	28 days	Mon 17/08/23	Wed 13/09/23
Tower Light (High Mast), Height 35 m	28 days	Mon 17/08/23	Wed 13/09/23
LPL Lights (Traffic Control Lights) Type 1	28 days	Mon 17/08/23	Wed 13/09/23
LPL Lights (Traffic Control Lights) Type 2	28 days	Mon 17/08/23	Wed 13/09/23
40 Watt LED Tunnel/Under Bridge Lights, Type BVP 281/Equivalent	28 days	Mon 17/08/23	Wed 13/09/23
Flashing Light	28 days	Mon	Wed

Table 2. Non-Critical Activities

Activity	Duration	Start	Finished
		17/08/23	13/09/23
Tower Light Lightning Protection (Including Grounding and Grounding Boxes)	28 days	Mon 17/08/23	Wed 13/09/23
NYFGBY 2C Cable - 10 mm2	84 days	Thy 08/06/23	Wed 08/30/23
NYFGBY 4C cable - 10 mm2	84 days	Thy 08/06/23	Wed 08/30/23
NYFGBY 4C cable - 16 mm2	84 days	Thy 08/06/23	Wed 08/30/23
NYFGBY 4C cable - 25 mm2	84 days	Thy 08/06/23	Wed 08/30/23
NYFGBY 4C cable - 35 mm2	84 days	Thy 08/06/23	Wed 08/30/23
BC cable - 10 mm2	84 days	Thy 08/06/23	Wed 08/30/23
PJU Panel (Including Box and Foundation)	28 days	Mon 07/08/23	Sun 03/09/23
PLN Meter Panel Boxes and Foundations	28 days	Mon 07/08/23	Sun 03/09/23
LPL Control Panel (LPL Foundation & Box Panel)	28 days	Mon 07/08/23	Sun 03/09/23
Electric control body	28 days	Mon 07/08/23	Sun 03/09/23
LPL lamp safety iron pole	28 days	Mon 07/08/23	Sun 03/09/23
Cable Protector or cable channel groove	90 days	Thy 08/06/23	Tue 05/09/23
Cable dugouts or cable channel grooves	90 days	Thy 08/06/23	Tue 05/09/23
"Galvanized Pipe Ø 6"" (2 way)"	90 days	Thy 08/06/23	Tue 05/09/23
Utility Pipe, type 3	90 days	Thy 08/06/23	Tue 05/09/23
PLN 240 kVA Power Connection	90 days	Thy 08/06/23	Tue 05/09/23
5 Island Toll Gate	90 days	Thy 08/06/23	Tue 05/09/23
Provisional Sum for Redirection and Existing Utility Protection	112 days	Thu 03/23/23	Sun 07/23/23
Gateway Office	120 days	Thu 03/23/23	Mon 07/31/23

The results for the display of resource analysis can be seen in the image below

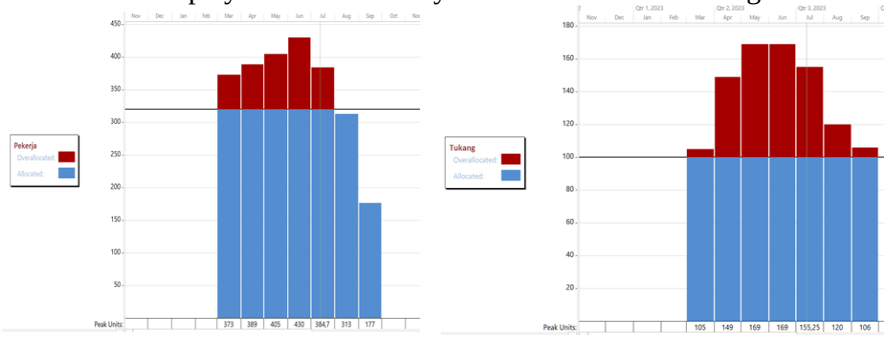

Figure 3. Comparison of labor requirements based on CPM analysis and project realization

