

ANALYSIS OF PROJECT TIME AND COST CONTROL WITH CPM, PERT AND CRASHING PROJECT METHODS IN SHOP BUILDING PROJECTS AT CV. MENTARI PERMAI

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ABSTRACT

Delays in completing the Kelapa Dua shop-house construction project at CV. Mentari permai is a problem that often arises and affects the overall project work. The purpose of this research is to determine the critical path, calculate the costs incurred in the construction of the Kelapa Dua shop-house construction project with the duration of the initial and accelerated work and calculate the percentage of achievement of the shop construction project at CV. Mutia Enchantment of Nature. To overcome these delays, several control methods are used in project management. The methods used in this research are the Critical Path Method, PERT (Program Evaluation and Review Technique) and the Crashing Project. The results of the CPM planning method analysis obtained the project completion time for 91 days from the initial duration of 154 days. Whereas in reality the CPM method, the project completion time is 101 days from the initial duration of 167 days. In the PERT method, the project completion time is 107 days from a duration of 181 days with a probability of completion of 0.62%. And in the crashing project there is an acceleration of the completion duration for 9 days with an increase in costs of Rp. 26,545,194 and a total cost of Rp. 506,613,766.

Keywords: Project Management, Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), Crashing Project

PROEM

Management of quality construction work is the dream of every project implementer. Every project in construction work will be qualified if it can be implemented according to what has been planned, meaning that the work can be realized perfectly. If the construction project work has been carried out perfectly, of course there will be many advantages for the implementing company and its customers. But in reality this perfect implementation is very difficult to realize, the reason is that there are many obstacles in the implementation process. Obstacles in project implementation have a serious impact, meaning that they have a major influence on the course of each project.

CV. Mentari Permai is a company engaged in the field of General Contractor, Supplier and General Trading. So far, the company in determining the time and cost is only based on experience and not based on mathematical calculations. This often causes the development process to experience problems in the completion time which can affect the time and costs set by the company.

This study aims to analyze the project schedule using the PERT (Project Evaluation and Review Technique) and CPM (Critical Path Method) methods so that it can be known how long a project can be completed and look for possible acceleration of project implementation time. Crashing Project is carried out to see the amount of costs if project activities experience delays.

THEORETIC

The objective of project management according to that is to be able to carry out each project effectively and efficiently so as to provide maximum service to all customers. In more detail, the objectives of project management (Cha, et al., 2018; Hansen & Svejvig, 2022). On time, namely the time or schedule which is one of the main targets of the project, delays will result in losses (Do, Nguyen, Tran, & Aung, 2022; Rauzana & Dharma, 2022), such as additional costs, loss of opportunity for products to enter the market ; a) Right on budget (on budget), namely costs that must be incurred in accordance with a predetermined budget;, b) Precise specification (on specification) where the project must be in accordance with predetermined specifications.

Critical Path Method (CPM)

CPM is defined as a network analysis that seeks to optimize the total cost of a project by reducing or accelerating the total completion time of the project in question (Almatroushi, et al., 2020; Nahendra, et al., 2022). In calculating the determination of completion time, the following basic terminology is used (Banihashemi, et al., 2021): a) E (earliest event occurrence time), b) (latest event occurrence time), c) ES (earliest activity start time), d) EF (earliest activity finish time), e) LS (latest activity start time), f) LF (latest activity finish time), g) t (activity duration time). A project network diagram always begins with an event that indicates the start of the project and ends with an event that indicates the end of the project activity (Pandiyan, et al., 2020). Each project can consist of several paths or paths from the initial event to the final even (Dai, et al., 2020)t.

Basically the network is a way of depicting project activities in the form of symbols (Yu, et al., 2021).

Program Evaluation and Review Technique (PERT)

PERT or Program Evaluation and Review Technique is a method that aims to reduce as much as possible the delays or disruptions and production conflicts (Argiansyah, et al., 2021). Coordinating and synchronizing the various parts of the elements as a whole work accelerates the completion of the project (Izmailov, et al., 2016). In PERT, probability distribution is used based on three time estimates for each activity, namely pessimistic time, realistic time and optimistic time. Optimistic time is an estimate of time that has a very small possibility of being achieved. Pessimistic time is an estimate of another time that has a very small possibility of being realized (Suwarni, 2019). Realistic time is time based on estimator estimates (Wen, et al., 2019; Sitanggang, et al., 2019). The steps in the PERT calculation are: a) Determine the estimated time of the activity, b) Determine the standard deviation, c) Determine the activity variance and d) Knowing the probability of reaching the target.

