Optimization of construction project implementation time using critical path method (CPM) case study of national brain center hospital construction project

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Abstract

This study examines the application of the Critical Path Method (CPM) to optimize the project schedule of the National Brain Center Hospital construction in Jakarta. The project, designed to expand the hospital's medical, educational, and research facilities, encountered significant delays caused by ineffective scheduling, weak control mechanisms, and external challenges. The main objective of this research is to identify the causes of delays and demonstrate how CPM can be effectively used to improve project scheduling and time performance. Data were collected through field observations, stakeholder interviews, and analysis of project documentation, including work breakdown structures (WBS) and progress reports. Using QM for Windows, the CPM model was developed to identify activity relationships, determine the critical path, and calculate total project duration. The analysis revealed that the actual critical path duration was 504 days, exceeding the planned schedule. Several non-critical activities were found to have large float times, indicating inefficiencies in task sequencing and resource allocation. The results highlight CPM's effectiveness in providing a systematic and quantitative approach to project scheduling. By identifying critical activities and optimizing time allocation, CPM enables project managers to implement corrective actions such as crashing and fast-tracking to reduce delays. This study concludes that applying CPM enhances project control, increases scheduling accuracy, and supports timely decision-making. Therefore, CPM is recommended as a strategic method for improving time management and ensuring successful completion of complex construction projects.

Keywords

Project management, Critical path method, Construction management, Time optimization, National brain center hospital

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Introduction

In the implementation of infrastructure projects, delays become a major challenge frequently encountered at both national and regional levels [1]. The impact of these delays not only leads to increased project costs but also results in decreased construction quality, disruptions to public services, and reduced trust from stakeholders toward project implementers [2]. Common factors contributing to delays include insufficiently developed scheduling management that fails to anticipate and control delays, resulting in an inability to prevent deviations from planned timelines; communication problems among owners, contractors, and field supervisors; weather conditions that can damage materials; as well as limitations in human resources and equipment [3]. These issues highlight the need for further research to identify the primary causes and effective mitigation strategies to address project delays in the construction sector, particularly in Indonesia.

To address delay issues in construction projects, many studies have applied the Critical Path Method (CPM) as a tool to optimize project scheduling [4]. CPM is used to identify the project's critical path, which determines its total duration, enabling project managers to recognize activities that must be prioritized and to take corrective actions such as crashing and fast-tracking to accelerate completion [5]. Various studies show that CPM can improve scheduling accuracy, strengthen time control, and support timely decision-making to reduce delays.

However, previous studies have given limited attention to the efficiency of non-critical activity sequences that have large floats, which can potentially lead to wasted time and resources [6]. In addition, few studies have thoroughly evaluated how schedule optimization can enhance overall project control and support fast and accurate decision-making. The application of CPM in this study focuses not only on identifying the critical path but also on optimizing the sequence of non-critical activities so that resources can be allocated more efficiently and project duration can be minimized without significantly increasing costs. This analysis aims to optimize construction project schedules through the systematic application of CPM, thereby reducing project duration, improving the accuracy of planning and time control, and assisting project managers in making effective decisions to ensure timely project completion.

Method

The Critical Path Method (CPM) was applied in this study to identify the critical path that determines the overall project duration of the National Brain Center Hospital construction. The analysis began with the collection of project activity data, including work items, activity durations, and precedence relationships, which were structured into a Work Breakdown Structure (WBS). These data were then entered into the QM for Windows software and analyzed using an Activity-on-Node (AON) network diagram. The CPM calculations generated the earliest start (ES), earliest finish (EF), latest start (LS), latest finish (LF), and slack values for each activity, enabling the identification of critical activities with zero slack. Based on this analysis, the total project duration and the critical path were determined, and a Gantt chart was produced as a supporting visualization tool for schedule monitoring and control. The application of CPM in this study provides a deterministic framework for schedule analysis, supporting project managers in setting work priorities, monitoring critical activities, and identifying potential opportunities for schedule improvement through better sequencing and resource allocation.

