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Analysis of Consultant Building Project Management Using the CPM (Critical Path Method)

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Abstract

Critical Path Method (CPM) is a technique used to plan and organize project schedules by identifying the critical path, which is one of the most important aspects of project success. This research aims to formulate the completion time of the consultant office building construction project using the CPM method. Data collection techniques in this study were carried out through various activities, including field observations, interviews, and literature studies. The results showed that the application of CPM in project planning and scheduling can determine the critical path and identify the shortest duration for project completion. CPM enabled the acceleration of project completion from 592 days to 469 days, saving 123 days. This study confirms that the quality of project planning and control significantly affects the successful completion of the project. The findings support the use of CPM for time efficiency improvement on similar construction projects and recommend further research on the application of CPM on various other types of projects.

Keywords: Critical Path Method (CPM), Project Management, Building Construction, Project Scheduling, Project Planning.

Introduction

Project management methods are used to manage construction or development projects that aim to produce work done effectively and efficiently (Calderon-Tellez et al., 2024). Therefore, the main goal of project management is to achieve targets, such as the time required, the quality of materials, and the funds required from the beginning to the end of construction (Lestari et al., 2022).

Building construction is one of the infrastructures in the area; it can improve the quality of life to meet the needs and activities of the people who live in it. Building construction will generally be influenced by effectively implemented project planning and control (Lestari et al., 2022).

In most cases, projects have time constraints, which means that they must be completed before or exactly at the predetermined time(Tijani et al., 2024). However, in reality, a project sometimes does not run according to the predetermined schedule. Some things always slow down construction activities, one of which is rain (Pires & Varajão, 2024).

Activity planning is very important to enable the project to run, be implemented, and be completed at the right time (Gunasti et al., 2019). Three factors determine whether a construction project can be implemented successfully: time, quality, and money. Time control, also known as project scheduling, is an important factor for completing projects; good project scheduling must be made based on the right time estimation, which can be achieved by applying the critical path method (CPM) (Saputra et al., 2021).

One of the techniques used in project schedule management is the Critical Path Method (CPM), where scheduling is one of the aspects that most contribute to project success. The phrase "Critical Path" refers to a set of procedures used to estimate the project completion time. This estimate is based on the project's minimum completion time (Miranda & Tripiawan, 2019).

Literature Review

Project management is an effort to manage a project to achieve the desired results. It involves the process of planning, organizing, directing, coordinating, and supervising human and material resources so that the project achieves its goals. It can be considered a combination of science and art in managing projects (Pujiyono, 2017).

A project is a series of tasks that are carried out within a certain time, using certain resources, to produce the best results in the future. Resources are key to project success (Jusmidah, 2016).

In achieving the goals set for a project, there are limitations known as the Triple Constraint or three constraints, namely cost/budget, time/schedule, and quality. Project success is technically measured by the extent to which these three objectives can be met. Therefore, an effective arrangement is needed so that the three elements can be combined as needed, known as project management (Soeharto, 1997).

The critical path method is a technique used to plan and organize project schedules by identifying the critical path, which is a series of tasks that must be completed on time so that the project can be completed on schedule. Net diagram, often known as an arrow diagram, is a graphical representation of network operations that utilizes arrows and special symbols to describe the relationship between various activities in the project (Sutomo, Anwar, & Firmanto, 2016).

Research (Telaumbanua et al., 2017)shows that using the CPM method greatly saves project work time on earthworks, foundations, and structures, resulting in results 24 days faster than not using the CPM method on previous development projects. Then according to (Nalhadi & Sunanta, 2017) the use of the CPM method can save project work time from 126 days to 92 days so the work becomes faster. Meanwhile, according to (Hidayat & Ramadhany, 2021) the results of the time analysis using the CPM method follow the data obtained from direct observation in the field that the processing time is not following the time given or not on time, resulting in work delays. Therefore, this study aims to formulate the completion time of the consultant office building project using the CPM method.

