ANALYSIS OF THE ACCELERATION OF TIME AND COST OF IMPLEMENTING BUILDING CONSTRUCTION PROJECTS USING THE CRITICAL PATH METHOD (CPM) METHOD

Heru Nur Yaqin, Hanie Teki Tjendani, Budi Witjaksana
Universitas 17 Agustus 1945 Surabaya, Indonesia
Email: berkahya18@gmail.com, hanie@untag-sby.ac.id, budiwitjaksana@untag-sby.ac.id

ABSTRACT

KEYWORDS
cost, duration, CPM, schedule, construction

This study aims to obtain the form of project work network in the Probolinggo City Hospital Development Project, to determine the effect of accelerating the duration of Probolinggo City Hospital Development work on network planning and to find out the amount of costs incurred before and after the acceleration of the duration of project work. The method used is the acceleration method with modification of the scheduling of the CPM model. CPM method planning is a recommendation in choosing from many existing methods, because there is a calculation of the earliest time the project starts, the last time the project starts as well as the earliest time to finish and the last time to finish so that it can be known the time lag of all activities. Data Used are primary and secondary data related to the sequence and relationship of activities, implementation time and cost budget plan (RAB). In this thesis, the author takes scheduling data from the Probolinggo City Hospital Development Project which will be used as the basis for writing this thesis in conducting CPM analysis and accelerating the duration of work with additional overtime working hours and calculating the total cost of the acceleration to be used as comparison material in the writing results. Based on the analysis that has been carried out using the Microsoft Project 2016 application, the normal duration of structural work is 81 working days and has 18 critical units of 31 work items. After the acceleration was carried out, there was a decrease in the duration of the work of the structure to 74 working days. The difference in duration decrease was 7 days or 9.45%. The total initial cost with the normal duration for structural work is IDR 28,563,131,560, while after acceleration, the project cost for structural work becomes IDR 28,635,083,793

INTRODUCTION

Project scheduling is an activity that sets the timeframe of project activities to be completed, raw materials, labor and time required by each activity. Scheduling is necessary so that project implementation can continue to take place according to the schedule plan that has been made. However, often project scheduling experiences problems, one of which is the occurrence of delays. Scheduling delays can adversely affect quality, time and cost. The construction of the Probolinggo City Hospital was delayed so that there was a minus deviation in progress due to the difference in the time of work implementation between the contractor's offer and those in the contract, resulting in disruption to the start of work implementation and due to the cash flow of underprivileged contractors. It is feared that the retreat of the implementation schedule may interfere with the implementation of the project, therefore it is necessary to accelerate the duration by using the Critical Path Method (CPM) to analyze the acceleration of the duration and its impact on costs.

Analysis of The Acceleration of Time and Cost of Implementing Building Construction Projects Using The Critical Path Method (CPM) Method

Vol. 4, No. 2, 2023

It is hoped that the results of this research can add insight for students, especially academics, about the analysis of a project using the CPM Method.

It is expected to provide information or recommendations to the relevant institutions (further research) regarding critical pathways and ways to accelerate project implementation, especially in structural work.

It is expected to provide information or recommendations to the owner, implementing contractor and MK consultants regarding critical paths and ways to accelerate project implementation, especially in structural work.

Table 1 Previous Research

No	Researchers	Heading	Method	Variable	Conclusion
1	Alan Duta Prayogi, 2015	Acceleration of Scheduling and Time in Building Buildings With Critical Path Method (CPM) and Program Evaluation Review Technique (PERT) (Case Study of Mall Building Project	Based on the anlysis carried out that the duration of the CPM is 427 days with the probability that it can be completed in 427 days is 81.56%. And for acceleration analysis using the Time Cost Trade Off method	Project Cost	In using the Critical Path Method (CPM) and Project Evaluation Review Technique (PERT) methods in the Dinoyo Mall building building, it is to detail the plan and sequence of activities, work, calculate normal time (m), determine optimistic time (a), and pessimistic time (b) on each job, and use the Microsoft Project 2007 application with input

According to Husen (2009), a project is a combination of resources such as material people, equipment, and capital / costs that are collected in a temporary organizational forum to achieve goals and objectives.

A project is an effort carried out in a responsible way to produce a product, service that produces a certain result (Lewis, 2005).