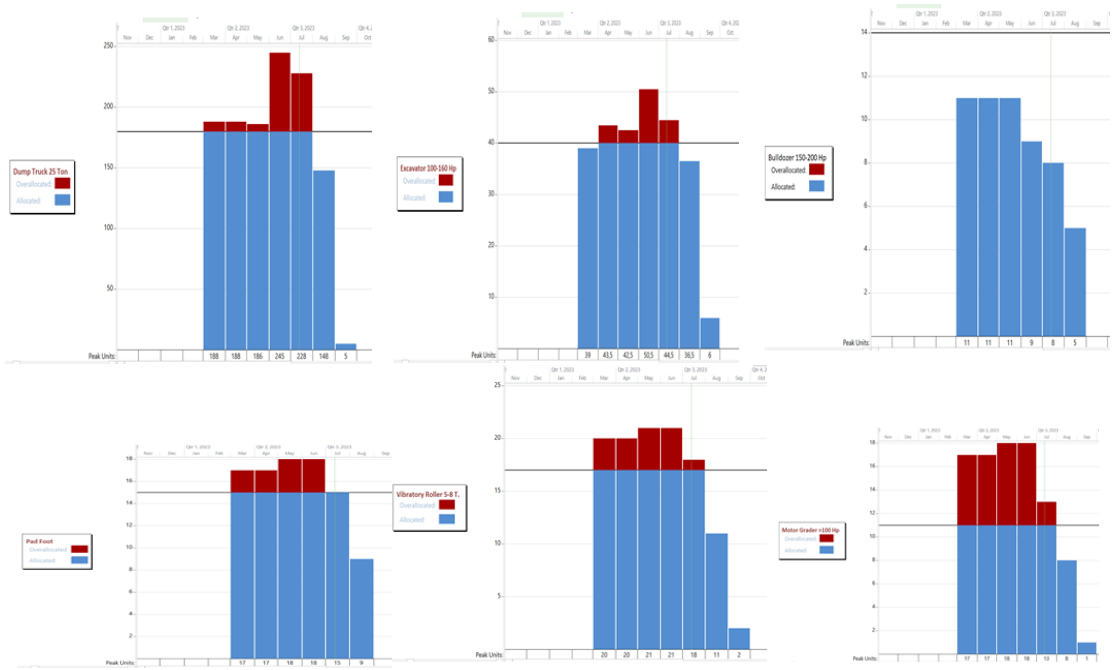

Figure 4. Comparison of Heavy Equipment requirements based on CPM Analysis and project realization

4.3 Project Evaluation

Based on the visualization and critical and non-critical activities that exist on the project, if the project is implemented under current conditions, it will be able to reach the completion target by the end of September. This is of course taking into account several things such as all critical activities are not done too late, and no non-critical activities exceed the latest finish that has been set based on the time standard. The problem of late completion of previous project activities after being traced was caused by delays in land acquisition by the local government. This causes the schedule to be delayed which will ultimately cause the completion of the project to be delayed.

5. CONCLUSION

5.1 Discussion of Delays in Project Completion

In a road construction project, there are many parties involved. These parties include the Central Government, Regional Government, Stakeholders, Communities, to the Judiciary Institution. All of these must synergize to be able to complete the project within the desired deadline. In the case at hand, the delay in completing this project was caused more by the activities of third parties who were late in carrying out land acquisition. This caused the project to start too late.

5.2 Discussion of Activities that Need to be Scheduled

The activities that need to be scheduled to be carried out in the completion of this project consist of the following activity groups:

1. General activity group
2. Workplace cleaning activity group
3. Demolition activity group
4. Earthwork activity group
5. Structure excavation activity group
6. Drainage activity group
7. Subgrade activity group
8. Subbase activity groups
9. Pavement activity group

10. Concrete structure activity group
11. Structural steel work activity group
12. Other work activity groups
13. Traffic light lighting and electricity activity group
14. Toll plaza activity group
15. Existing utility switching and protection activity groups
16. Facility activity groups and toll gates

It is this entire group of activities that still needs to be scheduled so that the project can be completed by the desired deadline at the end of September.

5.3 Discussion of the Project Schedule with the CPM Method

To be able to complete this project with the remaining activities, work is required to start from March 24 2023 to September 30 2023. In contrast to without CPM scheduling, the completion of the project could be delayed if it is not scheduled with CPM. If there are activities that can cause delays, they can be mitigated from the start.

5.4 Further Discussion of Strategies to Prevent Project Schedule Delays

In order to prevent further project delays, it is very important for the project leader to be able to complete critical activities according to the deadlines that have been set through this CPM method. If there are indications that it will cause the schedule to be late, then additional resources become necessary. The critical activities that need to be considered in completing this project can be seen in Table 3 below.

Table 5.1. Critical Activities

Activity	Duration	Start	Finished
Critical: Yes	**191 d**	**Fri 03/23/23**	**Tue 09/30/23**
Common Borrow Material 5 - 10 km	126 days	Thu 03/23/23	Sun 06/08/23
Basic Soil Preparation	154 days	Thu 03/23/23	Sun 03/09/23
Drainage Layer	159 days	Thu 03/23/23	Fri 08/09/23
Lean Concrete (t = 10 cm)	163 days	Thu 03/23/23	Tue 12/09/23
Concrete Pavement	172 days	Thu 03/23/23	Thu 09/21/23
Concrete Barrier Single Face	181 days	Thu 03/23/23	Sat 09/30/23

For causes of delay due to other parties, then for the next project it is necessary to set clear rules and penalties so that each party involved in this project will always complete their activities according to a predetermined schedule.