Research Method

This research uses descriptive analysis. According to Arikunto (2011), it is explained as research to analyze the situation and others listed then the results are described in the form of a research report. Research techniques with descriptive methods are carried out by analyzing an object and systematic description of the actual situation in a project.

Research activities use the Critical Path Method (CPM), which is a method used to develop project planning and scheduling (Kasid & Hermansyah, 2018). The research took place from January to May 2024, including the results of the research process in the Microsoft Project application. The research location is on Jl. Samratulangi, Gg. Gotong Royong, Blok B, Samarinda City with a planned contract of 3 floors of work in an estimated time of 2 years.

The stages of data sources in this project management research use primary data and secondary data, which are two types of data needed to meet the criteria so that data can be analyzed using CPM (Algifari, 2018). Primary data comes from data obtained directly through interviews and direct observation with project workers including data on the number of workers, working hours, work processes, tools and materials used in the project and work arrangements. Meanwhile, Secondary Data is obtained from publications in the form of journals, books, articles and theses as well as other data directly related to the object of research as a source of analysis so that the data is optimal for application.

Data collection techniques in this study were carried out through various activities, including field observations, interviews, and literature studies. Observations include what is done in the field, and direct interviews with the project workers involved to get detailed information about the data used in the project as well as conducting a literature review of previous research as a source of support such as journals and books (Iwawo et al., 2016).

Data analysis in this study determines the list of work activities, determines the sequence of project work carried out, then makes a network diagram and estimates the project completion time required for the development project. Furthermore, determining the crisis path with float or slack that has a value of 0 and the total float is generated from LE-ES or LF-EF (Sofiah & Siswoyo, 2024).

Result and Discussion

General

In this case study, the object of research is the Construction of a Consultant Office Building located on Jl. Samratulangi, Sungai keledang, Samarinda Seberang District, Samarinda City. By collecting data supported by existing literature, the author reviews the project's architectural work implementation schedule by creating a new schedule using the Critical Path Method (CPM).

In making the analysis, project data was obtained from the launching contractor in the form of a Time Schedule (Curva S). These data are used in planning a new schedule using the Critical Path Method (CPM).

Work Items

Table 1 Work Items of Consultant Office Construction Project Jl. Samratulangi, Samarinda Seberang, Samarinda City

No	Work Items
I	**PREPARATION**
1	Making Building Drawing
2	Cleaning the Site
3	Making a Temporary Warehouse
II	**1ST FLOOR**
1	Foundation Installation
2	Wall Construction
3	Kitchen Construction
4	Toilet Construction
5	Staircase Construction
III	**SECOND FLOOR**
1	Column and Beam Installation
2	Wall Construction
3	Staircase Construction
IV	**THIRD FLOOR**
1	Column or Beam Installation
2	Wall Construction
3	Roof Structure Installation
V	**PAINTING**
VI	**WINDOW AND DOOR INSTALLATION**
VII	**CEILING INSTALLATION**
VIII	**CERAMIC INSTALLATION**
IX	**ELECTRICAL INSTALLATION**
X	**PLUMBING INSTALLATION**
XI	**FINISHING**
1	Water Reservoir Installation

Table 2 Architectural Works

No	Architectural Works
1	Preparation
2	Foundation Laying of 1st Floor
3	Wall Construction 1st Floor
4	Kitchen Construction
5	Toilet Construction

6	Construction of Stairs to 2nd Floor
7	Erection of Columns and Beams of 2nd Floor
8	Wall Construction of 2nd Floor
9	Construction of Stairs to 3rd Floor
10	Erection of Columns and Beams of 3rd Floor
11	Construction of 3rd Floor Wall
12	Installation of Roof Structure
13	Painting
14	Door and Window Installation
15	Ceiling Installation
16	Ceramic Installation
17	Electrical Installation
18	Plumbing Installation
19	Finishing

Data Analysis

The project data to be used in the preparation of the new project scheduling is data from the project "S" curve. Rescheduling using the critical path method (CPM) is done so that the shortest duration and critical path are obtained.

