

# Implementation of CPM and PERT Method in Canteen Development Project CV Super Makmur

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## ABSTRACT

Project management is the science and art concerned with planning, organizing, implementing, and controlling projects to achieve predefined goals by utilizing available resources optimally. The CPM (Critical Path Method) method is a deterministic approach that identifies the longest path of activities in a project, while the PERT (Program Evaluation and Review Technique) method is used to plan, estimate and control completion time by considering the uncertainty in each project activity. The goal to be achieved from this research is that the application of the method and implementation of the CPM and PERT methods can optimize project completion by knowing critical activities, operations, estimated time, costs and project resources, as well as reducing the risk of delays and additional project costs. This research adopts a quantitative approach and applies descriptive analysis using the CPM and PERT methods. Based on the analysis results, it is known that there are two critical paths, namely A-C-E-I and B-D-G-K, so accelerating the project time without delaying or waiting for completion in 11 weeks, with a value of  $Z = 2.27$  in the normal distribution table shows the number 0.9984, meaning the probability that the project can be completed during 11 weeks is 99%. because there is an additional fee of IDR 2,588,940 which is an additional acceleration fee. So, the cost of completing a 12-week project is IDR 1,171,739,257 while for 11 weeks it is IDR 1,174,328,197.

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## 1. INTRODUCTION

Project management is the science and art concerned with planning, organizing, implementing, and controlling projects to achieve predefined goals by making optimal use of available resources. One important aspect of project management is time management, i.e., the ability to complete projects according to a predetermined schedule. Project time management involves

activities such as defining, sorting, estimating, and scheduling project activities, as well as monitoring and controlling changes to project schedules. Project time management is very influential on project success, because it can save costs, improve quality, and satisfy stakeholders. Therefore, project management and implementation of project timeliness is very important and needs to be well studied by project managers and project team members.

CV Super Makmur is a company engaged in construction services. This company has many clients, both from the government and private sectors, who need construction services for various construction needs and needs related to construction project activities. To improve service quality and capacity, CV Super Makmur plans to build a new canteen on land owned by PT Tubaindo Coal Mining as the Owner of this project.

The construction of this new canteen is a complex project and requires a lot of resources, both human, material, and financial. The project also has many activities that are interrelated and influence each other. Therefore, good project planning and control is needed so that the project can be completed on time, within budget, and according to specifications.

One method that can be used to plan and control projects is the CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) methods. This method can assist project managers in determining critical activities, estimating the time, cost, and resources needed for each activity, as well as determining the critical path that indicates the sequence of activities that should be prioritized. Using this method, project managers can optimize project scheduling, reduce the risk of delays, and improve project efficiency. The Critical Path Method is a method used to plan, estimate, and control project costs and resources by considering dependencies between project activities. CPM uses one estimated time for each activity, which is normal time. Using specific algorithms, CPMs can calculate the start time, end time, slack, and cost for each activity, as well as determine the critical path and optimal cost of the project. Program Evaluation and Review Technique is a method used to plan, estimate, and control project completion time by considering the uncertainty that exists in each project activity. PERT uses three time estimates for each activity: optimistic time, most likely time, and pessimistic time. Using a specific formula, PERT can calculate the average time and variance for each activity, as

well as determine the critical path and project performance index.

Abdurrasyid et al. [1] implementing CPM and PERT methods in the shipbuilding project management information system at PT. Eternal City. They show that this method can help the project Manager in determining critical activities, estimating time, costs, and resources project power, and reduce the risk of project delays and surcharges. Anggara Hayan [2] applying CPM and PERT methods in the implementation of paving road construction projects in Paras Village, Pangkur District, Ngawi Regency, East Java. They show that the method This can achieve time effectiveness in the work on paving road projects. Naura Mutia Astari et al., [3] conduct an analysis of XYZ Museum project planning using CPM and PERT methods. They show that this method can calculate the meantime, variance, path critical, performance index, optimal cost, and project S-curve.

Based on the description above, the author is interested in conducting research entitled "Implementation of CPM and PERT Methods in CV Super Makmur Canteen Development Project". This study aims to analyze and evaluate the application of CPM and PERT methods in the CV Super Makmur canteen construction project, as well as provide recommendations to improve project performance.

## 2. METHODS

### 2.1 Types of Research Methods

Sugiyono [4] Describe research methods as "a scientific way to obtain data with specific purposes and uses. The scientific way means that research activities are based on scientific characteristics, namely rational, empirical, and systematic". Rational means that research activities are carried out in reasonable ways, so that they are affordable by human reasoning. Empirical means that the ways in which it is carried out can be observed by the human senses, so that others can observe and know the means used. Systematic, meaning that the process used in the study uses certain steps that are logical.

According to Sugiyono [4] Understanding quantitative methods is: Quantitative method is a research method based on the philosophy of positivism, and is used to examine certain populations or samples, data collection using research instruments, quantitative or statistical data analysis, with the aim of testing hypotheses that have been previously determined. In this study, data collection using surveys, "The survey method is one of the quantitative research methods that is often used by novice researchers. The method aims to see how events take place at a certain time occur, and whether there is an impact on other events. The last thing is called the cause-and-effect method (casual)".

