



Analysis of time efficiency in the implementation of a 2-story shophouse construction project on Jl. Pasundan Samarinda using the CPM (Critical Path Method)

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ABSTRACT

Delays in project execution are one of the main challenges that can significantly affect the cost and quality of the work results. This study aims to evaluate the time efficiency of the construction project of a two-story shop house on Jl. Pasundan, Samarinda by applying the Critical Path Method (CPM). This method is used to identify the critical path of the project, which is a series of activities that determine the shortest completion time of the project and have no time slack (float). This study applies a quantitative descriptive approach through case study methods, relying on primary data from interviews and field observations as well as secondary data in the form of project documents. The analysis shows that the project has a critical path in the order of activities $A \rightarrow B \rightarrow C \rightarrow D \rightarrow E \rightarrow F \rightarrow G \rightarrow H \rightarrow L \rightarrow M \rightarrow N \rightarrow O \rightarrow P \rightarrow Q$, with a total working time of 108 days. Each activity on the critical path has a total float of zero, indicating that delays in these activities will directly affect the entire project schedule. The use of the CPM method in this project has proven successful in providing a comprehensive picture of time control and can serve as a basis for decision-making in medium-sized construction project management.

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INTRODUCTION

Delays in construction project implementation remain a recurring issue, including in various regions in Indonesia, such as the city of Samarinda. This problem not only causes technical impacts but also affects financial and operational aspects, especially for project owners. Such projects should be completed within a specified timeframe to be used promptly by entrepreneurs. However, in reality, many similar projects experience deviations from the schedule due to a lack of effective time planning from the outset. This is where project management plays a crucial role. According to Suprihanto, (2014) It states that management is a function related to achieving specific results through others. In this sense, the process of decision-making is already apparent; among other things, the manager must determine specific goals or objectives to be achieved, then

decide on the parties, time, and method to carry out the work to achieve the set objectives. A project is a combination of resources such as people, materials, equipment, and capital/costs gathered in a temporary organizational structure to achieve goals and objectives. Project Management is the application of knowledge, expertise, and skills, the best technical ways, and limited resources to achieve predetermined goals and objectives in order to obtain optimal results in terms of cost, quality, time, and work safety (Husen, 2009).

One of the main challenges in the implementation of construction projects is the delay in completion time, which can lead to increased costs and dissatisfaction among project owners. Delays in construction projects are a major cause of inflated costs and decreased quality of work, which can ultimately harm all parties involved. Therefore, proper planning and time management are necessary to improve the efficiency of project execution. Managing time in a project is very important; it can even be said to be one of the key factors for the success of a project. If time is not managed well, project costs can balloon, and the quality of the construction may also decline. Given the high demand for business space and the market's demands to complete projects quickly and on time, time control becomes increasingly important.

Therefore, a method is needed that can clearly illustrate the sequence of project activities along with the estimated time required to complete them. One widely adopted approach in project time planning is the Critical Path Method (CPM). According to Astari dkk., (2022). CPM is a method that details each activity in a project, including its predecessor activities, normal duration, and estimated costs. This information serves as the foundation for constructing a project network diagram. Astari dkk. (2022), also emphasize that CPM provides a breakdown of each activity, its dependencies, duration, and associated costs – data that are essential for creating a work schedule. According to Asba, & Altarans, (2024). CPM is considered the most commonly used system among various network-based scheduling methods.

The critical path is a vital aspect of CPM, as it includes tasks that, if delayed, can halt the entire project Sholahuddin & Octavia, (2024). CPM helps identify this critical path, which consists of the longest sequence of dependent tasks that determines the minimum project completion time. Understanding this path allows project managers to concentrate on key activities that significantly impact the overall timeline Husna dkk., (2022). Additionally, CPM enables the identification of project duration and highlights critical tasks. Pratama & Kartini, (2020) point out that construction projects often face constraints such as limited budget, defined scope, and fixed timelines, all of which must be managed to ensure efficiency and effectiveness. CPM works on the principle of network scheduling, assuming that the duration of each phase is already known, allowing for an accurate estimation of total project completion time.

As such, companies should establish clear goals or contracts that outline project schedules from the beginning until completion. Work scheduling must therefore be carried out carefully, taking into account various potential risks, which are often illustrated using Gantt Charts. However, even with Gantt Charts, unexpected issues may arise. For this reason, a scheduling method like CPM is essential for aligning project workflows, clearly showing the flow of activities, and determining task priorities. By applying CPM, the scheduled time can be optimized, as the method is relatively simple and allows for the identification of tasks that can be expedited (*crashed*) as well as a better understanding of the project's critical path Widianita, (2023).