Defined as a systematic effort to determine standards that are in accordance with the goals and objectives of planning, designing information systems, comparing implementation with standards, analyzing possible deviations, then carrying out the necessary corrective actions so that resources can be used effectively and efficiently in order to achieve goals and objectives (Mockler, 1972).

Project scheduling is the activity of establishing the timeframe of project activities to be completed, raw materials, labor as well as the time required by each activity.

States that network planning is a tool used to plan, schedule and control the progress of a project. Here are some of the terms used to network the project (Gray and Larson, 2006).

Network Diagram is a visualization of a project based on network planning. Network Diagram is a network that contains the trajectories of activities and sequences of events that exist during the project organizer. Network Diagram consists of activity

Vol. 4, No. 2, 2023

[**Analysis of The Acceleration of Time and Cost of Implementing Building Construction Projects Using The Critical Path Method (CPM) Method**]

symbols, event symbols and when necessary symbols of relationships between events (dummy) (Iwawo, 2016).

Defines CPM as a project management model that prioritizes cost as the object being analyzed. CPM is a network analysis that seeks to optimize the total cost of a project through a reduction in the total completion time of the project. The use of the CPM method can save time in completing various stages of a project (Siswanto, 2007). Microsoft Project is software that can be used to design projects and manage the project. The completeness of facilities and its extraordinary ability in processing project data make this software the most widely used by computer operators because its existence is able to help and facilitate users in completing work, especially identifying critical work and related to project data (Setiawan, 2009).

RESEARCH METHOD

The research location is located on Jalan Profesor Hamka, Karenglor Village, Kedupak District, Probolinggo City. The research time is two months, starting from October to November 2022.

In this study, the Critical Path method (CPM) method will be used. In this method, there are two kinds of estimated time and cost for each activity. To find out the steps that will be carried out in this study, namely (Heizer and Render, 2015):
1. Define the project and define the working fractional structure of all structural activities contained in the project;
2. Determine which activities should be worked on first and which ones should follow the old activities;
3. Describes a network that connects all activities or creates a network diagram;
4. Determine the critical path to be used to assist in project scheduling re-planning

RESULT AND DISCUSSION
General Project Data

The project that is the object of research is the Probolinggo City Hospital Development Project. The location of the Probolinggo City Hospital Development Project is located on Jalan Profesor Hamka, Karenglor Village, Kedupak District, Probolinggo City.

Data Processing

Table 2 Detailed Budget Plan Cost of Structural Work Project

No	Types of Work	Total Price	Activity Code
1	Earthworks		
	Soil Excavation	IDR 111,815,277.99	A
	Sirtu's Patronage	IDR 1.040.325.000,00	B
	Urug Sand Under Foundation and Floor t.10 cm	IDR 65,135,945.71	C
	Working Floor Under Foundation and Floor t.10 cm	IDR 234,605,260.58	D
	Urugan soil back excavated	IDR 41,266,462.50	And

Analysis of The Acceleration of Time and Cost of Implementing Building Construction Projects Using The Critical Path Method (CPM) Method

Vol. 4, No. 2, 2023

2	Bottom Structure Work		
	Stake Work	IDR 3,101,140,000.00	F
	Pile Cap Foundation Work	IDR 1,320,606,233.03	G
	Sloof Foundation Work	IDR 3,178,141,803.12	H
	SFL Basic Lt. Column Work – 1,300	IDR 222,445,986.35	I
	Basic Lt. Plate Work	IDR 2,483,650,565.36	J
	Ramp Jobs	IDR 704,382,108.70	K
	Pit Lift Work	IDR 267,750,000.00	L
	Stair Work	IDR 151,200,000.00	M
3	Upper Structure Work		
	1st Floor (One)		
	Column Work	IDR 671,151,052.44	N
	Beam Work	IDR 2,548,123,262.00	Or
	Plate Works Lt.1	IDR 1,825,621,032.15	P
	Ramp Jobs	IDR 403,115,071.14	Q
	Stair Work	IDR 151,200,000.00	R
	2nd (Second) Floor		
	Column Work	IDR 671,151,052.44	S
	Beam Work	IDR 2,229,666,948.92	T
	Plate Works Lt.2	IDR 1,783,229,711.24	In the
	Ramp Jobs	IDR 403,115,071.14	In
	Stair Work	IDR 151,200,000.00	In
	Floor3 (Three)		
	Column Work	IDR 562,766,457.72	X
	Beam Work	IDR 1,637,741,918.66	And
	Plate Works Lt.3	IDR 910,187,676.44	With
	Ramp Jobs	IDR 284,670,865.28	AA
	Stair Work	IDR 151,200,000.00	OFF
	4th (Fourth) Floor		
	Column Work	IDR 465,738,474.58	AND
	Beam Work	IDR 608,877,515.50	TO
	Plate Works Lt.4	IDR 181,910,807.99	AE

