Analysis of Project Management Control in Wooden Stilt House Construction Using the Critical Path Method (CPM)

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Abstract
Building traditional wooden stilt houses in Samarinda often encounters issues with time efficiency and project implementation, mainly caused by insufficient planning, dependence on local workers, and less-than-ideal material procurement. This study investigates project management control in such construction activities by applying the Critical Path Method (CPM) to improve implementation efficiency. A library research approach and secondary data analysis, based on the project's time schedule, were utilized. By applying both forward and backward pass techniques, the analysis was able to determine the project's critical path and assess the total float for each individual activity. The results indicated that 14 out of 15 tasks were classified as critical, significantly influencing the overall project duration. As a result of applying CPM, the project timeline was reduced from the initially planned 188 days to 172 days, leading to a 16-day time saving. Systematic scheduling and early identification of critical activities enabled more effective allocation of time and resources. Additionally, non-critical tasks were scheduled concurrently, preventing delays in the overall workflow. These findings demonstrate that CPM is an effective tool for managing small-scale housing projects, contributing to improved productivity and project continuity. Moreover, the method supports project managers in prioritizing tasks, making timely decisions, and ensuring the successful delivery of construction projects within limited resources.

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Keywords: Project management, Stilt Wooden House, Critical Path Method, Time Efficiency

1. Introduction

According to Angkasa (2017) [2], stilt wooden houses are traditional buildings whose main framework is predominantly or entirely constructed from wood. One defining trait of these homes is their raised floors, which are held up by multiple wooden columns. This stilt design enables construction on sloped or unstable terrains, such as riverbanks, coastal areas, or swamps. Prijotomo (1999) [18] states that Indonesian traditional architecture is largely dominated by stilt wooden houses built using natural wood joinery systems without nails or other fasteners. This study highlights that the proper application of project management in house construction can accelerate completion processes and reduce costs, emphasizing the critical role of project management in achieving time and cost efficiency (Anggraini *et al.*, 2025) [1]. Effective project management optimizes the construction process, from selecting quality timber materials, technical supervision of construction, to final project completion that meets safety and comfort standards. A project is a complex and non-routine undertaking, limited by time, budget, and resources, producing a unique deliverable. Project management is the effort to achieve clearly defined objectives as efficiently and effectively as possible (Nurhidayah 2024) [14]. To ensure a project runs according to plan, good project management is necessary to avoid failure and minimize risks. This includes managing project activities such as scheduling and human resource management directly involved in the project (Perdana & Rahman, 2019) [17].

Project success or failure is often caused by inadequate planning and ineffective control, leading to inefficiencies, delays, reduced quality, and cost overruns (Saputra *et al*., 2021) [19]. Ensuring that every stage of construction is finished promptly and within financial constraints relies heavily on strong project management practices. The Critical Path Method (CPM) stands out as a reliable approach for organizing and monitoring project timelines. CPM enables project managers to estimate the overall duration needed for each project phase and to analyze how resource allocation correlates with the time required for completion (Dwiretnani & Kurnia, 2018) [3].

CPM is a planning technique based on a network diagram depicting sequences of activities and events during project execution, represented by symbols (Ikhtisholiyah, 2017). Critical path analysis seeks to optimize total project cost by reducing or accelerating project completion time (Dwiretnani & Kurnia, 2018) [3].

Sigit *et al*. (2024) [21] assessed CPM's effectiveness in house construction and indicated that its use remains limited and is not yet systematically applied in small-scale housing projects. Hariyanto *et al*. (2020) [7] identified two types of traditional stilt houses, uma mbolo and uma ruka, constructed using traditional earthquake-resistant techniques. These houses are built manually based on local knowledge without modern project management methods. Research on wooden house construction technology shows that stilt house building in the region still relies on traditional, hereditary techniques and local craftsmanship skills, without formal project management methods like CPM (Nasution *et al*., 2019) [12].

Therefore, this study aims to analyze project management control in stilt house construction using the critical path method. The construction of stilt wooden houses in Samarinda has increased alongside the growth of micro and small enterprises. However, projects often experience delays due to suboptimal time planning, reliance on local labor, and material supply constraints. Geographic challenges, such as unstable soil and limited logistical access, further complicate project execution. Systematic project management in small-scale stilt house construction is rarely applied, despite the potential to improve time efficiency and quality. Hence, this study was conducted on stilt house projects in Samarinda to analyze execution time and cost efficiency.

