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Implementation of Critical Path Method (CPM) in Project Management of Type 45 House Construction in Samarinda

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Abstract

Project management is a very important area to ensure that projects are successful, especially in terms of achieving their goals on time, within budget, and to the set quality. With a focus on planning, organizing, executing, and controlling projects, this study aims to examine how project management principles are applied in the implementation of construction projects in Indonesia. The method used was descriptive qualitative, and data were collected through literature research and documentation. The results showed that the understanding and application of project management methods such as Critical Path Method and cost and time control approaches have a great impact on project efficiency and efficiency. Therefore, it is highly recommended to improve management skills as well as the use of information technology in project management to improve overall project performance.

Keywords: Construction project, Project Management, CPM Method.

Introduction

In every project implementation, there needs to be good project management of schedules. The merit of a project is determined by the efficiency with which it is completed in relation to the allotted time (Badrin, 1997). Therefore, the time factor becomes very important in completing a project. So, a way is needed so that the completion of the house structure can be done quickly, to meet the needs of the house must be fast and can be used immediately by the community (Fadila et al., 2024).

A project is a collection of activities that are focused on a main result. The project can be in the form of housing construction, buildings, facilities, and so on. Based on the statement above, a project is an activity that contains tasks that need to be completed within a certain

period of time and uses a budget and resources to achieve the goals that have been set (Perdana & Sari, 2022).

With good optimization and control, a project can certainly run according to the planned time target (Maarif et al., 2022). Harold Kerzner, quoted by Soeharto (1999) stated, looking at the management insight based on function and when combined with the system approach will be as follows: "Project management is planning, organizing, leading, and controlling company resources to achieve predetermined short-term goals. Furthermore, project management uses a system approach and hierarchy (activity flow) as well as horizontal" construction of production facilities (Sugiarta, 2022).

Project management is management that this term encompasses all aspects of project management, including planning, implementation, control, and coordination. It is a comprehensive process that ensures the timely and cost-effective execution of a project while maintaining the desired quality standards. In such circumstances, the complexity inherent in the management and execution of a construction project is known to escalate, so good management is needed to control a construction project, and the success of a construction project depends on its implementation (Mewengkang et al., 2023).

Project management is a method for addressing issues that emerge in the course of a project because project management is made in order to avoid, or in other words, minimize the failure or risk of a development project. One of the scheduling methods used in implementing a good project is by using the CPM method. CPM determines the range of an activity that can occur by calculating the fastest duration and the activity that is late (Fadila et al., 2024).

The CPM method, or critical path, is a model depicting a network of project activities (Chasan et al., 2022). CPM functions as a tool that produces project completion deadlines (Perdana & Sari, 2022). CPM or Critical Path Method is a project activity model that is depicted in the form of a network. The activities are represented by points on the network, and events that mark the beginning or end of an activity are represented by arcs or lines between points (Agus Marwan et al., 2024).

This study uses the CPM method for project scheduling (Surahman, Angga Kusumah, & Tomby, R. S., 2024). In CPM, there are cost and time estimates that include normal estimates and acceleration estimates. Critical activities are identified through the optimal path is characterized by its maximum total duration, enabling the most expeditious project completion. This study involves collecting detailed data, analyzing, and reconstructing project activities into a work network, by calculating forward, backward, and slack or total float. After that, the critical path is determined and represented in the form of a manually designed CPM network planning (Syahputra et al., 2024).

This study aims to analyze project management comprehensively through the CPM method. The main objective is to visualize the entire project workflow in the form of a clear Network Diagram. Furthermore, this study will determine the most efficient project implementation time duration based on CPM calculations. Identification of project activities that have slack or free time is also an important focus. Finally, this study aims to calculate the estimated total cost required to complete the entire project implementation.

Literature Review

A project is a set of planned actions completed in a given amount of time with a given distribution of resources in order to accomplish predefined objectives (Fazis, 2022). In addition, according to Husen, a project is a combination of resources such as humans, materials, equipment, and capital costs that are collected in a temporary organizational framework to achieve targets and goals (Rompis, 2019).

Project management is the discipline of overseeing an organization by designing activities that manage the use of limited resources in order to deliver effective and efficient projects, while always taking existing constraints into account (Pangestu, 2021). To simplify project management by leveraging online resources and holding regular meetings to track budgets and delegate tasks, prioritizing user-friendly tools should be a key focus at the outset of a new project (Prihandoko, 2022).