Critical Path Method (CPM)

CPM calculation, Calculations are carried out by forward and backward calculations to obtain the total float value, jobs with total float = 0 are called critical jobs, so that it is known which jobs are jobs on the critical trajectory.

Critical Path Method Calculation Technique

In the calculation of time, three basic assumptions are also used, namely: First, the project has only one initial event (start) and one terminal event (finish). Second, the fastest time the initial event occurs is day zero. Third, the slowest time the terminal event occurs is LS = ES.

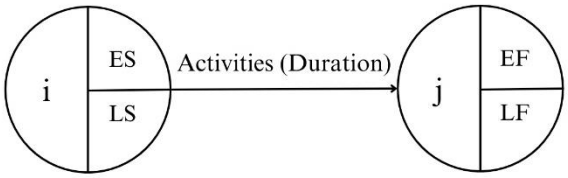


Figure 1 Total Float Formula

Description:

ES: earliest start time (Early Start)

LS: the slowest start time (Late Start)

EF: earliest finishing time (Early Finish)

LF: the latest finish time.

i: previous activity

j: activity under review

The calculation method consists of two stages, namely forward computation and backward computation.

- Forward computation (forward pass): Starting from Start (initial event) to Finish (terminal event) to calculate the fastest completion time of an activity (EF), the fastest time of the start of an activity (ES)
  (EF=ES+D) =
  Earliest Start + Duration
- Backward pass calculation: Starting from Finish to Start identify the slowest time of an event (LF), the slowest time of an event (LS) and the slowest time of an event (L).
  (LS=LF-D) =
  Latest Finish - Duration
- If a job is divided into two or more jobs, the LF of that job is equal to the LS of the next smallest job.
- Activity Float is the availability of a certain amount of time to delay or extend the implementation time of an activity. The formula for Total Float is:
  TF = LS-ES or
  TF = LF-EF

Predecessor (Job Relationship)

The following is the Predecessor of the architectural work item of the Consultant Office Building Construction project in Table 3.

Table 3 Activities of Architectural Works for the Construction of Consultant Office Building

No	Type of Work	Activity Code	Previous Activity	Duration (Days)
1	Preparation	A	-	9
2	Foundation Laying of 1st Floor	B	A	53
3	Wall Construction 1st Floor	C	B	13
4	Kitchen Construction	D	C	19
5	Toilet Construction	E	C	10
6	Construction of Stairs to 2nd Floor	F	C	27
7	Erection of Columns and Beams of 2nd Floor	G	D, E, F	27
8	Wall Construction of 2nd Floor	H	G	53
9	Construction of Stairs to 3rd Floor	I	H	10
10	Erection of Columns and Beams of 3rd Floor	J	I	27
11	Construction of 3rd Floor Wall	K	J	53
12	Installation of Roof Structure	L	K	15
13	Painting	M	L	51
14	Door and Window Installation	N	M	3
15	Ceiling Installation	O	L	121
16	Ceramic Installation	P	O	60
17	Electrical Installation	Q	O	30
18	Plumbing Installation	R	O	10
19	Finishing	S	N, P, Q, R	1

Based on the table above, there are several types of work from the construction process. The process starts from the beginning to the end of the project activities. This activity can be summarized in several letters and followed by further work, and there is also time in the project. The following is a picture of the work network obtained from the table above:

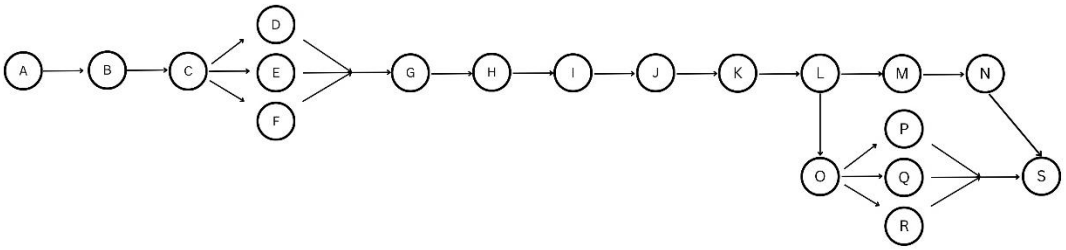


Figure 2 CPM Work Network

After obtaining the work relationship, the next step is to create a work network and find the critical path.