This CPM is used to analyze the progress of projects or activities during the project to predict the total duration of the work. CPM is essentially a time-oriented method, in the sense that CPM will end with the determination of the execution time. This method identifies the critical path of activities by determining the dependencies between activities, so that the project can be completed on time (Rika Widianita, 2023).

The purpose of this research is to analyze time efficiency in the implementation of a two-story retail building project located on Jl. Pasundan, Samarinda, using the CPM method. This research aims to identify the critical path of the project activity sequence to determine the

minimum duration for the overall project completion. Furthermore, this research will also evaluate potential delays and examine activities that have float or time slack, so that project management can make more informed decisions and allocate resources more effectively. By systematically applying the CPM method, this study is expected to provide an accurate representation of project time planning and control, as well as produce practical recommendations that can be implemented by construction industry practitioners to improve efficiency and effectiveness in time management, especially in medium-scale construction projects such as the development of shop houses.

RESEARCH METHOD

This research is a quantitative descriptive study aimed at describing and analyzing the time efficiency of the construction project of a two-story shop on Jl. Pasundan, Samarinda using the CPM method. A quantitative approach is used because this study utilizes project activity execution time data for numerical analysis. The research method applied in this study is the case study method. Case studies are understood as a scientific research approach that is conducted intensively, in depth, and systematically on a subject of study, whether it be a program, event, or activity at the individual, group, institution, or organization level (Rahardjo, 2022). The goal of this approach is to gain a comprehensive understanding of the context and dynamics of the phenomenon being researched, thus allowing the researcher to uncover in-depth aspects that may not be accessible through other methods (Yin, 2018). Case studies are an empirical approach in research aimed at thoroughly examining a current phenomenon in the context of real life. This method becomes particularly relevant when the dividing line between the phenomenon being studied and its environmental context is not clearly visible, thus requiring a holistic and contextual analysis to understand the interrelations among elements within it. The type of research used by the author in this study employs quantitative descriptive methods. Qualitative research is a structured investigation of a particular phenomenon by collecting measurable data using statistical, mathematical, or computational methods (Priadana & Sunarsi, 2021).

The research location is on a project for the construction of a two-story shop located on Pasundan Street, Samarinda. This project was chosen because it represents a type of medium-scale construction project commonly found in developing urban areas, yet it has not been extensively studied scientifically. Every project requires scheduling during the planning stage, and briefly, scheduling in construction is a method for determining and setting the execution time. The time schedule or Project Schedule is prepared by the project manager to organize the team members in the project and to inform the organization about how the project will be executed. Every project requires a Time Schedule, and this serves as a tool for the project manager or site manager to check whether the project and team are progressing as planned or not. In construction projects, there are various types of scheduling instrument models that are typically used for projects of various sizes, both small and large, whether in formal or informal contexts (Sulistia & Agustina, 2023). This research uses two types of data, namely primary and secondary data. Primary data is collected through direct interviews with project implementers and field observations. Meanwhile, secondary data is obtained from project documents such as the time schedule, project activity list, and progress reports. The data analysis process begins by identifying all activities in the project, including the duration of each activity and the dependency relationships between those activities. Based on the analysis using the Critical Path Method (CPM) to calculate the earliest and latest start and finish times for each activity, including calculating the float values. In a project that is desired to be completed within a specified timeframe, the duration of activities can be accelerated at the cost of increased expenses. To accelerate the project completion time, acceleration of the duration of activities on critical paths is carried out, on the condition that the reduction in time does not create new critical paths. One way to speed up the implementation time is by adding the desired hours. With the addition of working hours (Aggraini & Kartini, 2021). The results of this analysis

aim to assess the extent to which the project implementation time runs efficiently, by comparing the actual field performance with the estimates based on CPM calculations. In addition, this analysis will also reveal which activities caused delays. The findings are expected to provide insights into the effectiveness of applying the CPM method in managing the time of medium-scale construction projects and serve as a reference for more optimal time planning in the future.

RESULTS AND DISCUSSIONS

The implementation of the 2-story project lasted for 108 days involving five workers. All material provision including sand, stone, cement, and wood was fully managed by the project owner before the construction started. A work breakdown structure is a method of organizing a project into hierarchical reporting.

The work breakdown structure is typically used to break down each task into more detailed tasks based on project documents, including contracts, drawings, and project specifications, then adjusted according to the sequence of activities.(Astari dkk., 2022b). Data on the Project Development Activity Plan is obtained based on data and the results of interviews with the parties executing the development project of the 2-story shop (Perdana & Sari, 2022). The details of the activities are as shown in Table 1 below.

