Time Control Analysis of the Construction of the Joyoboyo Intermodal Terminal Pedestrian Tunnel to the Surabaya Zoo

Original Article

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Abstract

The primary objective of this research is to examine the timeline for the construction of a pedestrian tunnel connecting the Joyoboyo Intermodal Terminal (TIJ) with the Surabaya Zoo (KBS). The construction of this tunnel is considered a crucial project aimed at enhancing accessibility and alleviating congestion along the Joyoboyo road. The estimated cost for this project is Rp 31,996,921,529.00 and it is scheduled to be completed within 135 calendar days. The results showed that the main factors of project delays were due to delays in the procurement of 40cm diameter piles, interference due to inundation due to undetected PDAM pipes. Using the CPM method, the identification of the critical trajectory enabled the optimisation of the project duration and reduced the risk of delays. In addition, incremental cost analysis showed the relationship between time acceleration and increased project cost. By identifying key factors causing delays and implementing strategic planning methodologies such as the CPM, the project was able to enhance efficiency and mitigate potential setbacks. Furthermore, the study shed light on the economic implications of time acceleration, emphasizing the importance of balancing speed with cost considerations in construction projects.

Keywords: Critical Path Method (CPM), Time Control, Project Management, Pedestrian Tunnel, Joyoboyo Intermodal Terminal.

1. Introduction

A common problem that is often faced in various parts of the world, including Indonesia especially in Surabaya, is the delay of construction projects (Wirabakti et al., 2017). These delays can have a major impact on the contractor's reputation, project cost, and client satisfaction (Sudarson, 2020). Some of the main factors that often cause construction projects to be delayed include internal factors such as inadequate planning, weak project management, limited resources, financial problems, poor quality of work and for external factors weather conditions, regulatory changes, social and natural disasters (Sugiyarto et al., 2013). The impacts of construction project delays include cost overruns, late fees, disruption of activities for the surrounding community and increased risk of work accidents or building damage (Ramadhani et al., 2022).

Surabaya City Transportation Department is the executor of authority in the field of transportation in Surabaya City as regulated in the Surabaya Mayor Regulation. In order to support the Surabaya City Government in the implementation of its authority, especially in terms of improving accessibility services that are comfortable and safe for the community, currently the Surabaya City Government is carrying out the construction of a pedestrian tunnel

as an access / connecting route between Joyoboyo Intermodal Terminal (TIJ) and Surabaya Zoo (KBS). With the construction of the pedestrian tunnel is expected to provide convenience and safety crossing for visitors Surabaya Zoo, as well as reduce traffic congestion on the road Joyoboyo and surrounding areas.

The construction of the pedestrian tunnel from Joyoboyo Intermodal Terminal to Surabaya Zoo has been delayed due to social conflict with the community around the project site regarding the certainty of the impact of handling in the form of fence closures that result in the community being unable to carry out economic activities (unable to sell). There are several utilities that still need to be moved or diverted from the area that will be affected by the tunnel. The existence of water puddles from several PDAM pipes that were not detected during pile installation. Traffic flow diversion / traffic engineering that experienced delays in implementation because coordination with FORKOMPINDA and other related agencies was still needed. Thus, we can see from the description above that there have been undetected delays in the implementation of the work that affect the schedule of activities.

As in the Pedestrian Tunnel Construction project from Joyoboyo Intermodal Terminal to Surabaya Zoo which experienced delays. This project has a planning target of 135 (one hundred thirty-five) calendar days, which started on 30 May 2024 and is planned to end on 11 October 2024 with a nominal project cost of Rp 31,996,921,529.00.

The project was planned to be completed at week 20 but at week 7 when the cut-off experienced a deviation of -7.205%. At the time of writing the project is still ongoing. Inaccurate planning of a project can affect project implementation and can cause problems on the project that affect all workers involved in the project. Therefore, in planning a project must be appropriate and in accordance with the characteristics of the project concerned, in order to be able to deal with the uncertainty of project implementation conditions there must be scheduling planning. Problems that often arise in a project are project delays, this can lead to an extension of the project implementation period caused by setbacks in the implementation stage (Astari et al., 2022).