Based on the description above, researchers concluded that the research method is a way to collect data. Thus, the research method used by researchers is using quantitative methods and using survey research.

Data sources in this study include internal data, namely data obtained directly from the place and institution of the research company so that information (secondary data) of research is not obtained through intermediaries.

## 2.2 Data Collection Techniques (Population and Sample)

Sampling technique is a way to determine the number of samples in accordance with the sample size that will be used as the actual data source, by paying attention to the properties and distribution of the population in order to obtain a representative sample [5]. In this study the sampling techniques used were Non-Probability Sampling. There are several types of techniques sampling that can be used inside Non-Probability Sampling However, researchers only use Purposive Sampling (intentional sampling).

Purposive Sampling is a way (technique) of sampling by setting a target chosen from the entire population that really understands and knows what the researcher wants, so that the researcher will get both

quantitative and qualitative data in accordance with the problem studied.

This technique was chosen by the researcher because of the data needed in this study such as the price of wages for workers who will be interviewed directly to manual workers (handymen), the dependency relationship of each job to be interviewed directly to the supervisor or head handyman who has a work area in the construction field, and the causes of delays in each work both technical and non-technical that will be interviewed to the supervisor or The head of the related handyman who has a working area in the construction field.

## 2.3 Variable Operationalization

This research adopts a quantitative approach and applies descriptive analysis using CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) methods. Two types of variables were used in this study, namely independent variables and dependent variables. The independent variable in this study consists of CPM (X1) and PERT (X2), while the variable (Y) is the project completion time or estimated project time.

Variables X and Y are two variables related to project management. Variable X is the CPM and PERT method, while variable Y is project timeliness. Here are the explanations and indicators used for each variable.

### 2.3.1 Definisi CPM

CPM (Critical Path Method) is a deterministic approach that identifies the longest activity path in a project, whereas. The indicators used for the CPM method are:

- 1) Activity Time (AT): The actual time the project activity was completed.
- 2) Start Time (ES): The fastest time possible to start an activity.
- 3) End Time (EF): The fastest time possible to complete an activity. The formula is
 
$$EF=ES+T$$
- 4) Last End Time (LF): The last possible time to complete an activity without delaying the project.

- 5) Last Start Time (LS): The last possible time to start an activity without delaying the project. The formula is  

$$LS=LF-T$$
- 6) Slack (S): The time available to postpone an activity without delaying the project. The formula is  

$$S=LF-EF=LS-ES$$
- 7) Critical Path (CP): An activity path that has zero slack and specifies the duration of the project.

### 2.3.2 PERT Definition

PERT (Program Evaluation and Review Technique) is a method used to plan, estimate, and control project completion time by considering the uncertainty that exists in each project activity.

- 1) Optimistic Time (a): The fastest time it takes to complete an activity.
- 2) Pessimistic Time (b): The longest time it takes to complete an activity.
- 3) Most Likely Time (m): The time most likely to take to complete an activity.
- 4) Average Time (T): The average time it takes to complete an activity. The formula is,

$$T = \frac{O + 4M + P}{6} \text{ or } te = \frac{a + 4m + b}{6}$$

Where:

- Te = expected time  
a = optimistic time  
b = pessimistic time  
m = most likely time

- 5) Time Variance (V): A measure of the uncertainty of the time it takes to complete an activity. The formula is

$$V = \frac{(P - O)^2}{36}$$

### 2.3.3 Definition of project completion time or estimated project time

Project timeliness is a measure of how well a project can be completed according to a predetermined schedule. Project timeliness is very influential on project success, because it can save costs, improve quality, and satisfy stakeholders. The indicators used for project timeliness are:

- 1) Project Completion Percentage (PP): The percentage of projects completed to date. The formula is

$$PP = \frac{EV}{PV} \times 100\%$$

- 2) Earned Value (EV): The value of work completed to date.

$$EV = PV \times PP$$

- 3) Planned Value (PV): The value of the work planned to be completed to date. The formula is

$$PV = BAC \times PT$$

- 4) Budget at Completion (BAC): The total budget of the project.

- 5) Percentage of Time (PT): The percentage of time that has elapsed from the project schedule. The formula is

$$PT = \frac{AT}{DT} \times 100\%$$

- 6) Real Time (AT): The time that has elapsed from the beginning of the project to the present.

- 7) Duration Time (DT): The total duration of the project.

- 8) Schedule Variance (SV): The difference between the value of completed work and the value of planned work. The formula is

$$SV = EV - PV$$

- 9) Schedule Performance Index (SPI): The ratio between the value of work completed and the value of planned work. The formula is

$$SPI = \frac{EV}{PV}$$

- 10) Estimate at Completion (EAC): An estimate of a project's total budget based on current performance. The formula is

$$EAC = \frac{BAC}{SPI}$$

- 11) Estimate to Complete (ETC): The estimated cost required to complete the rest of the project. The formula is

$$ETC = EAC - AC$$

- 12) Actual Cost (AC): The actual cost that has been incurred to date.