Planning in managing a project needs to consider all aspects such as budget costs, finance, resource management, production management, price, effectiveness, efficiency, marketing, quality, time and environment can be well organized so that the results of the project are in accordance with the targets and objectives planned by Siswanto (Mar'aini, 2022). The expected goal of project management is to manage management functions so that optimum results are obtained according to existing and established requirements and to manage resources efficiently and effectively (Chandra, 2023).

The function of project management conducted by Rodhi, (2024) consist of: (1) Leading and directing all resources in the project to achieve project goals; (2) Project obligations and responsibilities; (3) Ensuring the implementation of the project and the availability of supporting facilities in accordance with the established plan; (4) Ensuring the implementation of project handling activity administration based on the agreed provisions; (5) Ensuring the availability of materials, labor, and equipment in accordance with the schedule that has been made; and (6) Guaranteeing that controls are in place for costs, quality, and timelines, as well as maintaining workplace safety.

1). Critical Path Method (CPM)

CPM is based on the aspect that uses the equality between linear duration and budget. Each activity is completed earlier than the normal duration by skipping activities for a certain budget. Therefore, if the project completion duration is less than satisfactory, certain activities will be skipped in order to decide the project in a shorter duration. CPM can estimate the duration required to carry out project activities and can determine the priority of activities that must be supervised efficiently so that activities can be completed according to plan. This method is called the critical path, because this method will form a critical path network that must receive special supervision attention (Sa'adah, 2022).

The advantage of CPM lies in its ability to empirically schedule a project. This method facilitates effective and efficient project analysis, planning, and scheduling by highlighting the critical path and activities that have a direct impact on the overall project schedule. (Sinurat, 2024). The critical route technique, which refers to the order of network terminal pieces, is a

fundamental and crucial instrument in project management. Understanding each path made up of project activities and the vital path connecting them is the fundamental and crucial component of this approach. (Rembulan, 2023).

2). Activity Duration Time

The duration of an activity in network methods refers to the amount of time needed to complete a specific activity from its beginning to its end, usually measured in hours, days, or weeks. In the CPM (Critical Path Method), activity duration is calculated to estimate how long it will take to finish each task, typically by relying on a single, fixed time estimate. This approach is suitable when the duration of activities can be accurately predicted and does not vary significantly. The method employs a specific formula to determine the duration of each activity (Koilam, 2020):

$$D = \mathrm{V}/Pr.\,N$$

Description :

D = duration of activity (days)

V = volume of activity (m3, m2, kg)

Pr = average work productivity (m3/day)

N = number of workers and equipment (people)

3). Critical Path

Steps to determine the critical path using the CPM method (Daud, 2024): 1). Determine Each Activity, from the work breakdown structure, a list of the overall project work activities can be made. The list of work activities can be used to add information on the sequence and duration of work in the next step. 2). Determine the Sequence of Activities, each activity has a dependency on other activities. Making a list of dependencies between activities can help the author to create a CPM network diagram. 3). Create a Network Diagram, after the relationship between activities has been worked on, the next step is to create a Network Diagram. In this assignment, the author creates a CPM Network Diagram with activities on the arrow or Activity on Arrow. 4). Estimated Project Completion Time, in this final assignment, the author gets an estimate of the project completion time from the initial planning that was done. 5). Find the Critical route: The critical route is a set of tasks from a project that cannot be delayed and that demonstrate how they are related to one another. The more critical paths in a project, the more activities that must be monitored. The accumulation of the longest duration of time in the critical path will be used as an estimate of the overall project completion time. The critical path is obtained from a network diagram that shows the relationship and sequence of activities in a project.

Research Method

Research location

The research location is the area where the research has been conducted. Determining the research location is a very important step in research, because with this determination it can show that the object and purpose have been determined to make it easier for the author to conduct research (Lafaifa Wibawa dkk. 2022). This research was conducted in Samarinda City. The selection of this location is based on the consideration that the location is an area where business activities and housing projects are located.