Therefore, project control is very important in this case the author uses the Critical Path Method (CPM) method in controlling the project. Critical Path Method (CPM) is a project management method that allows us to find the series of tasks that last the longest during the project. This series of tasks is called the critical path (Iwawo et al., 2016). The critical path is very important because any delays on this path will have a direct impact on the length of the project (Purba, 2021). The goal is to optimise the project completion time, prevent delays, increase the efficiency of resource use, make it easier to make decisions.

Critical Path Method (CPM) in project management is the cornerstone of project planning even today (Dwiretnani & Kurnia, 2018). How long a project takes often depends on the most important tasks that make it up. Every project, regardless of its size or budget, has some core tasks that are important to complete (Polii et al., 2017). A task is considered critical if it is delayed, thus slowing down the completion of the overall project. The critical path in project management is the longest set of activities that must be completed on time for the entire project to be completed. Any delay in critical tasks will delay the entire project.

Critical Path Method (CPM) revolves around finding the most important tasks in the project timeline, identifying task dependencies, and calculating task durations (Siregar & Iffiginia, 2019). Critical Path Method (CPM) was developed in the late 1950s as a methodology to solve the problem of increasing costs due to inefficient scheduling (Gunasti et al., 2019). Since then, the Critical Path Method (CPM) has become popular for planning projects and prioritising tasks. Critical Path Method (CPM) is able to provide valuable insights into the right way to plan projects, allocate resources, accelerate milestones, and schedule tasks. Based on

this background, this research aims to analyse the time control of the construction of a pedestrian tunnel connecting Joyoboyo Intermodal Terminal (TIJ) with Surabaya Zoo (KBS).

2. Methods

2.1. Research subject

Construction of the Joyoboyo Intermodal Terminal Pedestrian Tunnel to Surabaya Zoo.

2.2. Research Type

This research uses a qualitative approach to describe problems and research focus. Qualitative methods are social research measures to obtain descriptive data in the form of words and images. This is in accordance with what is revealed by (Moleong, 2006) that the data collected in qualitative research is in the form of words, pictures, and not numbers.

2.3. Data Collection Procedure

In conducting this research, data is collected that is used to analyse the discussion of this research, to facilitate the analysis, data that is directly related to the project is needed, these data include:

a. Primary data

Primary data is data obtained directly in the field, which includes Field Observation. The author conducts direct study research on the Pedestrian Tunnel Construction project from Joyoboyo Intermodal Terminal to Surabaya Zoo.

b. Secondary Data

Secondary data is a source of data obtained through published and unpublished contractors directly, including:

1. Cost Budget Plan (RAB) for Pedestrian Tunnel from Joyoboyo Intermodal Terminal to Surabaya Zoo
2. Project Schedule
3. Project Weekly Report
4. Price List of Materials and Labour Wages

Data collection techniques are the methods used to obtain data. The data in this study are time schedule, plan drawings, price lists of materials and wages, and weekly reports recapitulating project cost calculations. The data was obtained from the supervisory consultant who supervised the construction of the project. The price list and materials are partly obtained from the project implementer in the field.

2.4. Data Analysis Technique

Data analysis techniques are carried out systematically and logically according to the theoretical basis which aims to obtain the truth of an object of the problem, so that later it will make it easier to accumulate scheduling or time and cost using the critical path method (CPM).

The data analysis technique carried out in the implementation of the study of the samples taken, namely:

1) Detail the plan and sequence of work activities
2) Calculate productivity and duration of work to determine normal time (m), optimistic time (a) and pessimistic time (b) for each job.
3) Planning scheduling implementation with consideration of productivity efficiency using the critical path method (CPM).

4) Use Microsoft excel to determine critical work. Looking at the weekly report of the project in order to find out the point that is experiencing delays.

3. Results and Discussion

3.1. Determination of Major Work (Major Item)

Data obtained from the cost budget plan by determining the main work of the Joyoboyo intermodal terminal pedestrian tunnel construction project to the Surabaya zoo. To determine the main work is done by:

1) Describe all types of work in the List of Quantities and Prices (BQ).
2) Calculate the weight of the work.
3) Arrange the work with the largest weight to the smallest.
4) Calculate the accumulated weight from the largest to the smallest up to an amount of 80%.
5) All work items within the 80% amount becomes the main work.