Table 1 Order of Project Work Activities

No	Job Code	Code	Preliminary Work	Duration (Days)
1	Preparation	A	-	6
2	EarthworkFoundation Structure	B	A	3
3	Work and Slope WorkColumn	C	B	4
4	Structure WorkColumn	D	C	3
5	Structure WorkGround Floor	E	FG	3
6	Slab WorkRooftop Casting	F	H	4
7	Rooftop Casting	G	H	4
8	Wall & Floor Installation	H	FG	25
9	Installation of Rolling	I	H	2
10	Installation of Ceramics & Natural StoneInstallation	J	H	17
11	Installation of Window	K	H	15
12	Ceiling Work	L	KM	14
13	Painting Work	M	H	25
14	Sanitary Work	N	L	6
15	Installation of Sanitary Accessories	O	N	2
16	Electrical Work	P	H	8
17	Installation of Electrical Accessories	Q	P	5

Critical Path Method (CPM) Completion

The result of network calculations using CPM is a timeline for project schedule development. This timeline can be easily converted into a calendar schedule that can be easily used in project implementation.(Arifudin, 2012). Table 2 presents data on Earlier Start (ES), Earlier Finish (EF), Latest Start (LS), Latest Finish (LF), and the slack time for all activities.

Table 2 CPM Calculation

No	Job	Duration	ES	EF	LS	LF
1	Preparation	6	0	6	0	6
2	EarthworkFoundation	3	6	9	6	9
3	Work and Slope WorkColumn	4	9	13	9	13
4	Structure WorkColumn	3	13	16	13	16
5	Structure WorkGround Floor	3	16	19	16	19
6	Slab WorkRoof Casting	4	19	23	19	23
7	Roof Casting	4	19	23	19	23
8	Wall & Floor Installation	25	23	48	23	48
9	Installation of Rolling	2	48	50	71	73
10	Installation of Ceramics & Natural StoneInstallation	17	48	65	26	73
11	Installation of Window	15	48	63	58	73
12	Ceiling Work	14	73	87	73	87
13	Painting Work	25	48	73	48	73
14	Sanitary Work	6	87	93	87	93
15	Installation of Sanitary Accessories	2	93	95	93	95
16	Electrical Work	8	48	56	65	73
17	Installation of Electrical Accessories	5	103	108	103	108

Table 2 shows the results of the critical path calculations that include the elements of ES, EF, LS, and LF, which are directly related to the acceleration or delay in completing an activity. The next step is to create a network diagram for the 2-story shophouse construction project based on the list of activities that have been previously established. This process begins with organizing the activity network and entering the duration for each job. The next step is to create a project network diagram for the residential house construction based on the known work activities. It starts with creating the work network and entering the duration values for the activities. The network diagram for each construction phase is then depicted as shown in Figure 1.

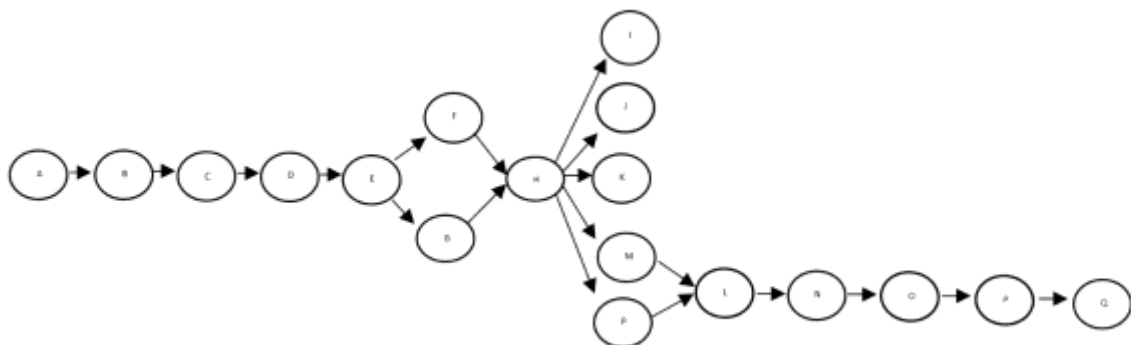


Figure 1 Work Network Diagram

After designing and understanding the work network structure, the next stage is to compile a work network diagram by calculating the critical path. This step is carried out through a forward pass calculation to obtain the earliest start time (ES) and the earliest finish time (EF). Subsequently, a backward pass calculation is performed to determine the latest start time (LS) and

the latest finish time (LF). The results of all these calculations can be further analyzed to determine the critical path and to identify slack in each activity. The details of these calculation results can be seen in the table 2