Results

CPM is a deterministic project scheduling technique, first developed by DuPont Corporation in the late 1950s to manage chemical plant maintenance projects. This method aims to identify the critical path that determines the shortest duration of project completion. According to the 7th edition of the PMBOK Guide [7], the implementation of CPM involves several key stages: (1) identification of all project activities through the Work Breakdown Structure (WBS), (2) determination of dependencies between activities, (3) estimation of the duration of each activity, and (4) analysis of the project network using Activity-on-Node (AON) diagrams to calculate the earliest start/latest finish and identify critical activities. Table 1 shows work activity data on the National Brain Center Hospital construction in Jakarta. The data was obtained through analysis of project data provided directly by the project leader.

Work breakdown structure (WBS)

The following is the work activity data on National Brain Center Hospital construction in Jakarta including activity symbols, time and predecessors, including:

Table 1. Work Breakdown Structure

No.	Activity Type	Symbol	Time (days)	Predecessors
1	Project Management & Milestone	A	77	
2	Planning	B	39	A
3	Preparation Work	C	30	B
4	Substructure Work	D	29	C
5	Superstructure Work	E	17	D
6	Canopy Steel Work	F	27	E
7	Architecture and Interior Work	G	39	F
8	Facade Work	H	33	G
9	MEP Work	I	32	H
10	Substructure Work	J	29	C
11	Superstructure and Floor hardener Work	K	17	J
12	Architecture and Interior Work	L	39	K
13	Facade Work	M	33	L
14	MEP Work	N	32	M
15	Substructure Work	O	29	C
16	Superstructure Work	P	17	O
17	Architecture and Interior Work	Q	39	P
18	Facade Work	R	33	Q
19	MEP Work	S	32	R
20	Substructure Work	T	29	C
21	Superstructure Work	U	17	T
22	Architecture and Interior Work	V	39	U
23	Facade Work	W	33	V
24	MEP Work	X	32	W
25	Substructure Work	Y	29	C

No.	Activity Type	Symbol	Time (days)	Predecessors
26	Superstructure Work	Z	17	Y
27	Architecture Work	AA	39	Z
28	Test Commissioning	AB	8	I, N, S, X, AA
29	General Cleaning	AC	7	AB
30	Tunnel Work	AD	38	AC
31	Bridge Work	AE	29	AC
32	Infrastructure and Landscape Work	AF	37	AD, AE
33	PLN Electricity Connection	AG	16	AF
34	Existing MEP Relocation Work	AH	40	AG
35	General Test Commissioning	AI	7	AH
36	General Cleaning	AJ	1	AI
37	Defect List	37	27	AJ
38	Bast 1	38	1	AK

The data contained in the Work Breakdown Structure is then visualized in the form of a Critical Path or Network Planning diagram to identify the dependency relationships among the activities within the project. Based on Figure 1, the dependency relationships among the project activities can be clearly observed. For example, activity B cannot begin until activity A has been completed. However, there are also activities that can be carried out simultaneously, such as activity 4 in four different building classifications, which is illustrated through the use of dummy arrows.