- 13) Variance at Completion (VAC): The difference between the total project budget and the estimated total project budget. The formula is

$$VAC = BAC - EAC$$

### 2.4 Data Collection Techniques

The research method used is quantitative, so researchers make direct observations in the field, process numerical

data observations and conduct direct interviews with the person in charge of project implementation in the right research and direct communication with the managing director of the CV project. Super Mamur.

Figure 2.1: Schedule of Activities

No	DESCRIPTION	%	WAKTU PELAKSANAAN PEKERJAAN = 3 BULAN																					
			Apr-23				May-23				Jun-23													
			1	2	3	4	1	2	3	4	1	2	3	4										
1	PEKERJAAN PENDAHULUAN	Rp 25.889.400,00	6,00	6,00																				
2	PEKERJAAN TANAH	Rp 29.912.688,00	8,00	4,00	4,00																			
3	PEKERJAAN PONDASI	Rp 83.003.268,00	15,00		5,00	5,00	5,00																	
4	PEKERJAAN BETON	Rp 178.184.451,00	6,00			1,50	1,50	1,50	1,50															
5	PEKERJAAN PASANGAN	Rp 253.096.700,00	26,00					6,50	6,50	6,50	6,50													
6	PEKERJAAN KUSEN PINTU CENDELA	Rp 71.567.600,00	10,00							2,50	2,50	2,50	2,50											
7	PEKERJAAN ATAP	Rp 263.105.000,00	9,00									3,00	3,00	3,00										
8	PEKERJAAN PLAFOND	Rp 111.328.750,00	8,00									2,00	2,00	2,00	2,00									
9	PEKERJAAN FINISHING	Rp 101.075.600,00	6,00											2,00	2,00	2,00								
10	PEKERJAAN PARIT DAN INSTALASI AIR	Rp 24.575.800,00	4,00												2,00	2,00								
11	PEKERJAAN LAIN - LAIN	Rp 30.000.000,00	2,00																	1,00	1,00			
Sub Total			100																					
RENCANA PROGRESS MINGGUAN (%) =			0	10,00	9,00	6,50	6,50	8,00	10,50	9,00	14,00	9,50	9,00	7,00	1,00									
RENCANA PROGRESS KOMULATIF (%) =			0	10,00	19,00	25,50	32,00	40,00	50,50	59,50	73,50	83,00	92,00	99,00	100									

This research adopts a quantitative approach and applies descriptive analysis using CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) methods. Two types of variables were used in this study, namely independent variables and dependent variables. The independent variable in this study consists of CPM (X1) and PERT (X2), while the dependent variable is Project Completion Time (Y). Variables X and Y are two variables related to project management. Variable X is the CPM and PERT method, while variable Y is project timeliness.

In conducting research, the data collected will be used to solve existing problems so that the data must be completely reliable and accurate. In a scientific study, data collection methods are intended to obtain relevant, accurate, and reliable materials.

The data collection methods to be used in this study are:

#### 2.4.1 Interview

Interviews as a technique for finding and collecting information are carried out by going directly to respondents to be asked for information about something they know (can be about an event, facts, or opinions of respondents [5]).

#### 2.4.2 Observation

Observation is the observation and recording carefully and systematically of the symptoms (phenomena) under study.

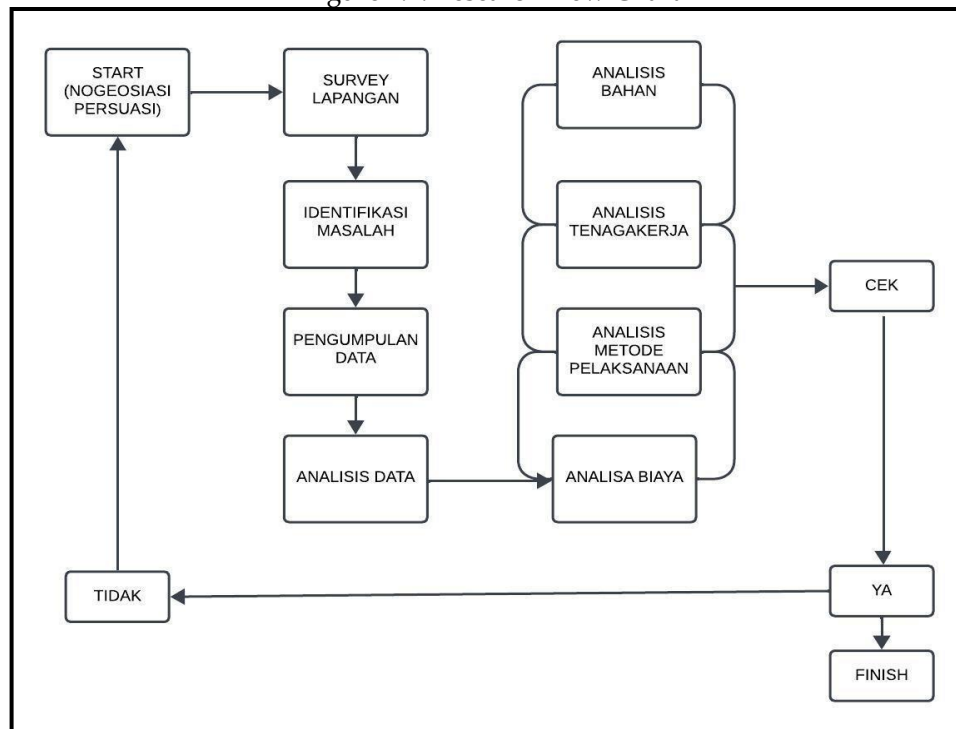
#### 2.4.3 Study Book

Data collection is carried out by reading literature books, journals, the internet, magazines, and previous research related to the research being conducted.