Literature Study Method

Literature study is a reference material or source of information that is used as a reference in research for writing journal articles (Sa'adah et al., 2022) This literature study aims to understand the concepts and methods and appropriate ways to overcome previously established problems and to achieve the desired goals. This literature study includes searching for references regarding relevant theories or research findings that have been conducted previously (Hidayat, 2020). In this research, literature studies are also focused on providing information about Network Planning, especially the Critical Path Method which is used to plan and control project implementation time, as well as workforce productivity (Pratasik et al., 2013).

Data Collection

The data used in this study is secondary data, secondary data is obtained through interviews with the person in charge (second party) in the form of 1) Sequence of project activity names 2) Duration used in the construction of the house project 3) Costs and wages of workers 4) Design and layout of the house 5) Relationship between activities in the construction of the house project (Ajeng Afifah Hendriputri, 2018) This data is then used as a basis for the project scheduling and cost planning analysis process.

Data processing

Research data processing is a systematic method in accordance with the theoretical basis of the problem. Usually, research data processing requires data that can then be processed (Maulidi et al., 2021). These stages include conducting a literature review that is relevant to the research topic, as well as collecting the required information, compiling a WBS (Work Breakdown Structure), calculating labor efficiency, and the time required for each activity, preparing a work network using CPM, and the help of Microsoft Project, and the next step is comparing the wishes of the academic community with the standard duration that has been determined, if the duration has met the wishes of the community then there is no need to accelerate the project by adding workers or working hours, and the next step is calculating the budget for the development costs (Maulidi Arifin, and Suyoso 2021)

Result and Discussion

Project Activities Overview

This study analyzes the process of implementing a type 45 house construction project that was fully built within 176 days, but with this method the project was completed faster within 127 days, carried out by 5 workers and Yuliandri Hermawan as the person in charge of project management. All materials such as stone, brick, cement, wood, and sand were prepared before the project began. Researchers obtained information by analyzing in depth using direct interviews with the person in charge.

The data collected included detailing the sequence of implementation of each stage of construction work activities, identifying activities that were a continuation of the previous stage, estimating the fastest time needed to complete each activity, and the normal or standard duration generally required under reasonable working conditions (Surahman et al., 2024). This data provides a comprehensive overview of the construction workflow and time efficiency across each segment of project activities.

Identifying project activities

The first step is to identify activities by describing or breaking down activities according to the list of activities for building a type 45 house in Samarinda City.

Table 1. Normal Time Activities According to RAB (Cost Budget Plan)

NO	WORK ACTIVITIES	KODE	DURATION (NORMAL)	PREDECESSORS
1	Preparation Work	A	6	A
2	Excavation Work	B	6	B
3	Structural Work	C	23	C
4	Wall Work	D	52	D
5	Frame and Window Work	E	18	E
6	Roof Work	F	10	F
7	Ceiling Work	G	5	G
8	Electrical Installation Work	H	12	H
9	Sanitary Water Installation Work	I	15	I
10	Bathroom + Kitchen Work	J	7	J
11	Floor Work	K	11	K
12	Painting Work	L	10	L
13	Finishing Work	M	1	M

Source: Processed Data (2025)

Based on the summary of project activities in Table 1. The researcher explains that the diagram is a work network with a normal duration. The construction process of this project began on February 3, 2025 and is estimated to be completed on July 29, 2025, with a total normal duration of 176 working days. Based on the information in Table 1, it can be arranged in a normal work network diagram as follows:

Analysis using the Critical Path Method (CPM) with normal duration

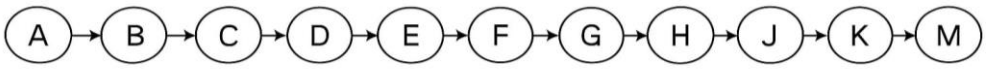

Figure 1. Normal Network according to RAB

Establish dependency relationships between project activities.