Source: Project Data

Vol. 4, No. 2, 2023

[**Analysis of The Acceleration of Time and Cost of Implementing Building Construction Projects Using The Critical Path Method (CPM) Method**]
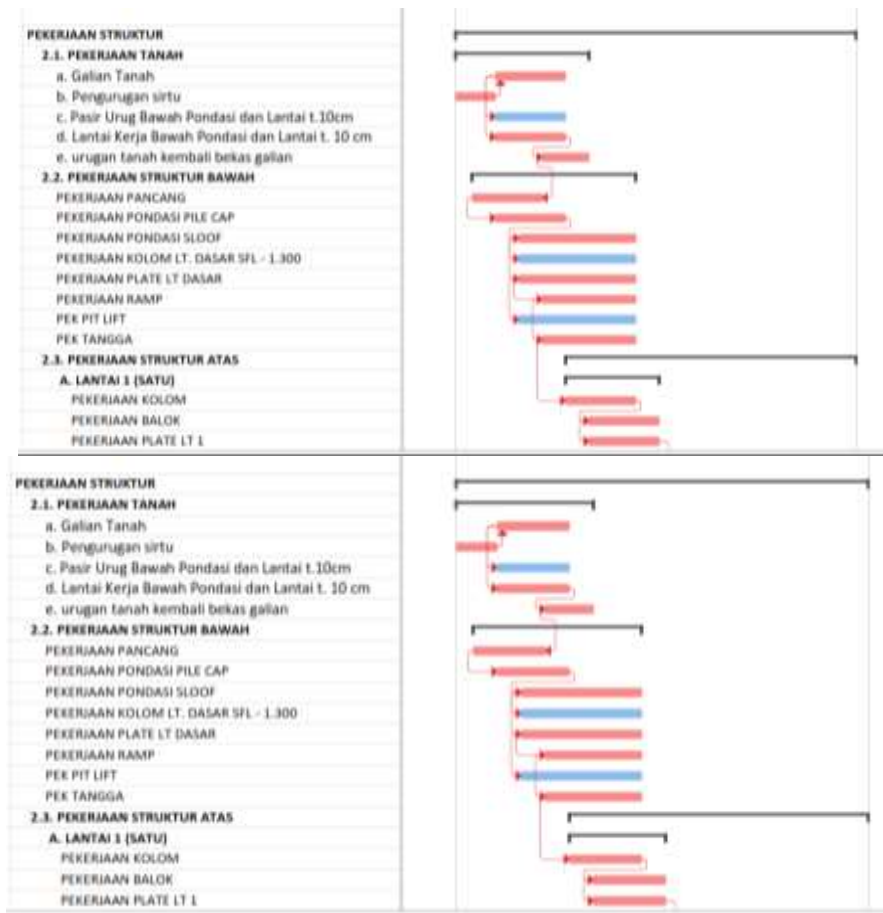

Figure 1 *Gantt Chart*
Source: Research Results

Table 3 Total Slack Based on *Microsoft Project* 2016

Task Name	Duration	Start	Finish	Total Slack	Predecessors
Structural Work	**81 Days**	**Wed 07/07/21**	**Sun 26/09/21**		
2.1. Earthworks	**40 Days**	**Wed 07/07/21**	**Sun 15/08/21**		
A. Soil Excavation	21 Days	Mon 19/07/21	Sun 08/08/21	0 Days	5
B. Sirtu	12 Days	Wed 07/07/21	Sun 18/07/21	0 Days	
C. Urug Sand Under Foundation And Floor T.10cm	21 Days	Mon 19/07/21	Sun 08/08/21	48 Days	4ss
D. Foundation Bottom Work Floor And Floor T. 10 Cm	21 Days	Mon 19/07/21	Sun 08/08/21	0 Days	4ss
E. Urugan Soil Back Excavated	14 Days	Mon 02/08/21	Sun 15/08/21	0 Days	7fs-7 Days