2. Literature Review

A project is defined as a coordinated series of temporary activities executed within a specific timeframe with allocated resources to achieve predetermined objectives (Fazis & Tugiah, 2022) [5]. Construction projects aim to meet cost, quality, and time targets. However, during execution, projects often face risks due to uncertainties, necessitating proper risk identification and analysis processes (Mas'ud *et al*., 2023) [11]. These risks may originate from internal or external factors that affect project performance and goal attainment (Fahlevi *et al*., 2019) [4]. To address these challenges, project management is a systematic effort to achieve clearly defined and established objectives as efficiently and effectively as possible (Nurhidayat *et al*., 2021) [15]. Furthermore, project control not only involves deviation identification but also corrective actions (Wibowo *et al*., 2020) [24].

Critical Path Method (CPM)

The Critical Path Method (CPM) is a time-based project scheduling approach that determines the minimum project duration by identifying the sequence of dependent tasks that have zero flexibility. Any postponement in these critical activities will immediately impact the overall project completion timeline. Besides serving as a planning tool, CPM also functions as an evaluative method to compare the planned schedule with actual timelines based on historical data or previous projects (Haris, 2019) [6].

Research Method

1. Research Location

The research location serves as the primary unit of analysis that must be determined by the researcher before deciding the number and selection of informants. This location reflects six important aspects: involved individuals, existing structures, perspectives used, research timeframe, geographical factors, and activities taking place at the site (Nur & Utami, 2022). Research activities for this project were performed in Samarinda City. The location was selected based on its strategic and easily accessible road access, facilitating unobstructed data collection in the field. Considering these aspects, the location is expected to provide a representative and adequate context to obtain valid and relevant data aligned with the research objectives.

2. Literature Study Method

The research applied a literature review approach, gathering, analyzing, and organizing sources including articles, books, and previous studies related to project management implementation. The collected data were then synthesized to present an overview of project management practices aimed at improving the effectiveness and quality of project execution. The data collection process involved selecting literature based on relevance, methodology, and research findings related to project management strategies, including planning, implementation, monitoring, and evaluation (Sari & Asmendri, 2020) [20].

3. Secondary Data Collection

The primary secondary data analyzed in this study consisted of project execution schedules (time schedules) obtained directly from the project organizers. These documents were thoroughly reviewed to ensure that all critical components, such as task lists, durations, sequences, and dependencies among activities, adhered to project management standards, for instance, through mapping in the form of network diagrams or Work Breakdown Structure (WBS). Each activity was broken down into hierarchically structured work packages, equipped with naming systems and unique identification codes to facilitate tracking and controlling tasks at every level.

This process followed a top-down decomposition approach, whereby main tasks were identified and broken down into sub-tasks to the lowest work package level, in accordance with the 100% rule. The determination of the WBS structure considered relevant orientations, such as project life cycle-based WBS or technology-based WBS, as explained in prior studies (Odedairo, 2024) [16].

4. Data Processing

The analyzed data presented a network planning system showing the connections between work elements through network diagrams, which help establish the order of activities and ensure efficient use of resources throughout the project (Surahman *et al*., 2024) [23].

CPM used the Activity on Arrow (AOA) approach to build the network, analyzing the relationships between activities using the master schedule to develop a model that maps out the sequence and dependencies of all tasks. For optimal time analysis, CPM uses two main calculations: the forward pass, which starts at the first activity and moves forward to determine the minimum possible times when each activity can begin (ES) and be completed (EF); and the backward pass, which begins at the last activity and works backward to find the latest finish (LF) and start (LS) times that keep the project on schedule. In AOA diagrams, arrows stand for activities, and nodes (circles) display essential information like ES, EF, LS, LF, and activity IDs, all of which support effective time planning and project control (Wijanarko & Purwaningsih, 2024) [25].

Fig 1: Network Diagram

Information:

ES: the soonest moment an activity is allowed to start within the project schedule (Early Start)

LS: the latest permissible time to start an activity (Late Start)

EF: the soonest an activity can be completed (Early Finish)

LF: the latest allowable time for an activity to finish (Late Finish)

i: preceding tasks

j: the activity currently being analyzed

In calculating project timelines, three fundamental assumptions are made: (1) the project begins with a single starting point and ends with a single finishing point; (2) the earliest the starting event can occur is at time zero; and (3) the latest the finishing event can occur is when the latest start (LS) matches the earliest start (ES). The process of determining project duration typically involves two main steps (Lubis *et al*., 2021; Sinurat & Misdalena, 2024) [9, 22]:

1. **Forward Computation:** Begin at the project's starting point and proceed toward completion to identify the earliest possible finish (EF), the earliest start (ES), and the soonest an event can commence (E).
   Formula:

   EF=ES+D

   (Earliest Start plus Duration)
   If an activity is dependent on two or more preceding tasks, its ES is determined by the highest EF among those predecessors.