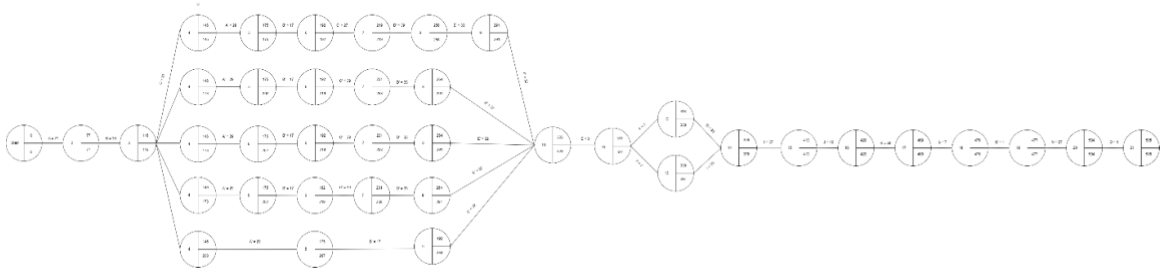

Figure 1. Network diagram

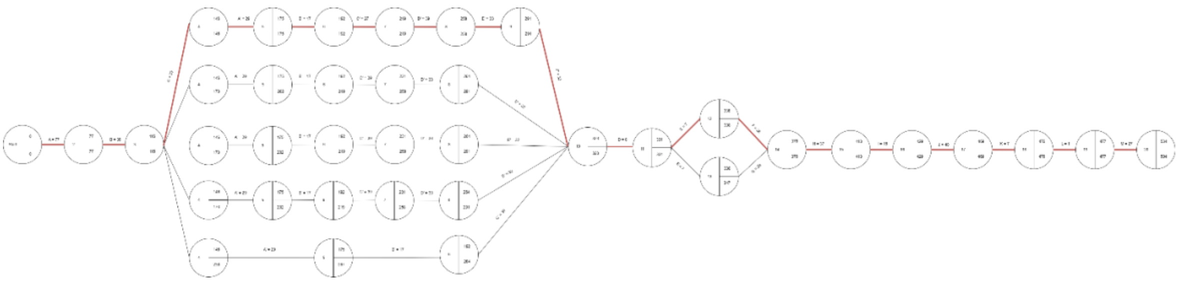

Figure 2. Critical path diagram

Using the network diagram and the Critical Path Method (CPM) with normal time, the critical activities shown in Figure 2, were identified along the path A, B, C, D, E, F, G, H, I, AA, AC, AD, AF, AG, AH, AI, AJ, and AK. After determining which activities fall on the critical events, the next step is to establish the critical path using CPM. This involves forward pass calculations, backward pass calculations, and determining total slack, as presented in Table 2.

The results of the data analysis are as follows. First, based on the CPM calculation, the total project duration is 504 days, with the critical path consisting of activities A, B, C, D, E, F, G, H, I, AA, AC, AD, AF, AG, AH, AI, AJ, and AK. Second, the probability of completing the project, based on the time management results from the CPM method, shows that the company's target duration is 534 days. Meanwhile, the expected completion time obtained from the critical path calculation is 504 days.

Table 2. Calculation of slack values and critical path

No	Activity Type	Symbol	Predecessor	Duration (day)	Advanced Calculations		Countdown		Slack	Information
					ES	EF	LS	LF		
1	Project Management & Milestone	A		77	0	77	0	77	0	Critical
2	Planning	B	A	39	77	116	77	116	0	Critical
3	Preparation Work	C	B	30	116	146	116	146	0	Critical
4	Substructure Work	D	C	29	146	175	146	175	0	Critical
5	Superstructure Work	E	D	17	175	192	175	192	0	Critical
6	Canopy Steel Work	F	E	27	192	219	192	219	0	Critical
7	Architecture and Interior Work	G	F	39	219	258	219	258	0	Critical
8	Facade Work	H	G	33	258	291	258	291	0	Critical
9	MEP Work	I	H	32	291	323	291	323	0	Critical
10	Substructure Work	J	C	29	146	175	173	202	27,17	Non Critical
11	Superstructure and floor hardener Work	K	J	17	175	192	202	219	27,17	Non Critical
12	Architecture and Interior Work	L	K	39	192	231	219	258	27.17	Non Critical
13	Facade Work	M	L	33	231	264	258	291	27.17	Non Critical
14	MEP Work	N	M	32	264	296	291	323	27.17	Non Critical
15	Substructure Work	O	C	29	146	175	173	202	27.17	Non Critical
16	Superstructure Work	P	O	17	175	192	202	219	27.17	Non Critical
17	Architecture and Interior Work	Q	P	39	192	231	219	258	27.17	Non Critical
18	Facade Work	R	Q	33	231	264	258	291	27.17	Non Critical
19	MEP Work	S	R	32	264	296	291	323	27.17	Non Critical
20	Substructure Work	T	C	29	146	175	173	202	27.17	Non Critical
21	Superstructure Work	U	T	17	175	192	202	219	27.17	Non Critical
22	Architecture and Interior Work	V	U	39	192	231	219	258	27.17	Non Critical
23	Facade Work	W	V	33	231	264	258	291	27.17	Non Critical
24	MEP Work	X	W	32	264	296	291	323	27.17	Non Critical
25	Substructure Work	Y	C	29	146	175	238	267	92.33	Non Critical
26	Superstructure Work	Z	Y	17	175	192	267	284	92.33	Non Critical
27	Architecture Work	AA	Z	39	192	231	284	323	92.33	Non Critical
28	Test commissioning	AB	I, N, S, X, AA	8	323	331	323	331	0	Critical
29	General Cleaning	AC	AB	7	331	338	331	338	0	Critical