6. CONCLUSION

The conclusions from this study are as follows:

1. The cause of the delay in this project was due to other parties, especially in terms of land acquisition
2. Activities that need to be scheduled to achieve the expected targets are grouped into 16 activity groups as follows: General activity group, Workplace cleaning activity group, Demolition activity group, Earthwork activity group, Structure excavation activity group, Drainage activity group, Subgrade activity group, Group subbase activity, Pavement activity group, Concrete structure activity group, Structural steel work activity group, Miscellaneous work activity group, Traffic light and electrical lighting activity group, Toll plaza activity group, Existing utility diversion and protection activity group, Activity group facilities and toll gates.

3. The schedule obtained using the CPM method is that the schedule needs to be prepared from 24 March 2023 to 30 September 2023.
4. A strategy that can be implemented to prevent project delays is to ensure that each critical activity is carried out according to the deadline set. Because, any delay in critical activities will cause the project schedule to be delayed. Resources for the critical path must be really paid attention to, so that there are no delays on the critical path. To prevent delays in the project in the future, the parties involved need to arrange rewards and punishments so that the project can be completed well. Or by taking over activities on critical paths carried out by sub contractors or even replacing subcontractors who do not perform on the work

REFERENCES

Abdurrasyid, Luqman, Abdul Haris, dan Indrianto. 2019. Implementasi Metode PERT dan CPM pada Sistem Informasi Manajemen Proyek Pembangunan Kapal. Khazanah Informatika, vol. 5, no. 1, 2019, p. 28-36

Alaydrus A M, dan Hardjomuljadi S, 2018, Analisis faktor keterlambatan dimulainya pelaksanaan proyek konstruksi pada model kontrak rancang bangun, Jurnal Konstruksia, 10(1), pp. 95-116.

Andiyan et.al. 2020. Construction Project Evaluation Using CPM-Crashing, CPM-PERT and CCPM for Minimize Project Delays. Virtual Conference on Engineering, Science and Technology (ViCEST) 2020, Journal of Physics: Conference Series, 1933 (2021) 012096

Anggara, H. 2005. Perencanaan dan Pengendalian Proyek dengan Metode PERt-CPM: Studi Kasus Fly Over Ahmad Yani, Karawang. Journal the Winners, Vol. 6, No. 2: 155-174.

Collier, Zachary A. et.al. 2018. Scenario Analysis and PERT/CPM Applied to Strategic Investment at an Automated Container Port. ASCE-ASME J. Risk Uncertainty Eng. Syst., Part A: Civ. Eng., 2018, 4(3): 04018026

Dannyanti, E. 2010. Optimalisasi Pelaksanaan Proyek dengan Metode Pert dan CPM (Studi Kasus Twin Tower Building Pascasarjana Undip). Skripsi, FT Undip. Semarang.

Gray, C., Simanjuntak, P., Lien K.S., Mspaitella, P.F.L., Varley,R.C.G. 2007. Pengantar Evaluasi Proyek. Gramedia Pustaka Utama. Jakarta.

Handoko, T.H. 1999. Manajemen Personalia dan Sumber Daya Manusia. BPFE. Yogyakarta.

Hughes, Bob & Mike Cotterell. 2002. Software Project Management. Edisi Ke-3. McGraw-Hill. London.

Iluk, Tsalist, Ahmad Ridwan, dan Sigit Winarto. 2020. Penerapan Metode CPM Dan PERT Pada Gedung Parkir 3 Lantai Grand Panglima Polim Kediri. JURMATEKS Vol 3 No 2 Tahun 2020, p. 163-176

Karabulut, Mertcan. 2017. Application of Monte Carlo simulation and PERT/CPM techniques in planning of construction projects: A Case Study. Periodicals of Engineering and Natural Sciences, Vol.5, No.3, December2017, pp. 408–420

Kholil, Muhammad, Bonitasari Nurul Alfa, dan Madjumsyah Hariadi. 2018. Scheduling of House Development Projects with CPM and PERT Method for Time Efficiency (Case Study: House Type 36). IConCEES 2017, IOP Conf. Series: Earth and Environmental Science 140 (2018) 012010

Lermen, Fernando Henrique et. al. 2016. Optimization of Times and Costs of Project of Horizontal Laminator Production using PERT/ CPM Technical. Independent Journal of Management & Production, vol. 7, no. 3, 2016, p. 833-853.