Table 4 Forward and Reverse Calculation Results

No	Symbol	Time (days)	Forward Calculation		Backward Calculation	
			ES	EF	LS	LF
1	A	9	0	9	0	9
2	B	53	9	62	9	62
3	C	13	62	75	62	75
4	D	19	75	94	75	102
5	E	10	75	85	75	102
6	F	27	75	102	75	102
7	G	27	102	129	102	129
8	H	53	129	182	129	182
9	I	10	182	192	182	192
10	J	27	192	219	192	219
11	K	53	219	272	219	272
12	L	15	272	287	272	287
13	M	51	287	338	287	465
14	N	3	338	341	465	468
15	O	121	287	408	287	408
16	P	60	408	468	408	468
17	Q	30	408	438	408	468
18	R	10	408	418	408	468
19	S	1	468	469	468	469

For more details, the forward and backward calculations are described in the Network Diagram as shown in Figure 1 below.

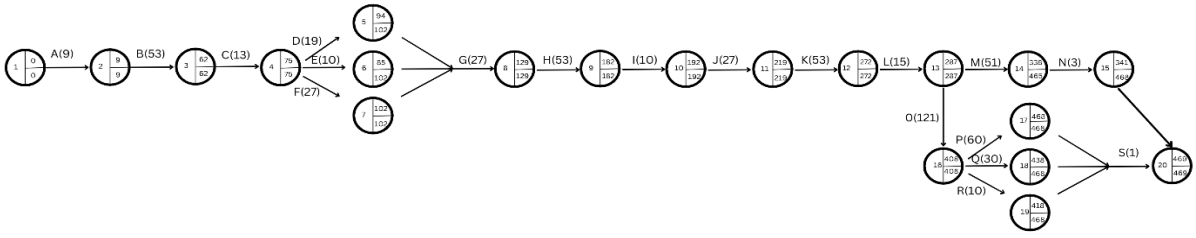


Figure 3 Network Diagram

Float/Slack Determination

After knowing the critical path and already knowing the results of the forward and backward calculations, then calculate the total float, which is as follows:

Total Float (TF) = LF - EF or LS - ES
TF (A) = 9 - 9
= 0 (Critical)
TF (B) = 62 - 62
= 0 (Critical)
TF (C) = 75 - 75
= 0 (Critical)
TF (D) = 102 - 94
= 9 (Not Critical)
TF (E) = 102 - 85
= 17 (Not Critical)
TF (F) = 102 - 102
= 0 (Critical)
TF (G) = 129 - 129
= 0 (Critical)
TF (H) = 182 - 182
= 0 (Critical)
TF (I) = 192 - 192
= 0 (Critical)
TF (J) = 219 - 219
= 0 (Critical)
TF (K) = 272 -272
= 0 (Critical)
TF (L) = 287 - 287
= 0 (Critical)
TF (M) = 465 - 338
= 127 (Not Critical)

TF (N) = 468 - 341
= 127 (Not Critical)
TF (O) = 408 - 408
= 0 (Critical)
TF (P) = 468 - 468
= 0 (Critical)
TF (Q) = 468 - 438
= 30 (Not Critical)
TF (R) = 468 - 418
= 50 (Not Critical)
TF (S) = 469 - 469
= 0 (Critical)

Determination of Critical Path

The critical path is an activity path that has a free float value (FF) = total float (TF) = 0. Based on the table above with the Critical Patch Method (CPM) calculation, the Critical Path / Critical Path in Architectural work for the Consultant Office Building construction project is path **A + B + C + F + G + H + I + J + K + L + O + P + S** with a total duration of **469 working days**.