Analysis of The Acceleration of Time and Cost of Implementing Building Construction Projects Using The Critical Path Method (CPM) Method

Vol. 4, No. 2, 2023

2.2. Lower Structure Work	**49 Days**	**Mon 12/07/21**	**Sun 29/08/21**		
Piling Work	21 Days	Mon 12/07/21	Mon 02/08/21	0 Days	8sf
Pile Cap Foundation Work	21 Days	Mon 19/07/21	Sun 08/08/21	0 Days	10ss+7 Days
Sloof Foundation Work	35 Days	Mon 26/07/21	Sun 29/08/21	0 Days	11fs-14 Days
Lt Column Work. Sfl Base - 1,300	35 Days	Mon 26/07/21	Sun 29/08/21	65 Days	12ss
Basic Lt Plate Work	35 Days	Mon 26/07/21	Sun 29/08/21	0 Days	12ss
Ramp Jobs	28 Days	Mon 02/08/21	Sun 29/08/21	0 Days	14ss+7 Days
Pek Pit Lift	35 Days	Mon 26/07/21	Sun 29/08/21	65 Days	14ss
Pek Stairs	28 Days	Mon 02/08/21	Sun 29/08/21	0 Days	15ss
2.3. Upper Structure Work	**48 Days**	**Mon 09/08/21**	**Tue 26/09/21**		
A. 1st Floor (One)	**28 Days**	**Mon 09/08/21**	**Sun 05/09/21**		
Column Work	21 Days	Mon 09/08/21	Sun 29/08/21	0 Days	17ss+7 Days
Beam Work	21 Days	Mon 16/08/21	Sun 05/09/21	0 Days	20fs-14 Days
1st Plate Work	21 Days	Mon 16/08/21	Sun 05/09/21	0 Days	21ss
Ramp Jobs	21 Days	Mon 16/08/21	Sun 05/09/21	0 Days	22ff
Pek Stairs	14 Days	Mon 23/08/21	Sun 05/09/21	0 Days	23fs-14 Days
B. 2nd Floor (Two)	**35 Days**	**Mon 16/08/21**	**Tue 20/09/21**		
Column Work	21 Days	Mon 16/08/21	Sun 05/09/21	0 Days	24ss-7 Days
Beam Work	28 Days	Mon 16/08/21	Sun 12/09/21	0 Days	26ss
2nd Lt Plate Work	21 Days	Mon 23/08/21	Sun 12/09/21	0 Days	27ff
Ramp Jobs	21 Days	Mon 30/08/21	Mon 20/09/21	0 Days	28ss+7 Days
Pek Stairs	7 Days	Mon 30/08/21	Sun 05/09/21	44 Days	29ss

Vol. 4, No. 2, 2023

[**Analysis of The Acceleration of Time and Cost of Implementing Building Construction Projects Using The Critical Path Method (CPM) Method**]

C. 3rd (Third) Floor	**35 Days**	**Mon 23/08/21**	**Sun 26/09/21**		
Column Work	21 Days	Mon 23/08/21	Sun 12/09/21	37 Days	30ss-7 Days
Beam Work	21 Days	Mon 23/08/21	Sun 12/09/21	37 Days	32ss
3rd Lt Plate Work	21 Days	Mon 30/08/21	Sun 19/09/21	37 Days	33ss+7 Days
Roof Ramp Work	21 Days	Mon 06/09/21	Sun 26/09/21	37 Days	34ss+7 Days
Pek Stairs	7 Days	Mon 13/09/21	Sun 19/09/21	37 Days	35ss+7 Days
D. 4th Floor (Four)	**21 Days**	**Mon 06/09/21**	**Sun 26/09/21**		
Column Work	14 Days	Mon 06/09/21	Sun 19/09/21	37 Days	36ff
Beam Work	14 Days	Mon 13/09/21	Sun 26/09/21	37 Days	38ss+7 Days
4th Lt Plate Work	7 Days	Mon 20/09/21	Sun 26/09/21	37 Days	39ss+7 Days

Source: Research Results

Based on the table above, there is a critical trajectory where the critical trajectory is the one that has a total value of slack = 0. The following is an explanation of the results of the calculation of the total float above:

a. Critical Path is, a path that has total slack = 0 i.e. , B – D – E – F – G – H – J – K – M – N – O – P – Q – R – S – T – U – V ;
b. The normal time of completion on the work of the structure is 81 days;

After a critical trajectory is found, and the normal time of completion of the structural work, the next step is to calculate the acceleration of the duration of the work by adding overtime working hours.