After identifying and arranging the sequence of activities, the next step is to arrange the relationship between project activities by arranging the activities that precede them. In this case, there are several possibilities that occur, namely: 1) complete an activity concurrently with other activities, 2) complete an activity after the completion of the previous activity, and 3) complete an activity without waiting for the completion of the preceding activity. (Saputra et al., 2021)

The sequence of activities appropriate for the construction of a type 45 (7x15) house project is as follows:

Table 2. Dependency Relationships on Project Activities

NO	WORK ACTIVITIES	KODE	DURATION (NORMAL)	PREDECESSORS
1	Preparation Work	A	6	-
2	Excavation Work	B	6	A
3	Structural Work	C	23	B
4	Wall Work	D	52	C
5	Frame and Window Work	E	18	D
6	Roof Work	F	10	E
7	Ceiling Work	G	5	F
8	Electrical Installation Work	H	12	G
9	Sanitary Water Installation Work	I	15	H
10	Bathroom + Kitchen Work	J	7	I
11	Floor Work	K	11	J
12	Painting Work	L	10	D, F
13	Finishing Work	M	1	K

Analysis of the network image obtained from the table above:

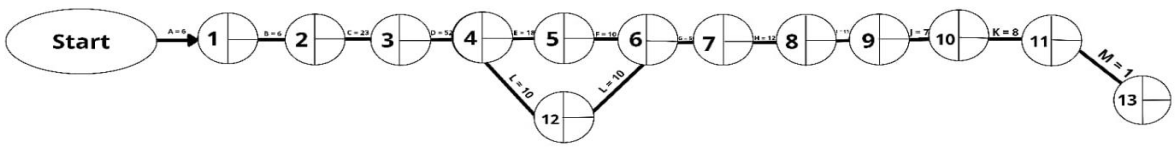

Figure 2. CPM Network

After obtaining a working relationship, the next step is to create a network with a logical and systematic project flow and activities. This network is built using the Critical Path Method (CPM) approach using the Activity on Node (AON) technique, where each activity is represented by a node and connected based on its dependencies. By using this network, forward and backward calculations are carried out to obtain the time of each activity's earliest start (Early Start/ES), earliest end (Early end/EF), latest start (Late Start/LS), and latest Finish (Late Finish/LF)

Table 3. Forward and Backward Calculation Results

NO	SYMBOL	DURATION	FORWARD CALCULATION		BACKWARD CALCULATION	
			ES	EF	LS	LF
1	A	6	0	6	0	6
2	B	6	6	12	6	12
3	C	23	12	35	12	35
4	D	52	35	87	35	87
5	E	18	87	105	87	105
6	F	10	105	115	105	115
7	G	5	115	120	115	120
8	H	12	120	132	120	132
9	I	15	132	147	132	147
10	J	7	147	154	147	154
11	K	11	154	165	154	165
12	L	10	115	125	87	97
13	M	1	165	166	165	166

The critical path is obtained after the nodes and time are filled, for further details are explained in the network diagram shown in Figure 4 below.

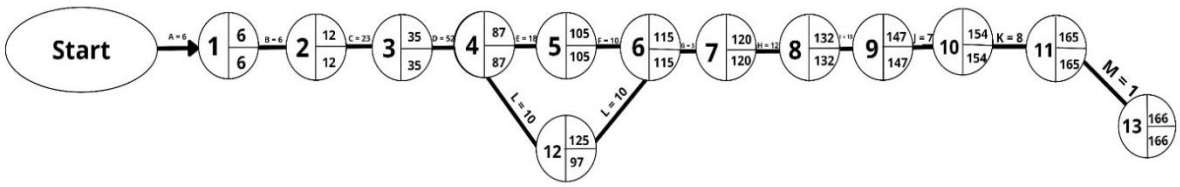

Figure 3. Critical Network Diagram

In this case, CPM is used to calculate the budget and time required for the Construction of Type 45 7x15) in Samarinda City. Project work that is carried out completely and reaches the target is a must in order to achieve this goal. CPM can be used as a reference for working on projects according to the planned time. In addition, this method helps identify activities that should not be delayed by knowing the critical path, so that project management can focus more on activities that affect the overall duration of the project. The results of the analysis show that it takes 127 days to complete the type 45 house construction project.

Figure 5. Development Progress

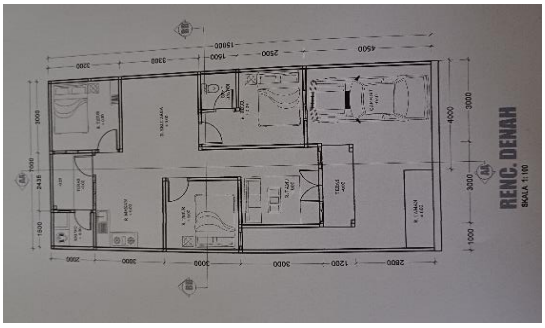

Figure 6. Building Plan

The image above is documentation in a type 45 house construction project. Picture 5 shows the progress of construction that has reached the stage of wall and roof construction. While picture 6 shows the layout plan of the project room, this plan is a reference in compiling the sequence of work and determining the dependency between activities in the work network. This documentation is used as visual evidence as the ongoing construction stage and ensures the conformity between implementation in the field with the work schedule in the CPM method.