### 2.5 Data Processing and Analysis Techniques

The research flow chart from the start of persuasion negotiation to the completion of research activities, as follows:

Figure 2.2: Research Flow Chart



In this study, the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) methods will be used, especially in scheduling a project. In the CPM method, there are two estimates of time and cost for each activity contained in the network. The two estimates are the estimated completion time and cost that is normal (normal estimate) and the estimated time and cost that is accelerated (Crash Estimate). In determining the estimated time for completion, the critical path will be known, the path that has the series of activities with the longest total amount of time and the fastest project completion time. So, it can be said that the critical path contains critical activities from the beginning to the end of the path. To find out the steps to be carried out in this study, namely:

- 1) Collect data such as project work drawings, Time Schedule & S Curve, Unit Price Analysis (AHS), and Work Break Down Structure (WBS).
- 2) Conduct an inventory of activities, which is to break down the main activities of the project into detailed work components into a table for easy description.

- 3) Furthermore, by providing activity IDs of all work items into the table for easy identification. ID can be letters of the alphabet.
- 4) Calculate the duration and cost of each activity resulting from the calculation of worker productivity based on unit price analysis based on observations and interviews in the field, namely the volume of work, the number of workers, the price of workers, and the productivity of workers per week. In this calculation, the unit used is the week.
- 5) Rearrange the components of the activity into a chain in a logical order of dependence between each job based on literature study, observation and direct interviews with supervisors or head craftsmen in the field. Determining the logic of dependence between activities is carried out with three possible relationships, namely preceding activities, preceded activities, and free (Dummy).
- 6) Perform time analysis calculations using CPM and PERT methods. In

this calculation, researchers use POM QM software for windows.

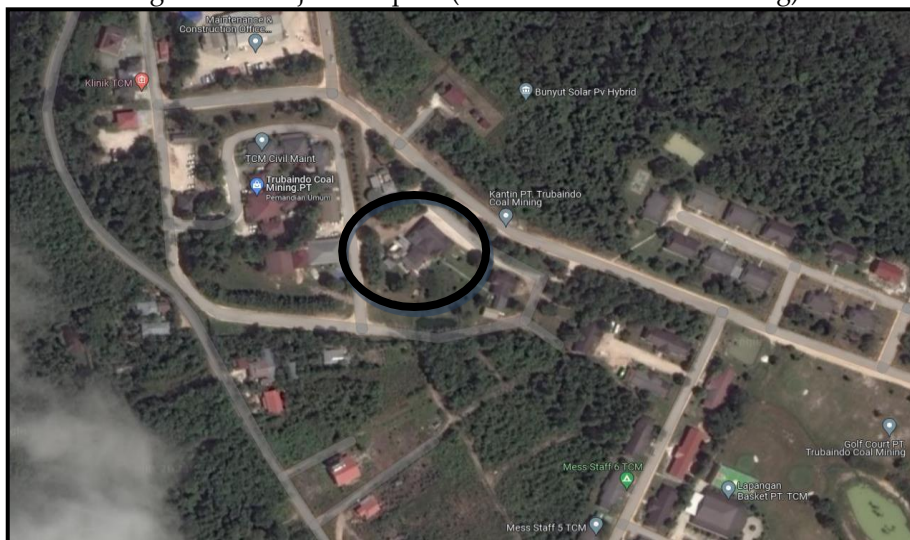
- 7) After the calculation of the determination of the critical path.
- 8) The next step is to draw network planning, nodes that contain letters from activities, the results of calculations of ES, EF, LS and LF, then arrows that indicate the direction from the previous activity to the next activity, the activity code that has been determined, the dummy of the activity that has been determined and the critical activities that have been

obtained. In this network planning description, researchers use help software in the form of POMQM for Windows V5.

**2.6 Research Location and Schedule**

The research was conducted on the construction of the canteen construction of PT Terubaindo Coal Mining by CV Super makmur in East Kalimantan Province, Kutai Batar Regency, for approximately (3) three months. Address CAMP bunyut Office kecamatan melak - Kalimantan Timur, Kabupaten Kutai Barat Pos 75775, Indonesia:

Figure 2.3: Project site plan (PT Terubaindo Coal Mining)



**2.6.1 Research Schedule**

The research will be carried out for 3 (Three) months starting from November 1,

2023 - January 31, 2024. Researchers will make observations, observations and interviews.