Accelerating Project Duration
Duration of Work With Additional Overtime Working Hours, For the calculation of the duration of accelerated time is carried out by assuming the amount of duration according to the circumstances in the field. This type of accelerated activity in the Probolinggo City Hospital Development Project is work that is on a critical track.

Analysis of The Acceleration of Time and Cost of Implementing
Building Construction Projects Using The Critical Path Method
(CPM) Method

Vol. 4, No. 2, 2023

Table 4 List of Calculations for Adding Overtime Working Hours

Activity Name	Normal Time	Time Accelerated	Time After Accelerated	Additional Overtime (Hours)	Total Overtime Fee Per Day (Rp)
Sirtu	12	4	8	4,000	IDR 260,000.00
Working Floor Under Foundation and Floor t.10 cm	21	7	14	4	IDR 377,500.00
Urugan soil back excavated	14	4	10	3,2	IDR 208,000.00
Stake Work	21	4	14	4	IDR 745,000.00
Pile Cap Foundation Work	21	7	14	4	IDR 745,000.00
Sloop Foundation Work	35	12	23	4,1739	IDR 576,521.74
Basic Lt. Plate Work	35	10	25	3,2	IDR 589,000.00
Ramp Jobs	28	10	25	3,2	IDR 421,000.00
Stair Work	28	10	18	4,4444	IDR 536,111.11
Column Work Lt.1	21	6	15	3,2	IDR 491,000.00
Beam Works 1st Floor	21	7	14	4	IDR 613,750.00
Plate Works Lt.1	21	7	14	4	IDR 648,750.00
Ramp Works 1st Floor	21	7	14	4	IDR 491,250.00
Staircase Works 1st Floor	14	5	9	4,4444	IDR 545,833.33
Column Work Lt.2	21	7	14	4	IDR 613,750.00
Block Works 2nd Floor	28	10	18	4,4444	IDR 681,944.44
Plate Works Lt.2	21	7	14	4	IDR 648,750.00
Ramp Works 2nd Floor	21	7	14	4	IDR 465,000.00

Source: Research Results

The next step is to calculate the cost due to the addition of overtime working hours. In the initial planning, the duration for structural work was 81 days with details of structural costs of Rp. 28,563,131,560.06

Table 5 List of Cost Calculations Due to Additional Overtime Working Hours

Activity Name	Time Accelerated	Total Overtime Fee Per Day (Rp)	Total Cost After Expedited
Sirtu	4	IDR 260,000.00	IDR 1,040,000.00
Working Floor Under Foundation and Floor t.10 cm	7	IDR 377,500.00	IDR 2,642,500.00
Urugan soil back excavated	4	IDR 208,000.00	IDR 832,000.00
Stake Work	4	IDR 745,000.00	IDR 2,980,000.00
Pile Cap Foundation Work	7	IDR 745,000.00	IDR 5,215,000.00
Sloop Foundation Work	12	IDR 576,521.74	IDR 6,918,260.87
Basic Lt. Plate Work	10	IDR 589,000.00	IDR 5,890,000.00
Ramp Jobs	10	IDR 421,000.00	IDR 4,210,000.00
Stair Work	10	IDR 536,111.11	IDR 5,361,111.11
Column Work Lt.1	6	IDR 491,000.00	IDR 2,946,000.00
Beam Works 1st Floor	7	IDR 613,750.00	IDR 4,296,250.00
Plate Works Lt.1	7	IDR 648,750.00	IDR 4,541,250.00
Ramp Works 1st Floor	7	IDR 491,250.00	IDR 3,438,750.00
Staircase Works 1st Floor	5	IDR 545,833.33	IDR 2,729,166.67
Column Work Lt.2	7	IDR 613,750.00	IDR 4,296,250.00
Block Works 2nd Floor	10	IDR 681,944.44	IDR 6,819,444.44
Plate Works Lt.2	7	IDR 648,750.00	IDR 4,541,250.00
Ramp Works 2nd Floor	7	IDR 465,000.00	IDR 3,255,000.00
		Total	**IDR 71,952,233.09**