Project Cost Planning

Project cost planning is a project management process that aims to assess and distribute funds for all project needs as a whole. This project cost estimate not only provides insight into the total daily and weekly expenditures for labor, but also includes the cost of materials, tools, and other needs. This is the main guideline in the cost monitoring process so that the project continues to operate according to plan and avoids overstated budgets.

Table 5. Equipment Cost Budget

NO	TOOLS	QUANTITY	PRICE	TOTAL
1	Arco	1	Rp 350.000	Rp 350.000
2	Grinding Machine	1	Rp 500.000	Rp 500.000
3	Hammer	3	Rp 65.000	Rp 195.000
4	Saw	2	Rp 80.000	Rp 160.000
5	Meter	2	Rp 29.000	Rp 58.000
6	Ladder	1	Rp 30.000	Rp 30.000
7	Electric drill	1	Rp 470.000	Rp 470.000
8	Hoe	1	Rp 74.000	Rp 74.000
9	Shovel	1	Rp 70.000	Rp 70.000
10	Bucket	5	Rp 13.000	Rp 65.000
11	Paint Brush	2	Rp 8.000	Rp 16.000
12	Paint Roll	1	Rp 41.000	Rp 41.000
13	Iron Ruler	1	Rp 19.000	Rp 19.000
14	Chisel	1	Rp 35.000	Rp 35.000
15	Cement Spoon	1	Rp 20.000	Rp 20.000
16	Water Level	1	Rp 250.000	Rp 250.000
17	Pliers	1	Rp 53.000	Rp 53.000
18	Screwdriver	1	Rp 20.000	Rp 20.000
SUB TOTAL				**Rp 2.426.000**

In this construction project, the existence of work tools greatly affects the smoothness and efficiency of the work. Based on the table above, the cost of work tools is estimated to reach Rp 2.426.000.

Material Cost Budget

The materials needed to build the house include 25 m^3 of sand, 135 sacks of cement, 3 m^3 of coral, 4 m^2 of natural stone, and 4 m^3 of foundation stone with a total cost of around Rp 26 million. 18,000 red bricks cost Rp 16.2 million. 175 pieces of 10 mm and 8 mm diameter iron and various sizes of wood add around Rp 6.5 million. Nail work, plywood, and other wood accessories cost Rp 12.6 million. For water and sanitation installations, various sizes of pipes, toilets, sinks, water taps, and jet showers are used with a total of around Rp 4.4 million. Doors and windows complete with frames, door leaves, hinges, and handles cost around Rp 20 million. Paint, gypsum, GRC, ceilings, and other supporting equipment cost around Rp 7 million. And for electrical installations such as cables, lights, switches, and sockets, it costs around Rp 3.1 million. The floor covering uses granite ceramics, wall ceramics, and a stove table for Rp 11 million. The metal roof and its equipment cost Rp 6.9 million. Additional materials such as roster, glass, bending wire, and varnish added around Rp 3.2 million. Therefore, the total cost of materials is **Rp119.071.000**. In construction, this cost is the largest expenditure component. The selection of materials in this construction was carried out by considering good quality so that the final construction result is sturdy, durable, and in accordance with the required technical standards.

Conclusion

This study shows that the CPM is very effective in planning and managing a type 45 (7x15) house construction project in Samarinda. Calculation of project implementation duration can be done accurately by describing all project activities in the work network and finding the critical path. In this project using the CPM method completed in 127 days with details of each activity and dependencies between activities analyzed systematically. The CPM method helps the project to be better controlled in terms of implementation time and resource allocation. They can also find tasks that can slow down the project as a whole. In addition, this study calculates the estimated project cost consisting of tools, materials, and labor, with a total cost of the main material of Rp119,071,000. With CPM, the decision-making process in project management becomes more organized, effective, and measurable. This allows the project to be completed on time, on cost, and on quality.

Declaration of conflicting interest

The authors of this paper affirm that they have no conflicts of interest.

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