Figure 2.4: Research Time



No.	Tahap Penelitian	Kegiatan	Tanggal Mulai	Tanggal Selesai	Durasi
1	Pengajuan Judul Penelitian	Penentuan Judu	23-Des-23	27-Des-23	4 Hari
		Pembuatan Rencana Penelitian	27-Des-23	30-Des-23	
2	Persiapan Penelitian	Identifikasi Sumber Data	31-Des-23	03-Jan-24	4 Hari
		Penyusunan Proposal	04-Jan-24	07-Jan-24	
3	Persetujuan Proposal	Presentasi Proposal	08-Jan-24	11-Jan-24	4 Hari
		Mendapatkan Persetujuan	12-Jan-24	15-Jan-24	
4	Pengumpulan Data	Survei dan Observasi	16-Jan-24	29 Jan 2024	14 Hari
		Wawancara dengan Stakeholders	30-Jan-24	02-Feb-24	
5	Analisis Data	Penerapan PERT dan CPM	03-Feb-24	16-Feb-24	14 Hari
		Analisis Statistik	17-Feb-24	22 Feb 2024	
6	Penyusunan Laporan	Penulisan Bab 1-4	23-Feb-24	07 Mar 2024	14 Hari
		Pengeditan dan Koreksi	08-Mar-24	12 Mar 2024	
7	Presentasi Hasil Penelitian	Persiapan Presentasi	13-Mar-24	15-Mar-24	3 Hari
		Presentasi di CV SUERMAKMUR	16-Mar-24	18-Mar-24	
8	Penyusunan Jurnal	Penulisan Jurnal	19-Mar-24	22-Mar-24	2 Hari
		Pengajuan ke Jurnal Terkait	23-Mar-24	23-Mar-24	
9	Evaluasi Penelitian	Evaluasi Keseluruhan Proses			
		Mendapatkan Feedback			

### 3. RESULTS AND DISCUSSION

PT Terubaindo Coal Mining's Bunyut canteen site construction project by CV Super Makmur in East Kalimantan Province, Kutai

Batar Regency, which is planned to start from November 1, 2023 for a period of 3 months which is targeted to be completed on January 31, 2024. To support this research, the following project data are needed:

Table 3.1: Project contract data CV SUPER MAKMUR

Project name	Construction of Bunyut site canteen
Location	East Kalimantan Province, Kutai Batar Regency
Taskmaster	PT Terubaindo Terubaindo Miniof
Planning consultant	CV. Super Makmur
Supervision Consultant	CV. Super Makmur
Execution time	Budget 2023-2024
Maintenance period	
Types of contracts	
Down payment	15% of contract value
Payment	Monthly certificate
Contract value + VAT	Rp. 1.195.100.000,-

As explained in the introduction, the scope and objectives of the research are summarized, research from beginning to finishing. The contract value for building work is Rp. 1.195.100.000,- and the duration of time for canteen building work items is only 3 months or 12 weeks. Based on the results of interviews and review of RAB documents for canteen construction projects, data were obtained related to the type of activity, the duration of each activity, the sequence of each

activity, the cost and the number of human resources involved.

In the Bunyut canteen site construction project of PT Terubaindo Coal Mining by CV Super Makmur in East Kalimantan Province, Kutai Batar Regency, there are several items and sub-work of canteen building work, namely work that includes from the beginning of preparation to the final work (finishing). Here are the items and sub jobs:

Table 3.2: Canteen construction project items and sub works

NO	JOB DESCRIPTION



1	PRELIMINARY WORK Site Cleaning Before and After the Project Pasang Building Board
2	EARTHWORKS Foundation Soil Excavation Urugan Tanah
3	FOUNDATION PAIR WORK Mixed Mountain Stone Couple 1 Pc: 3 Psr Beton Telapak (Chicken Claws) 1 Pc 2 Psr 3 Krl Concrete Repetition Telapak besi Ø 12 SNI
4	CONCRETE WORK Sloof Reinforced Concrete (200 kg Iron + Formwork) Reinforced concrete blocks (200 kg Iron + Formwork) Reinforced Concrete Column (200 kg Iron + Formwork) Floor Plate Thickness 10 Cm Concrete
5	SPOUSE WORK Passang Butco 1pcs 5PSR Wall Plastering + Acian Install Ceramic 40 x 40 Cm Unpolish Install the Uk ceramic plint. 10 x 40 Cm
6	WOODWORK Install Door Frames Install the Door Leaf Install Glass Cendela Install Door Slots Install Door Accessories Install Cendela Accessories
7	ROOFING WORK Install Horse Frame - Light Steel Horse Rooftop Metal Roof Install Roof Take Lisplang
8	CEILING WORK Pasang Rangka Plafond Kayu Pasang Ceiling Plywood 4 mm Pasang List Plafond
9	PAINTING WORK Wall Paint Cat Ceiling Cat Kusen + Cendela Paint Doors
10	TRENCH WORK AND WATER INSTALLATIONS Soil Excavation Deep trench making Besi Grating Pipa Pvc AW 3" + Accessories
11	OTHER JOBS Transportation Costs

	Other Fees
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In calculating the duration of a job there are several important components that must be known such as the list of work volume (BoQ), the coefficient of each job, and it must be known whether the work is done

manually or mechanically, if mechanical then it is necessary to know what type of heavy equipment and how much heavy equipment is used on the job.