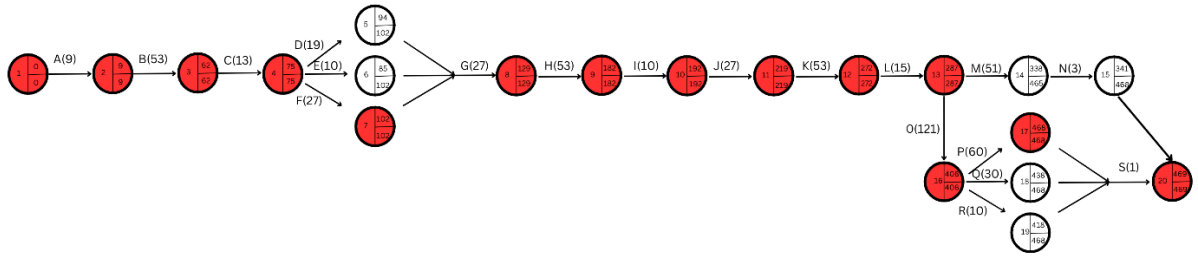
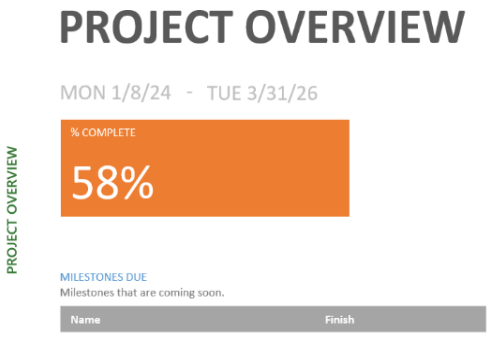
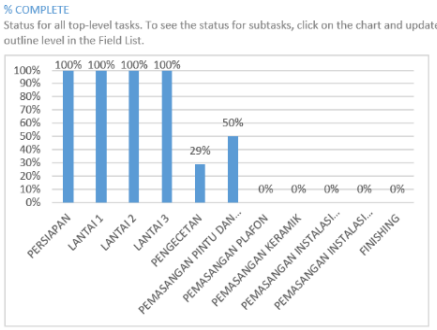


Figure 4 Critical Path

Microsoft Project Result





The building project is more than halfway done, with a completion rate of 58%. Some major activities, such as preparation and floor construction, have been completed entirely, but others, such as ceramic installation, electrical installation, and finishing, have yet to begin.

The next stage is to guarantee that any work that has not yet begun is completed as soon as possible to meet the project completion deadline. Effective time and resource management will be critical to completing the project on schedule.

At this stage, it is also critical to undertake regular progress assessments on the project. These evaluations will not only aid in the monitoring of work progress but will also allow for the early detection of faults, allowing required remedial actions to be implemented. This comprises an assessment of material availability, labour readiness, and equipment viability.

Risk management should also be considered. Any potential risks that may impede the project's progress must be recognized and examined, and mitigation techniques must be developed. For example, if material delivery is delayed or unexpected weather changes occur, the project must have a backup plan in place to deal with the problem.

In general, the success of this project will be heavily influenced by how managers manage time, resources, and risks. With a well-organized plan and good coordination, the project is expected to be completed on time and follow the established quality standards.

Conclusion

The study found that the Critical Path Method (CPM) is very effective in saving time during construction projects. According to the study, CPM can accelerate project duration significantly, depending on the type of work and project conditions. Construction projects are greatly influenced by quality planning and control. Projects can be completed ahead of schedule with proper CPM planning. This study was conducted at Jl. Samratulangi Gg. Gotong Royong Blok B Samarinda City shows that using CPM when planning and scheduling a consultant office building construction project helps in finding the critical path and determining the shortest time to complete the project. Direct observation data in the field shows that the implementation can be completed within 592 days; however, the given implementation time is 469 days, which means the work can be accelerated by 123 days. This research also recommends conducting further studies regarding the application of CPM on various other types of projects as well as examining factors.

Declaration of conflicting interest

There is no conflict of interest in this work.

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