From the data in the list of quantities and prices contained in appendix 4 sorted by work weight from largest to small, a table is obtained as follows:

Table 1. Main Work Items

No	Main Work Items	Contract Volume	Total Price (Rp)	Contractual Weight (%)
1.	Concrete Wall t:60 cm Fc'35 MPa (PC 450)	556.00	3,410,705,383.20	11.83
2.	Diameter 40 cm K600 Type C Piles	3,972.00	2,796,288,000.00	9.70
3.	SSP Rental and Retraction + Bracing	3,972.00	12,233,760,000.00	8.33
4.	SSP Rental Uk.400 mm, 12 m Length + Bracing	780.00	2,385,240,000.00	8.27
5.	Concrete Raft Foundation 60 cm Fc'35 MPa (PC 450)	631.80	2,151,616,469.65	7.46
6.	Backfill Soil Compaction Work	3,447.19	1,505,904,951.50	5.22
7.	Entrance Cover 8 mm Tempered Reflective Glass + Spider and Frame	305.72	1,395,477,368.80	4.84
8.	Land Excavation	9,268.16	769,257,280.00	2.67
9.	Pile Driving Including Stakes	5,627.00	721,100,050.00	2.50
10.	Concrete Plate t:60 cm Fc'35 Mpa (PC 450)	183.25	708,978,831.35	2.46
11.	Passenger Elevator 400 Kg Capacity	1.00	668,000,000.00	2.32
12.	Soil Disposal	9,263.66	507,185,385.00	1.76
13.	Fresh Air Fan (Cabinet Type): Capacity: 17,820 CMH	2.00	496,304,500.00	1.72
14.	Waterproofing Bitumen Membrane Double Sided + Polymer (Wall Plate + Top Plate)	2,738.36	422,802,784.00	1.47
15.	Class C Aggregate Work	1,098.50	419,417,186.50	1.45
16.	Stainless Steel Grill Cover	320.00	367,673,328.00	1.28
17.	Concrete Beam Latai 10x15 cm	24.00	322,526,898.72	1.12
18.	Mobilisation - Demobilisation	1.00	280,268,000.00	0.97
19.	U-Ditch 80/80 G.20 Tonne + Cover and Installation	117.00	233,853,750.00	0.81
20.	Jet Fan Capacity 3000 CMH: Capacity: 3000 CMH	7.00	231,059,150.00	0.80
21.	Homogeneous Tile 60x60 cm (Polished)	510.20	221,375,780.00	0.77
22.	Production and Sanding of AC - BC	207.15	205,801,453.50	0.71

No	Main Work Items	Contract Volume	Total Price (Rp)	Contractual Weight (%)
23.	32 cm wide PVC Waterstop	792.70	201,306,165.00	0.70
24.	Waterproofing Bitumen Coating (under Ceramic Floor)	820.97	183,568,892.00	0.64
25.	Backfill Building Floor Elevation	472.97	175,779,300.50	0.61
	Total Percentage			80.43

Source: Processed by the author 2024

From the table above, it can be seen that there are 25 main work items of the Joyoboyo intermodal terminal pedestrian tunnel construction project to Surabaya zoo with a total of 80.43% of all total work. The main work of the largest weight is the 60cm thick wall concrete work item with a value of Rp. 3,410,705,383.20 with a weight of 11.83% and the lowest is the backfill (*urugan sirtu*) work item Elevating the Building Floor with a value of Rp. 175,779,300.50 with a weight of 0.61%.

In the planning of a project to accelerate the estimated completion time of the project, the implementation time plan data is carefully examined. In this case, planning is an important element in project management. In the Joyoboyo intermodal terminal pedestrian tunnel construction project to the Surabaya zoo lasted 135 calendar days starting on 30 May to 11 October 2024.

From the project implementation work schedule, the S curve of the project can be seen. The S curve is a graph or diagram that shows the development or progress of a project or activity against time. The shape resembles the letter 'S', which results from changes in activity speed over time. Typically, S-curves are used in project management to monitor the progress of the project in accordance with the planning and schedule. The parts of the S curve are as follows:

1) Project Start

In the initial phase, the activity rate tends to be slow because the project is just starting, planning is still ongoing, and preparations are being made. This causes the graph to have a gentle or flat slope.