2. **Backward Computation:** To identify the maximum allowable times for each activity without impacting the project deadline, the analysis starts from the final event and traces back to the beginning. This backward review helps establish the latest possible completion (LF), the most delayed starting point (LS), and the latest moment an event can take place (L) while still keeping the project on track.
   The calculation for the latest start time is as follows:
   LS = LF − D (where D represents the activity's duration).
   When an activity leads to multiple subsequent tasks, its LF is set to the lowest LS of those following activities.
3. **Calculation of Time Float (Slack): Total** float, also known as slack, is the maximum period by which an activity can be delayed without affecting the overall project completion date. Activities that have zero float are classified as critical and are included in the critical path of the project schedule.
   The calculation is as follows:

   TF=LS−ES or TF=LF−EF

3. Results and Discussion

1. Overview of Project Activity Process

The housing project's construction was finished in 188 days, with a workforce of three individuals. Building materials, including sand, cement, and timber, were supplied by the homeowner, whereas some tools and equipment were brought by the workers themselves. Project information was collected through direct interviews with the homeowner.

Table 1: Project Task Breakdown

No.	Task Description	Task Code	Preceding Task(s)	Duration (days)
1	Initial Preparation	A	-	7
2	Foundation Work	B	A	16
3	Structural Work	C	B	15
4	Roofing Work	D	F	15
5	Wall Construction	E	F	21
6	Flooring Work	F	C	24
7	Septic Tank Work	G	E, D	6
8	Stairs + Garden Work	H	G	6
9	Tile Installation	I	H	25
10	Bathroom + WC Work	J	I	9
11	Electrical Installation	K	J	6
12	Doors + Windows Work	L	K	6
13	Wall + Ceiling Finishing	M	L	18
14	Painting Work	N	M	8
15	Finishing	O	N	5

Source: Processed Data (2025)

2. Project Network with Normal Duration Using CPM

Based on the activities outlined in Table 1, various types of work are involved throughout the house construction process on Jalan Kota Samarinda. The workflow progresses sequentially from the initial stage to project completion. Each activity is represented by a letter, followed by its subsequent tasks and the duration required for completion. The network diagram below is constructed using the information provided in the table above:

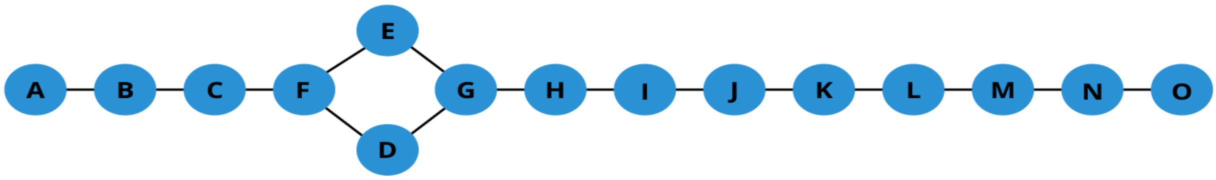

Figure 2. Critical Path Method Activity Network

3. Project Network with Forward and Backward Calculations Using CPM

After constructing the network diagram, the next step involved pinpointing the critical path. This process began with a forward analysis to determine the minimum possible start (ES) and completion (EF) times for every task. Subsequently, a backward analysis was conducted, working from the project's endpoint to its beginning, to establish the latest times each activity could commence (LS) and conclude (LF) without affecting the overall project deadline.

Table 2: Results of Forward and Backward Pass Computations

No.	Task Code	Duration (Days)	Forward Pass		Backward Pass	
			ES	EF	LS	LF
1	A	7	0	7	0	7
2	B	16	7	23	7	23
3	C	15	23	38	23	38
4	D	15	38	62	38	68
5	E	21	38	62	38	62
6	F	24	62	83	62	83
7	G	6	83	89	83	89
8	H	6	89	95	89	95
9	I	25	95	120	95	120
10	J	9	120	129	120	129
11	K	6	129	135	129	135
12	L	6	135	141	135	141
13	M	18	141	159	141	159
14	N	8	159	167	159	167
15	O	5	167	172	167	172

Source: Processed Data (2025)