No	Activity Type	Symbol	Predecessor	Duration (day)	Advanced Calculations		Countdown		Slack	Information
					ES	EF	LS	LF		
30	Tunnel Work	AD	AC	38	338	376	338	376	0	Critical
31	Bridge Work	AE	AC	29	338	367	347	376	8.83	Critical
32	Infrastructure and Landscape Work	AF	AD, AE	37	376	413	376	413	0	Critical
33	PLN Electricity Connection	AG	AF	16	413	429	413	429	0	Critical
34	Existing MEP Relocation Work	AH	AG	40	429	469	429	469	0	Critical
35	General Test Commissioning	AI	AH	7	469	476	469	476	0	Critical
36	General Cleaning	AJ	AI	1	476	477	476	477	0	Critical
37	Defect List	AK	AJ	27	477	504	477	504	0	Critical
38	Bast 1	AL	AK	1	504	505	504	505	0	Critical

Discussion

In this study, the Critical Path Method (CPM) was applied to estimate the duration of the National Brain Center Hospital construction project, resulting in a total completion time of 504 days. The analysis identified a critical path consisting of activities with zero slack, indicating that delays in these activities would directly extend the overall project duration. This result confirms the role of critical activities as key points of schedule control rather than as a direct solution for schedule optimization.

The CPM-based duration estimate suggests that the existing project schedule should be reviewed to improve its consistency with field conditions. By clearly identifying critical and non-critical activities, the analysis provides structured information that can support more focused supervision and more systematic resource allocation. However, the study does not perform further schedule optimization techniques, such as crashing or fast-tracking, and therefore does not quantify potential reductions in project duration or evaluate time–cost trade-offs.

The findings demonstrate that CPM is effective as a deterministic scheduling and diagnostic tool, offering a clear representation of activity interdependencies and priority sequences. Nevertheless, the results should be interpreted as a baseline for future analysis. Further studies could extend this work by incorporating optimization strategies and examining how the float of non-critical activities may be utilized operationally to improve flexibility without increasing project risk.

Conclusion

By obtaining the results of calculations, the CPM calculation obtained a project completion time of 504 days with the critical path being A, B, C, D, E, F, G, H, I, AA, AC, AD, AF, AG, AH, AI, AJ and AK. The data analysis results show that the Critical Path Method (CPM) estimates the construction project completion time to be 504 days. This analysis also takes into account the deadline set by the company, which is 534 days. This suggests that the schedule produced by CPM is reasonably realistic and provides a clear picture of the likelihood of successfully completing the project within the targeted timeframe. Therefore, CPM serves as an effective tool to assist project management in planning and controlling the execution duration to ensure it remains aligned with the project schedule.

References

[1] T.S. Soeparyanto, R. Nuhun, A. Annisa, Y. Yusran, H. Ariatno, and L. O. M. Zulfitrah, "Analysis Of Project Scheduling Using The CPM Method (Case Study of Prayer Room Construction in PT.X Empalecement Complex)," *J. Civ. Eng. Plan.*, vol. 5, no. 1, pp. 16-24, 2024.

[2] T. H. H. &. N. Y. P. Mursyid, "Analisis Manajemen Proyek pada Proyek Instalasi Pipa dengan Metode CPM di PT. Cahya Mandiri Gemilang," *Jurnal INTECOM: Jurnal Penelitian Multidisiplin Ilmu Komputer, Manajemen dan Sosial,* vol. 8, no. 5, 2025.

[3] D. Lock, Project Management, United Kingdom: Routledge, 2023.

[4] L. O. et.al., Manajemen Proyek Konstruksi, Makassar: CV. Tohar Media, 2023.

[5] A. A., "Analisis Penjadwalan Proyek New Product Development menggunakan Metode PERT dan CPM," Jurnal Ilmiah Teknik Industri, vol. 6, no. 1, pp. 63-70, 2019.

[6] R. M. M. A. &. W. M. Rabbani, "Penerapan Manajemen Proyek dengan Metode CPM dan PERT pada Proyek Pembangunan Perumahan Permata Nusa Indah," *Jurnal Ilmu Teknik Sipil Surya Beton,* vol. 5, no. 1, pp. 37-45, 2024.

[7] PMI, A Guide to the Project Management Body of Knowledge, Project Management Institute, 2021.