Table 3.3: Activities and Duration of Implementation for CPM Method

ID	Activities	Pre-Predictor	Duration (Week)
			A
B	Earthworks	Start	2
C	Foundation Work	A	3
D	Concrete Works	B	4
And	Spouse Work	C	4
F	Cendela Door Frame Work	C	4
G	Roof Work	D	3
H	Ceiling Works	A	4
I	Finishing Work	And	3
J	Trench work and water installations	F	2
Towards	Other Jobs	G	2
Time to Turnaround = 3 Months			12 Weeks

Table 3.4: Activities and Duration of Implementation for the PERT Method

ID	Activities	Pre-Predictor	Duration (Week)		
			a	m	b
A	Preliminary Work	Start	1	1	2
B	Earthworks	Start	1	2	3
C	Foundation Work	A	2	3	4
D	Concrete Works	B	3	4	5
And	Spouse Work	C	3	4	5
F	Cendela Door Frame Work	C	3	4	5
G	Roof Work	D	2	3	4
H	Ceiling Works	D	3	4	5
I	Finishing Work	And	2	3	4
J	Trench work and water installations	F	1	2	3
Towards	Other Jobs	G	1	2	3

Table 3.5: Cost of Canteen Construction

ID	Activities	Cost
A	Preliminary Work	IDR 25,889,400
B	Earthworks	IDR 29,912,688
C	Foundation Work	IDR 83,003,268
D	Concrete Works	Rp178.184.451

E	Spouse Work	Rp253.096.700
F	Cendela Door Frame Work	IDR 71,567,600
G	Roof Work	Rp263.105.000
H	Ceiling Works	Rp111.328.750
I	Finishing Work	Rp101.075.600
J	Trench work and water installations	IDR 24,575,800
K	Other Jobs	IDR 30,000,000
		Rp1.171.739.257

Based on the results of interviews with supervisors in the field, it can be known how many workers, handymen, kenek are combined into one group (team) in a work activity carried out manually.

- Supervisor = 1 Person
- Head Handyman = 1 Person
- Craftsman = 4 People
- Craftsman's Assistant = 6 People

In making a project planning schedule, the thing to know is the price of workers who will be used when carrying out work. So that the prices of these workers will be included in the AHSP to determine the total cost of the RAB. The following are the prices of workers obtained from interviews with field supervisors:

Table 3.6: Labor costs

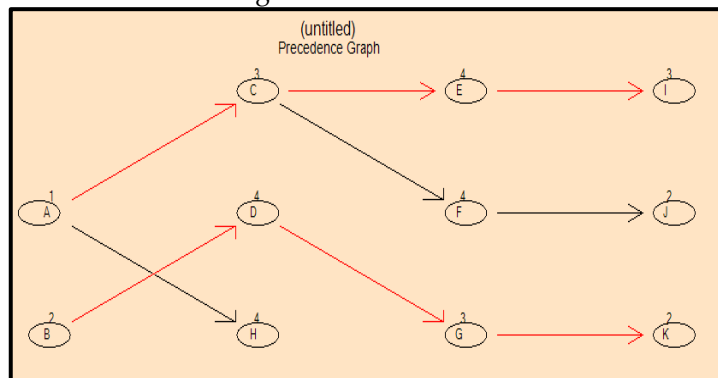
No	Types of Workers	Worker Price/hour
1	Head Handyman	IDR 165,000.00
2	Worker	IDR 120,000.00
3	Tukang Batu	IDR 150,000.00
4	Tukang Besi	IDR 150,000.00
5	Painter	IDR 150,000.00
6	Tukang Kayu	IDR 150,000.00

Next is the stage of implementation of the CPM and PERT methods

- 1) Implementation of the CPM method by constructing a project network

diagram using the AON (Activity on node) network. Then the data is processed using POM QM for windows ver.5 software

Figure 3.1: Critical Path



(Output POM QM for Windows)

From the calculation results, it is known that there are two critical paths, namely:

$$A-C-E-I = 1+3+4+3 = 11 \text{ minggu}$$

$$B-D-G-K = 2+4+3+2 = 11 \text{ weeks}$$

Figure 3.2: Slack time calculation

(untitled) Solution						
Activity	Activity time	Early Start	Early Finish	Late Start	Late Finish	Slack
Project	11					
A	1	0	1	0	1	0
B	2	0	2	0	2	0
C	3	1	4	1	4	0
D	4	2	6	2	6	0
E	4	4	8	4	8	0
F	4	4	8	5	9	1
G	3	6	9	6	9	0
H	4	1	5	7	11	6
I	3	8	11	8	11	0
J	2	8	10	9	11	1
K	2	9	11	9	11	0

(Output POM QM for Windows)

From the results of the slack time calculation, it is known that the time available to postpone an activity without delaying the project there are 8 activities A-C-E-I-B-D-G-K with a duration where the slack or float value is 0. So, there are two critical paths, namely A-C-E-I = 1+3+4+3 =11weeks B-D-G-K = 2+4+3+2=11 weeks. So, the acceleration of project time without delaying or waiting for the completion of the overall project can be completed in 11 weeks.