2) Mid Phase

Once the preparation is complete, work begins to progress more intensively, and the speed of the project increases. In the S-curve, this can be seen from the sharper slope, reflecting the faster increase in progress.

3) Final Phase

In the final stages of the project, activity begins to slow down as it nears completion and some work may be in the refinement or inspection phase. The slope of the graph slopes down again, reflecting the slowdown in speed.

4) Evaluation and Control

S-curves help project managers see if the actual progress is in line with the plan. If there is a deviation or difference from the planned curve, this could be a sign of constraints or the need for adjustments.

The S curve explains the progress of the project every week, in weeks 1 to 20 the project was completed by 56.92%. In week 20, an additional 5 weeks of effort was obtained for the construction of the Joyoboyo Intermodal Terminal Pedestrian Tunnel - Surabaya Zoo. The total project work time is 25 weeks with a total project cost of Rp 31,996,921,529.00 the total cost includes 11% tax.

3.2. Determining the Sequence of Work Implementation Methods

The following is a table of the sequence of work implementation methods for the Joyobo Intermodal Terminal Pedestrian Tunnel Construction project activities to Surabaya Zoo can be seen from table 2 below:

Table 2. Sequence of Work Implementation Methods

No	Work Item	Unit	Contract Volume
1	Mob demob	Ls.	1.00
2	40cm Diameter K600 Type C Piles	m'	3,972.00
3	Pile driving including ruyung	m'	5,627.00
4	SSP rental uk. 400 mm, 12 m length + Bracing	bar	780.00
5	Sheet pile piling and retraction + Bracing	bar	780.00
6	Soil Excavation	m³	9,268.16
7	Soil Removal	m³	9,263.66
8	Concrete Raft Foundation 60 cm fc' 35 mpa (PC 450)	m³	631.80
9	Concrete Wall 40 cm thick f'c 35 Mpa (PC 450)	m³	556.00
10	32 cm wide PVC Waterstop	m	792.70
11	Concrete floor beam 10X15	m³	24.00
12	Concrete Plate 60 cm thick fc' 35 mpa (PC 450)	m³	183.25
13	Waterproofing bitumen membrane double sided + polymer (wall plate + top plate)	m²	2,738.36
14	backfill elevation of the building floor	m³	472.97
15	Backfill soil compaction work	m³	3,447.19
16	Waterproofing Bitumen Coating (under floor tiles)	m²	820.97
17	Homogeneous Tile 60x60 (Polished)	m²	510.20
18	Class C Aggregate Work	m³	1,098.50
19	AC-BC Production and Sanding	ton	207.15
20	U Ditch 80/80 G. 20 Tonne + cover and Installation	Pcs	117.00
21	Stenlish steel grill cover	m'	320.00
22	Jet Fan Cap. 3000 CMH	unit	7.00
23	Fresh Air Fan (Cabinet Type)	unit	2.00
24	Passenger Elevator Capacity 400 KG	set	1.00
25	Entrance cover 8 mm tempered reflective glass + spider and frame	m²	305.72

Source: Processed by the author 2024

The sequence of work execution methods is determined from the list of work quantities to be carried out. For the Mobilisation Demobilisation work item, the mobilisation activity is to bring in the manpower, materials and tools required in the project activities and the Demobilisation activity at the end of the project is to return the manpower, materials and tools at the end of the project activities.

3.3. Determination of Work Duration

The Joyobo Intermodal Terminal to Surabaya Zoo Pedestrian Tunnel Construction project is divided into 2 segments to speed up the construction process. After the sequence of work implementation methods is determined, then the duration of each work item will be carried out. The following is the duration of each item of work performed on the Construction of the Joyobo Intermodal Terminal Pedestrian Tunnel to the Surabaya Zoo can be seen from table 3 below as follows:

Table 3. Duration of work

No.	Work Item	Unit	Contractual Volume	Capacity	Duration (Days)
1.	Concrete Wall 40 cm thick Fc'35 MPa (PC 450)	M³	556.00	92.67	6.00
2.	Pile Diameter 40 cm K600 Type C	M'	3,972.00	233.65	17.00
3.	SSP Erection and Retraction + Bracing	bar	780.00	21.67	36.00
4.	SSP Rental Uk.400 mm, 12 m length + Bracing	bar	780.00	-	-
5.	Raft Foundation Concrete 60 cm Fc'35 MPa (PC 450)	M³	631.80	90.26	7.00
6.	Backfill Soil Compaction Work	M³	3,447.19	215.45	16.00
7.	Entrance Cover 8 mm Tempered Reflective Glass + Spider and Frame	M²	305.72	38.22	8.00
8.	Soil Excavation	M³	9,268.16	1,324.02	7.00
9.	Pile Driving including Ruyung	M'	5,627.00	511.55	11.00
10.	Concrete Plate 60 cm thick Fc'35 Mpa (PC 450)	M³	183.25	30.54	6.00
11.	Passenger Elevator 400 Kg Capacity	Set	1.00	0.33	3.00
12.	Soil Disposal	M³	9,263.66	514.65	18.00
13.	Fresh Air Fan (Cabinet Type): Capacity: 17,820 CMH	Unit	2.00	0.15	13.00
14.	Waterproofing Bitumen Membrane Double Sided + Polymer (Wall Plate + Top Plate)	M²	2,738.36	342.30	8.00
15.	Class C Aggregate Work	M³	1,098.50	183.08	6.00
16.	Stainless Steel Grill Cover	M'	320.00	-	-
17.	Concrete Floor Beam 10x15 cm	M³	24.00	24.00	1.00
18.	Mob Demob	Ls	1.00	0.07	14.00
19.	U-Ditch 80/80 G.20 Tonne + Cover and Installation	Pcs	117.00	58.50	2.00
20.	Jet Fan Capacity 3000 CMH: Capacity: 3000 CMH	Unit	7.00	2.33	3.00
21.	Homogeneous Tile 60x60 cm (Polished)	M²	510.20	24.30	21.00
22.	Production and Sanding of AC - BC	Ton	207.15	41.43	5.00
23.	32 cm wide PVC Waterstop	M	792.70	198.18	4.00
24.	Waterproofing Bitumen Coating (under Ceramic Floor)	M²	820.97	205.24	4.00
25.	Backfill elevation of Building Floor	M³	472.97	118	4.00

Source: Processed by the author 2024

From the table above, it can be seen that the duration with the longest work is SSP + Bracing Piling and Removal with a duration of 36 days. This work consists of SSP + Bracing piling which is carried out after pile driving including ruyung and SSP + Bracing removal work after backfill compaction work. With the shortest duration is the 10x15 cm Floor Beam Concrete work which is only 1 day due to its small volume of about 24 m³.

The SSP+Bracing piling activity was divided into 2 segments to overcome the excess time so that 2 tools were needed simultaneously. Likewise, the SSP+Bracing retraction work was divided into 2 segments to shorten the work completion time.

3.4. Determination of Relationship between Activities

Determination of the relationship between the activities of the construction of the Joyoboyo Intermodal Terminal Pedestrian Tunnel to Surabaya Zoo is done by paying attention to the sequence of activities that have been made as above in Table 2 Sequence of Work Implementation Methods.

From the results of determining the relationship between activities, the order of which activities will be carried out first and which activities depend on the completion of the previous work or activity.

In writing the relationship between activities is done by giving arrows from the end node of each work item to the start node of the next work item, by giving the duration of completion of each activity. The relationship between these activities will determine the earliest or latest start of a job, as well as the earliest or latest end of the end of a work item. Overall, the dependency between activities will determine the overall amount of time needed to complete the work.