Source: Research Results

The total additional costs due to the acceleration of work on the critical path to structural work amounted to Rp 71,952,233.09 + Rp 28,563,131,560.06 = Rp 28,635,083.773.15.
Then the time efficiency obtained by using the *Critical Path Method* (CPM), is:
81 – 74 = 7 days, or $\frac{81-74}{74}$ x 100% = **9, 45** %

CONCLUSION

There are 18 critical work units obtained from the results of the analysis using Microsoft Project 2016.

The results of the cost analysis after accelerating the duration of critical activities obtained the total duration of structural work for 74 working days with the total cost on

Analysis of The Acceleration of Time and Cost of Implementing Building Construction Projects Using The Critical Path Method (CPM) Method

Vol. 4, No. 2, 2023

structural work of Rp. 28,635,083.7 7 3.15 and the time efficiency obtained 81 - 74 = 7 days, or 9,46%.

REFERENCES

Alfianti Erika. (2019). Optimization of Time and Cost in the Inpatient Building Construction Project of the Wonoayu Sidoarjo Health Center Using the CPM (Critical Path Method) Method. Surabaya. *Faculty of Engineering, Bhayangkara University*

Aulia M. Zikril. (2021). Application of the CPM (Critical Path Methid) Method in the Lau-Simeme Dam Construction Construction Project Package II District, Deli Serdang. North Sumatra. Faculty of Engineering, *University of Muhammadiyah North Sumatra.*

Azizah Nurul. (2017). Rescheduling of a 2-Storey Office Building Construction Project Using CPM and PERT Methods at PT. Sources of Successful Ventures. Jakarta. Faculty of Engineering, *Mercubuana University Jakarta.*

Dahlan Ahmad. Evaluation of Time and Cost Control Using Critical Path Method (CPM) and fast Track Method. Hapless. *ITN Malang.*

Ekanugraha. (2016). Evaluation of Project Implementation Using CPM and PERT Methods (Case Study of Construction of Binung Baru Terminal in Binung District). Yogyakarta. *Islamic University of Indonesia.*

Febriyanto. (2011). Analysis of CPM and PERT System as Project Efficiency Improvements (CV Case Study. XYZ). Buoyant. *Muhammadiyah Metro Lampung University.*

Hardianto the Great, (2015). Analysis of Time Management Control and Cost of Hotel Construction Projects with CPM Network (Case Study: Batiqa Hotel Palembang). Surakarta. *Muhammadiyah University of Surakarta.*

Kodijah Nyimas Syarifah, Sugandi Yahdin, and Novi Rustiana Dewi. (2013). Optimization of the Implementation of the Electric Signaling Construction Project at Kertapati Station with the Application of the Crash Program Method. Journal of Science Research, *Sriwijaya University, South Sumatra.*

Ndraha Bajisokhi. (2015). User of CPM Method (CRITICAL PATH METHOD) on the Barus Road Improvement project – Sibolga City Limits. Terrain. *Medan Area University.*

Oetomo Wateno. (2014). Protection and Construction Management of Contemporary Organizations (Part One). Jakarta. *PT. Mediatama Saptakarya.*

Prianto, C. 2008. TA Project Management of Office Building Construction Based on Critical Path Method Determination. Jakarta. *Mercubuana University.*

Prayogi Alan Ambassador. (2015). Acceleration of Scheduling and Time in Building Buildings Using the Critical Path Method (CPM) and the Evaluation Review Technique (PERT) program. Malang. *Faculty of Civil Engineering & Planning National Institute of Technology Malang.*

Rahayu, Mulyani & Arpan. (2016). Time Acceleration Analysis With Fast Track Method on Construction Project Case Study of Ibis Pontianak Hotel Construction Project. *Pontianak, Tanjungpura University Pontianak.*

Santosa. (2008), Project Management : Concept and Implementation. *Yogyakarta. Graha Science.*

Tardok Eigar Lamgok. (2018). Time Acceleration Analysis Using CPM and PERT

Methods in the Tanjung Priok Port Pier Construction Project. Surabaya. *Sepuluh Nopember Institute of Technology Surabaya.*