2) Implementation of the PERT method to calculate the duration of the canteen construction project by using POM QM for windows ver.5 software.

$$te = \frac{a + 4m + b}{6}$$

$$\sigma^2 = \left(\frac{b - a}{6}\right)^2$$

Table 3.7: TE Calculation Results

Activities	Duration (Week)			Tea
	a	m	b	
A	1	1	2	1,1667
B	1	2	3	2
C	2	3	4	3
D	3	4	5	4
And	3	4	5	4
F	3	4	5	4
G	2	3	4	3
H	3	4	5	4
I	2	3	4	3
J	1	2	3	2
Towards	1	2	3	2
Total	22	32	43	32,1667

From the result of the calculation te is 1 + 3 + 4 + 3 = 11.1167 weeks. Then proceed to calculate the standard deviation and variance.

Table 3.8: Calculation of Standard Deviation and Variance

Activities	Duration (Week)			tea	S	V (te)
	a	m	b			
A	1	1	2	1,1667	0,1667	0,0278
B	1	2	3	2	0,33	0,11
C	2	3	4	3	0,33	0,11
D	3	4	5	4	0,33	0,11

And	3	4	5	4	0,33	0,11
F	3	4	5	4	0,33	0,11
G	2	3	4	3	0,33	0,11
H	3	4	5	4	0,33	0,11
I	2	3	4	3	0,33	0,11
J	1	2	3	2	0,33	0,11
Towards	1	2	3	2	0,33	0,11
Total	22	32	43	32,2	3,47	1,1278

From the calculation of variance and standard deviation of the canteen construction project are:

$$\text{Variance} = \sigma_p^2 = (0,0270)^2 + (0,11)^2 + (0,11)^2 + (0,11)^2 = 0,1925$$

$$\sigma_p = \sqrt{0,1925} = 0,44$$

The final step is to determine what the probability is if the project is planned to be completed within 11 weeks, for example. Then first calculate the value of Z for T = 11 weeks.

$$Z = \frac{12 - 11}{0,44} = 2,27$$

Table 3.9: Calculation of total cost of Canteen construction

Method	Time	Cost
Before implementing CPM and PERT	12 weeks	Rp1.171.739.257
After applying CPM and PERT	11 weeks	Rp 1.174.328.197

From the calculation of the total cost of building the canteen, we can see that the project time can be accelerated from 12 weeks to 11 weeks with a difference of 1 week. And for the 11-week acceleration fee is greater because there is an additional cost of Rp2,588,940 which is an acceleration surcharge for 1 week. It can be concluded that before applying the CPM and PERT methods, the project duration is 12 weeks at a cost of Rp. 1,171,739,257, while after applying the CPM and PERT methods, the project duration is 11 weeks at a cost of Rp. 1,174,328,197.

#### DISCUSSION

Implementation of CPM and PERT methods by constructing project network diagrams using AON (Activity on node) networks in the Bunyut canteen site construction project of PT Terubaindo Coal Mining by CV Super Makmur in East Kalimantan Province, Kutai Batar Regency,

Next look at the probability value for  $Z = 2,27$  in the Z distribution table, the normal distribution table shows a probability number of 0.9984. means the probability that the project can be completed during 11 week is 99%. These results are in line with the results of the study Abdur Rassid [1] where they show that this method can help the project Manager in determining critical activities, estimating time, costs, and resources project power, and reduce the risk of project delays and surcharges.

with a contract value for building work, namely, Rp. 1,195,100,000, - and the duration of completion time for canteen construction project work for 3 months or 12 weeks. Canteen building work items activities that include from the beginning of preparation to final work (finishing) in the canteen construction project. The following work items and their codes, durations, and budget costs, (A) Preliminary Work with a duration of 1 week at a cost of Rp25,889,400, (B) Earthworks with a duration of 2 weeks at a cost of Rp29,912,688, (C) Foundation Work with a duration of 3 weeks at a cost of Rp83,003,268, (D) Concrete Work with a duration of 4 weeks at a cost of Rp178,184,451, (E) Spouse Work with a duration of 4 weeks at a cost of Rp253,096,700, (F) Cendela Door Frame Work duration 4 weeks at a cost of Rp71,567,600, (G) Roof Work with a duration of 3 weeks at a cost of Rp263,105,000, (H)

Ceiling Work with a duration of 4 weeks at a cost of Rp111,328,750, (I) Finishing Work with a duration of 3 weeks at a cost of Rp101,075,600, (J) Ditch Work and Water Installation for 2 weeks at a cost of Rp24,575,800, (K) Miscellaneous Work for 2 weeks at a cost of Rp30,000,000. It is known that workers in one group (squad) in the canteen construction project, supervisors 1 person, head handyman 1 person, handyman 4 people, and handyman helpers 6 people. By constructing a project network diagram using the AON (Activity on node) network. Then the data is processed using POM QM for windows ver.5 software, from the calculation results it is known that there are two critical paths because it has a slack value of 0, namely activity A-C-E-I = 1+3+4+3 =11weeks and activity B-D-G-K = 2+4+3+2=11 weeks.