In the Joyoboyo Intermodal Terminal Pedestrian Tunnel Construction project to Surabaya Zoo can be seen in table 4. In the table 4, it can be seen that the work starts from two non-interdependent works namely mobilisation and procurement of 40cm piles. From these two works, other interdependent activities starting from pile driving including ruyung, sheet pile + bracing, soil excavation, soil disposal, concrete foundation raft 60 cm fc' 35 mpa (PC 450), Concrete Wall 40 cm thick f'c 35 Mpa (PC 450), Concrete Plate 60 cm thick fc' 35 mpa (PC 450), Waterproofing Bitumen Coating (under floor tiles), Backfill soil compaction work, Sheet pile + Bracing removal, Class C Aggregate Work, AC-WC Production and Sanding and Demobilisation. While the relationship between other activities can be seen from table 4 below:

Table 4. Inter-activity Relationship Table

No.	Kode Kegiatan	Item Pekerjaan	Satuan	Volume Kontrak	Durasi Hari	Durasi Minggu
		STRUKTUR				
		PEKERJAAN PERSIAPAN				
1	A	Mob demob	Ls.	1.00	14	2.00
		PEKERJAAN TANAH				
2	B	Galian tanah	m³	9,268.16	10	1.43
3	C	Urugan sirtu peninggian lantai bangunan	m³	472.97	4	0.57
4	D	Pekerjaan pemadatan tanah urugan kembali	m³	3,447.19	16	2.29
5	E	Pembuangan Tanah	m³	9,263.66	18	2.57
		PEKERJAAN PERKUATAN TANAH				
6	F	Pemancangan dan pencabutan sheet pile + Bracing	btg	780.00	36	5.14
		PEKERJAAN STRUKTUR TUNNEL				
7	G	Tiang Pancang Diameter 40cm K600 Tipe C	m'	3,972.00	17	2.43
8	H	Pemancangan tiang pancang termasuk ruyung	m'	5,627.00	11	1.57
9	I	Waterstop PVC lebar 32 cm	m	792.70	4	0.57
10	J	Beton Raft Foundation 60 cm fc' 35 mpa (PC 450)	m³	631.80	7	1.00
11	K	Beton Dinding tebal 40 cm f'c 35 Mpa (PC 450)	m³	556.00	6	0.86
12	L	Beton Plat tebal 60 cm fc' 35 mpa (PC 450)	m³	183.25	6	0.86
		PEKERJAAN LANTAI				
13	M	Homogeneous Tile 60x60 (Polished)	m2	510.20	21	3.00
14	N	Cover grill stenlish steel	m'	320.00	2	0.29
		PEKERJAAN ENTRANCE dan PINTU DARURAT				
15	O	Penutup entrance Kaca reflective tempered 8 mm + spider dan rangka	m2	305.72	8	1.14
		PEKERJAAN PENGECATAN dan WATERPROFING				
16	P	Waterproofing Bitumen Coating (bawah keramik lantai)	m2	820.97	4	0.57
17	Q	Waterproofing bitumen membrane double sided + polymer (plat dinding + plat atas)	m2	2,738.36	8	1.14
		INFRASTRUKTUR				
		PEKERJAAN JALAN DAN SALURAN				
18	R	Pekerjaan Agregat Klas C	m3	1,098.50	6	0.86
19	S	Produksi dan Penghamparan AC-WC	ton	172.62	5	0.71
20	T	U Ditch 80/80 G. 20 Ton + cover dan Pemasangan	Pcs	117.00	2	0.29
		PEKERJAAN TATA UDARA				
21	U	Jet Fan Kap. 3000 CMH	unit	7.00	3	0.43
22	V	Fresh Air Fan (Type Cabinet)	unit	2.00	13	1.86
		PEKERJAAN HOME LIFT				
23	W	Passenger Elevator Kapasitas 400 KG	set	1.00	21	3.00

Source: Processed by the autor, 2024

4. Conclusion

The delay in the construction of the pedestrian tunnel connecting Joyoboyo Intermodal Terminal and Surabaya Zoo was caused by various technical and operational factors. One of the main factors was the delay in procuring the 40 cm diameter piles, which resulted in disruption to the schedule of subsequent activities. In addition, the piling caused a leak in the PDAM pipe, requiring additional time for repairs before work could resume. Changes to the project design also contributed, where the originally designed tunnel length of 156 metres changed to 172 metres, which automatically increased the volume of work and required additional implementation time. Another contributing factor was a mismatch in the number of machines on site in two segments of the project, which resulted in a reduction in the daily capacity of the works and exacerbated delays. The combination of these factors demonstrates the need for more careful planning and effective coordination in managing infrastructure projects.

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