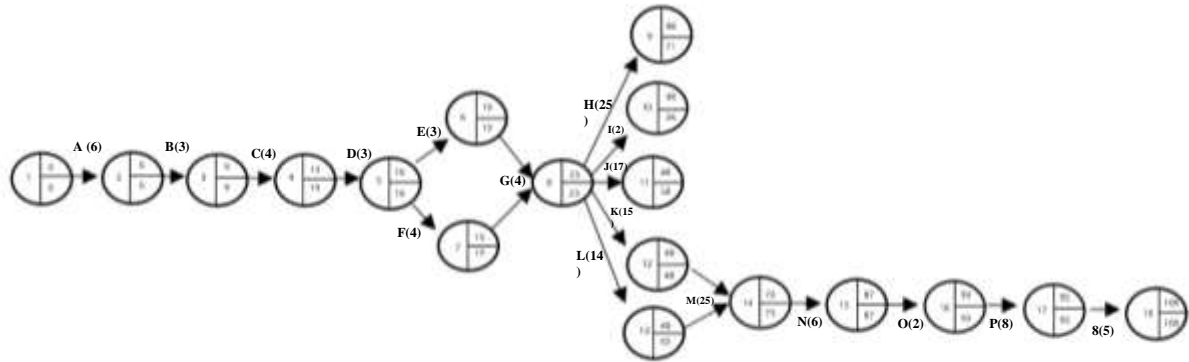


Figure 2 Forward and Backward Calculation Networks

After determining the critical path and obtaining the results of the forward and backward calculations, the next step is to calculate the total float using the following formula:

$$\text{Total Float} = \text{LF} - \text{EF} \text{ or } \text{LS} - \text{ES}.$$

Here are the total float calculations for each activity:

$$\text{TF(A)} = 6 - 6 = 0 \text{ (kritis)}$$

$$\text{TF(B)} = 9 - 9 = 0 \text{ (kritis)}$$

$$\text{TF(C)} = 13 - 13 = 0 \text{ (kritis)}$$

$$\text{TF(D)} = 16 - 16 = 0 \text{ (kritis)}$$

$$\text{TF(E)} = 19 - 19 = 0 \text{ (kritis)}$$

$$\text{TF(F)} = 19 - 19 = 0 \text{ (kritis)}$$

$$\text{TF(G)} = 23 - 23 = 0 \text{ (kritis)}$$

$$\text{TF(H)} = 71 - 48 = 0 \text{ (kritis)}$$

$$\text{TF(I)} = 26 - 48 = 0 \text{ (Tidak kritis)}$$

$$\text{TF(J)} = 58 - 48 = 0 \text{ (Tidak kritis)}$$

$$\text{TF(K)} = 48 - 48 = 0 \text{ (kritis)}$$

$$\text{TF(L)} = 65 - 48 = 0 \text{ (Tidak kritis)}$$

$$\text{TF(M)} = 73 - 73 = 0 \text{ (kritis)}$$

$$\text{TF(N)} = 87 - 87 = 0 \text{ (kritis)}$$

$$\text{TF(O)} = 93 - 93 = 0 \text{ (kritis)}$$

$$\text{TF(P)} = 95 - 95 = 0 \text{ (kritis)}$$

$$\text{TF(Q)} = 108 - 108 = 0 \text{ (kritis)}$$

The results of the forward and backward calculations that have been used to determine the total float are then organized to form a critical path network, which can be seen in the following image.

In this diagram, the critical path can be identified as the sequence of activities that has the longest duration and has no time slack (float). Based on visual analysis and activity data on the Gantt Chart, the identified critical path is: A → B → C → D → E → F → G → L → M → N → O → P → MQ.

The estimated completion time for the shop building project is calculated using the CPM (Critical Path Method) approach. To determine the minimum duration, the duration of each activity on the critical path is summed up. The calculation results indicate that the completion time for the shop building project requires approximately 108 days.

CONCLUSION

Based on the analysis results using the Critical Path Method (CPM) on the construction project of a two-story shop, it was found that the critical path consists of the sequence of activities: A → B → C → D → E → F → G → H → L → M → N → O → P → Q. These activities have a total float value of zero, which means any delay in these activities will directly affect the overall project completion delay. The calculation of the total duration of the critical path shows that this shop construction project requires a minimum completion time of 108 days. This result was obtained through forward pass and backward pass calculations, which then produced the earliest start time (ES), earliest finish time (EF), latest start time (LS), and latest finish time (LF) for each activity.

Thus, the implementation of CPM in this project provides very important information for schedule control and minimizing the risk of delays. This analysis can serve as a basis for project management decision-making to prioritize activities that are on the critical path in order to maintain the efficiency and effectiveness of the construction project of the two-story shop.

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