The implementation of CPM and PERT methods can prevent the risk of delays in project completion time, from the results showing that canteen construction projects can be completed within an estimated time of 11 weeks. This means that the duration of project completion through the CPM method is faster than the initial estimate stating that the project can be completed within 12 weeks. There is a difference of 1 week from the specified time. From the calculation result  $t_e = 1 + 3 + 4 + 3 = 11.1167$  weeks, followed by calculating standard deviation and variance =  $\sigma_p^2 = (0,0270)^2 + (0,11)^2 + (0,11)^2 + (0,11)^2 = 0,1925$   $\sigma_p = \sqrt{0,1925} = 0,44$ . Determine what the probability is if the project is planned to be completed in 11 weeks, then what is the probability. Then first calculate the value of Z for T = 11 weeks. Next, looking at the probability value for  $Z = \frac{12-11}{0,44} = 2,27$  on the Z distribution table, the normal distribution table shows a probability number of 0.9984. This means that the probability that the project can be completed over 11 weeks is 9.9%.

The implementation of CPM and PERT can help accelerate project completion, based on the results of the implementation of CPM (X1) and PERT (X2), the project time (Y) can be accelerated from 12 weeks to 11 weeks

with a difference of 1 week. For project acceleration costs, there is an additional fee of Rp2,588,940 which is an acceleration surcharge for 1 week. Where before applying the CPM and PERT methods, the project duration was 12 weeks at a cost of Rp. 1,171,739,257, while after applying the CPM and PERT methods, the project duration was 11 weeks at a cost of Rp. 1,174,328,197.

#### 4. CONCLUSION

Based on a case study that has been conducted on the Bunyut canteen site construction project of PT Terubaindo Coal Mining by CV Super Makmur in East Kalimantan Province, Kutai Batar Regency accompanied by a discussion analysis entitled Implementation of CPM and PERT Methods in the CV Super Makmur Canteen Development Project, several conclusions were obtained, namely:

- 1) The results of the analysis of the POM QM for windows ver.5 software application on the Bunyut canteen site construction project of PT Terubaindo Coal Mining by CV Super Makmur in East Kalimantan Province, Kutai Batar Regency, it is known that there are 2 critical work variance paths, namely A – C – E – I = 1 + 3 + 4 + 3 = 11 weeks and B – D – G – K = 2 + 4 + 3 + 2 = 11 weeks. With curitis path work items among others, Preliminary Work (A), Foundation Work (C), Spouse Work (E), Finishing Work (I). Curitis path variance, Earthwork (B), Foundation Work, Concrete Work (D), Cendela Door Frame Work, Roof Work (G), Miscellaneous Work (K).
- 2) The application of the CPM Critical Path Method method in the Bunyut canteen site construction project of PT Terubaindo Coal Mining by CV Super Makmur in East Kalimantan Province, Kutai Batar Regency, from the calculation results shows that the canteen construction project can be completed in an estimated time of 11

weeks. This means that the duration of project completion through CPM is faster than the initial estimate which states that the project can be completed within 12 weeks. There is a difference of 1 week from the specified time.

- 3) Application of the PERT method Program evaluation and review technique in the construction project of the Bunyut canteen site construction of PT Terubaindo Coal Mining By CV Super Makmur in East Kalimantan Province, Kutai Batar Regency, From the calculation results te is  $1 + 3 + 4 + 3 = 11.1167$  weeks, followed by calculating standard deviation and variance  $= \sigma_p^2 = (0,0270)^2 + (0,11)^2 + (0,11)^2 + (0,11)^2 = 0,1925$   $\sigma_p = \sqrt{0,1925} = 0,44$ . Determine what the probability is if the project is planned to be completed in 11 weeks, then what is the probability. Then first calculate the value of Z for T = 11 weeks  $Z = \frac{12-11}{0,44} = 2,27$ . Furthermore, looking at the probability value for Z = 2.27 in the Z distribution table, the normal distribution table shows a probability number of 0.9984. means the probability that the project can be completed in 11 weeks is 99%.
- 4) Based on the results of the implementation of CPM and PERT,

the project time can be accelerated from 12 weeks to 11 weeks with a difference of 1 week. And for the acceleration fee, there is an additional fee of Rp2,588,940 which is an acceleration surcharge for 1 week. Before implementing CPM and PERT the project duration was 12 weeks at a cost of IDR 1,171,739,257, while after implementing CPM and PERT the project duration was 11 weeks at a cost of IDR 1,174,328,197.

#### SUGGESTION

- 1) We recommend that project owners apply the CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) methods in the implementation of project builders because it can help project managers to optimize project completion by knowing critical activities, estimating time, costs, and project resources, as well as reducing the risk of delays and additional project costs.
- 2) In particular, data processing is recommended to use POM QM for windows ver.5 software because it is easy to access and can find out the accurate slactime value which is a guideline for network planning critical activities that have been obtained.

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