Levin, Richard I. & Kirkpatrick Charles A. 1972. Perencanaan dan Pengawasan dengan PERT dan CPM. Bhratara. Jakarta.

Maddeppungeng A, Intari D E, Oktafiani A, 2019, Studi faktor penyebab keterlambatan proyek konstruksi studi kasus proyek pembangunan 6 ruas jalan tol dalam kota Jakarta, Jurnal Konstruksia, 11(1), pp. 89-96.

Malik, Alfian. 2010. Pengantar Bisnis Jasa Pelaksana Konstruksi. ANDI Offset. Yogyakarta.

Mazlum, Mete dan Ali Fuat Guneri. 2015. CPM, PERT and Project Management With Fuzzy Logic Technique and Implementation On A Business. Procedia - Social and Behavioral Sciences 210 (2015) 348 – 357

Meredith, Jack R., & Mantel Jr, Samuel J. 2006. Project Management, A managerial Approach. Sixth Edition. John Wiley & Sons, Hoboken. New Jersey.

Muhamad, Amiruddin HI. 2013. Optimalisasi Pelaksanaan Proyek dengan Metode PERT dan CPM (Studi Kasus di Gedung SMA Negeri 1 Tidore Kepulauan, Provinsi Maluku Utara). Skripsi. Fakultas Teknik, UMY. Yogyakarta.

Munawaroh. 2003. Principle of Management Construction. Jendela Ilmu. Semarang.

Nagarajan. 2007. Project Management. New Age International Pvt. New Delhi.

Nazir, Moh. 2005. Metode Penelitian. Ghalia Indonesia. Bogor.

Prasetya, Hery & Fitri Lukiastuti. 2009. Manajemen Operasi. Media Pressindo. Yogyakarta.

Render, Barry & Jay Heizer. 2004. Manajemen Operasi. Salemba Empat. Jakarta. Render, Barry & Jay Heizer. 2005. Prinsip-prinsip Manajemen Operasi. Edisi Ketujuh. Salemba Empat. Jakarta.

Render, Barry & Jay Heizer. 2006. Operations Management. 8th Edition. Pearson Prentice-Hall Inc. New Jersey.

Ridho, M. Rizki & Syahrizal. 2014. Evaluasi Penjadwalan Waktu dan Biaya Proyek dengan Metode PERT dan CPM (Studi Kasus: Proyek Pembangunan Gedung Kantor Badan Pusat Statistik Kota Medan di Jl. Gaperta Medan, Sumatera Utara). Jurnal Teknik Sipil USU, Vol. 3, No. 1.

Rondinelli, A. Dennis. 1990. Proyek Pembangunan Sebagai Manajemen Terpadu: Pendekatan Adaftif terhadap Pelayanan Publik. Bumi Aksara. Jakarta.

Sahid, Dadang S.S. 2012. Implementasi Critical Path Method dan PERT Analysis pada Proyek Global Technology for Local Community. Jurnal Teknologi Informasi dan Telematika, Vol. 5: 14-22.

Schwalbe, Kathy. 2004. Information Technology Project Management. Edisi Ke-4. Course Technology, Inc. Boston.

Sinulingga, Sukaria. Metode Penelitian, Edisi 1, USU Press: Medan.

Siswanto. 2007. Operation Research Jilid II. Erlangga. Jakarta.

Soeharto, I. 1999. Manajemen Konstruksi dari Konseptual Hingga Operasional. Erlangga. Jakarta.

Subagya. 2000. Analisis Manajemen Proyek. Graha Pena. Bekasi.

Susilo, Yayuk Sundari. 2012. Analisis Pelaksanaan Proyek dengan Metode CPM dan PERT (Studi Kasus pada Proyek Pelaksanaan Main Stadium University of Riau). Jurnal Fakultas Teknik Sipil Universitas Riau: 1-16.

Taghipour, Mohammad et. al. 2020. Evaluating CCPM Method Versus CPM in Multiple Petrochemical Projects. Management, Volume 3, Issue 3, 2020 ISSN: 2617-4596, p. 1-20

Tampubolon. 2004. Pedoman Manajemen Proyek. Jilid 1. Afj Mobicons. Malang.

Taurusyanti, D. & Lesmana, M.F. 2015. Optimalisasi Penjadwalan Proyek Jembatan Girder Guna Mencapai Efektifitas Penyelesaian dengan Metode PERT dan CPM pada PT Buana Masa Metalindo. Jurnal Ilmiah Manajemen Fakultas Ekonomi, Vol. 1, No. 1 Tahun 2015: 32-36.