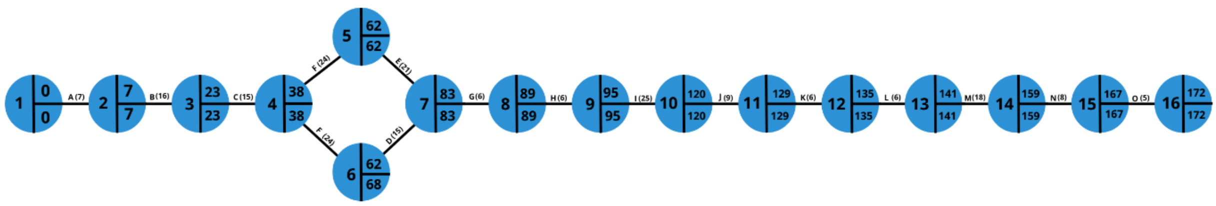

Fig 3: Network Diagram for Forward and Backward Pass Analysis

Once the critical path was established and the forward and backward pass times were determined, the total float for each task was calculated using the following method:

The total float for each activity can be determined using the formulas:

Total Float = LF – EF or LS – ES

Applying this to each activity yields the following results:

TF(A): 7 – 7 = 0 (This activity is critical)
TF(B): 23 – 23 = 0 (This activity is critical)
TF(C): 38 – 38 = 0 (This activity is critical)
TF(D): 68 – 62 = 6 (This activity is non-critical)
TF(E): 68 – 62 = 0 (This activity is critical)
TF(F): 83 – 83 = 0 (This activity is critical)
TF(G): 89 – 89 = 0 (This activity is critical)
TF(H): 95 – 95 = 0 (This activity is critical)
TF(I): 120 – 120 = 0 (This activity is critical)
TF(J): 129 – 129 = 0 (This activity is critical)
TF(K): 135 – 135 = 0 (This activity is critical)
TF(L): 141 – 141 = 0 (This activity is critical)
TF(M): 159 – 159 = 0 (This activity is critical)
TF(N): 167 – 167 = 0 (This activity is critical)
TF(O): 172 – 172 = 0 (This activity is critical)

In this context, total float (TF) for each activity is determined by finding the difference between the latest finish (LF) and earliest finish (EF), or alternatively, between the latest start (LS) and earliest start (ES). If an activity has a float of zero, it is considered critical, signifying that any postponement will directly impact the project's completion schedule. Among all activities, only activity D possesses a float greater than zero, which means it does not belong to the critical paththe results from the forward and backward pass computations, along with the float values, are illustrated in the following network diagram:

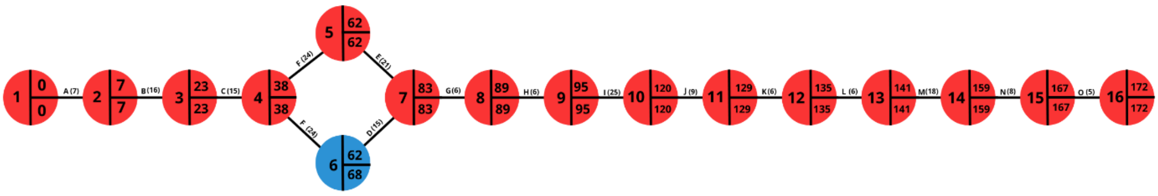

Fig 4: Diagram of the Critical Path

Based on the diagram, the critical path network is comprised of the following tasks: A (Initial Preparation), B (Foundation Work), C (Structural Work), F (Flooring Work), E (Wall Construction), G (Septic Tank Work), H (Stairs and Garden Work), I (Tile Installation), J (Bathroom and WC Work), K (Electrical Installation), L (Door and Window Installation), M (Wall and Ceiling Finishing), N (Painting), and O (Final Finishing). By summing the durations of these activities (7 + 16 + 15 + 24 + 21 + 6 + 6 + 25 + 6 + 6 + 18 + 8 + 5), the total time required to complete the project along the critical path is calculated to be 172 days.

The Microsoft Project report for the house construction project in the Tani Aman area is illustrated in the following figure:

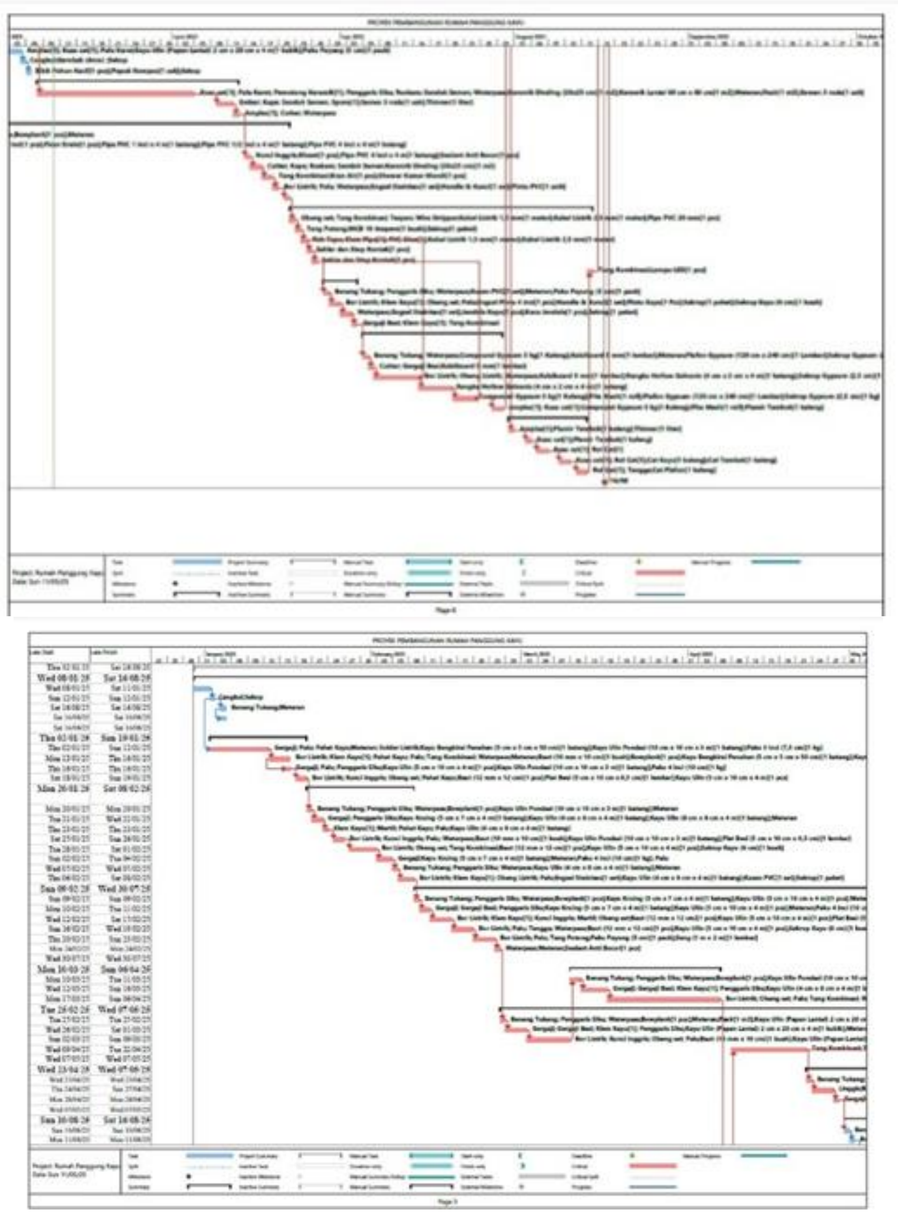

Fig 5: Gantt Chart

5. Conclusion

The use of the Critical Path Method (CPM) in the Tani Aman Village housing development improved time management by facilitating a more structured schedule and optimizing how resources were distributed throughout the project. This approach enabled project managers to prioritize activities effectively and allowed for the simultaneous execution of several tasks without disrupting the project's critical path. As a result, the initial project duration of 188 days was reduced to 172 days, achieving a time savings of 16 days. This success was supported by the accurate identification of key activities that determined the project's completion time, as well as efficient management of materials and equipment. Additionally, the flexibility of non-critical activities allowed for better allocation of labor and tools without hindering overall project progress. With a constant workforce, the implementation of CPM demonstrated that well-structured network planning and critical path analysis can significantly enhance the smooth execution and productivity of house construction projects.

6. Thank-You Note

The author would like to thank the previous researchers for their contributions in conducting research related to the development of stilt house construction methods using the CPM (Critical Path Method). Thanks to the findings of this previous research, I and other readers can gain comprehensive insights into the planning and implementation of stilt house construction projects. This valuable information is a strong foundation for further research aimed at developing more efficient, adaptive, and sustainable construction techniques. In this article, I intend to present a broader picture of the feasibility, efficiency, and effectiveness in saving project time through the CPM (Critical Path Method) method such as stilt house construction. It is hoped that construction planning can be more adaptable to local conditions, and real-time situational factors, which ultimately improves project outcomes and community relevance.

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