Crashing Project

The process of accelerating the time period is called Crashing Project (Natawidjana & Nurasiyah, 2020; Ruslan, 2019). The main objective of the program to speed up time is to shorten the schedule for completion of activities or projects with minimal cost increase. Done *Crashing Project* on every job that is on the critical path so it needs to be known before crashing. The several parameters that must be looked for to determine the acceleration of project time are as follows (McDonough III, 2000) a) Daily Productivity, b) Daily Productivity After Crash, c) Normal labor cost per hour = productivity per hour $\times$ unit price of worker wages;, d) Workers' overtime costs = $(1.5 \times \text{normal hourly wages for the first overtime}) + (2 \times n \times \text{normal hourly wages for subsequent overtime hours})$;; e) *crash cost* workers per day = normal cost per day + overtime costs for workers;; f) *crash cost* total workers = crash cost of workers per day $\times$ crash duration

METHODS

This research is a qualitative research. In this study, the data used are data on project activities and dependency relationships between activities as well as data on activity time,

project implementation schedule, project costs, estimated data on project workforce requirements, and other data related to research problems.

Data collection techniques in this study were observation and interviews. The observation method is a data collection method that is carried out by looking directly at the data collection carried out by CV. Mentari permai and look at the working environment, the project process, the equipment used and what raw materials are used in the project at CV. While the interview is holding a question and answer activity directly to the respondent. This method is carried out by conducting direct interviews with employees at the shop building project CV. Mentari permai on matters related to research such as how the project stages are carried out and what raw materials are used.

RESULTS

Before creating a network with the CPM method, a list of activities or work required in a project or process plan is required. For each activity, we need to know the predecessor activity (predecessor) and the activity that follows it (successor) and how long the activity takes.

Critical Path Method (CPM)

Based on table 1, a network diagram for a shop development project is depicted with the following planning time:

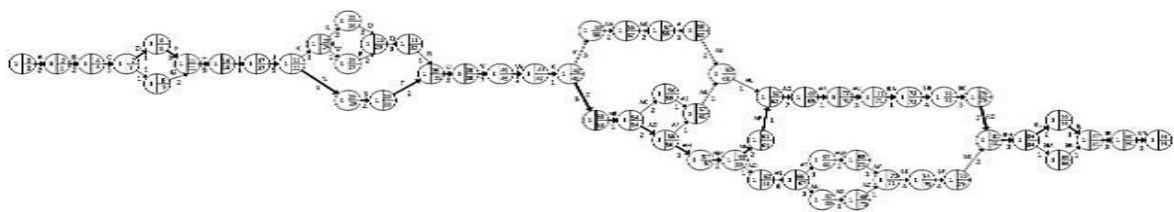


Figure 1. CPM Network (planning)

In the network diagram there is an activity path with the longest duration or an activity with slack 0, namely:

ABCDHFHIJNSTUVWXZ-AB-AD-AH-AM-AN-AP-AQ-AR-AV-BA-BB-BC-BD-BH-BI-BJ-BL-BN

$$=(2+2+3+1+3+5+1+5+7+4+2+3+7+2+1+5+1+2+1+2+2+1+7+1+1+1+4+3+2+3+3+1+2+1)$$

= 91 days

Based on table 1, the real-time real-time project network diagram is described as follows:

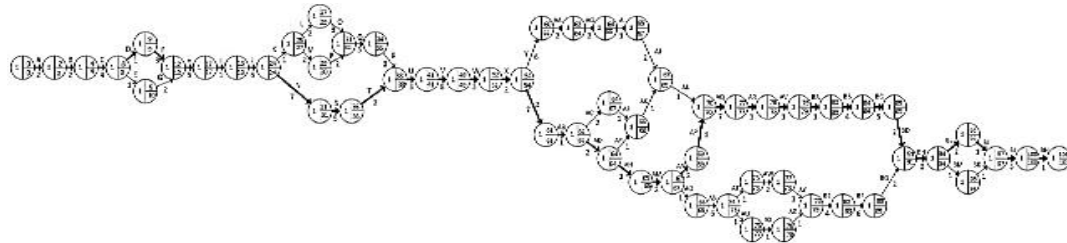


Figure 2. CPM Network (reality)

In the network diagram there is an activity path with the longest duration or an activity with slack 0, namely:

ABCDHFHIJNSTUVWXZ-AB-AD-AH-AM-AN-AP-AQ-AR-AV-BA-BB-BC-BD-BH-BI-BJ-BL-BN

$= (2+2+4+1+3+5+1+6+7+5+2+3+8+3+2+7+1+2+1+2+2+1+7+1+1+1+4+5+2+3+3+1+2+1)$

= 101 days

Program Evaluation and Review Technique (PERT)

Scheduling with the PERT method, begins with estimating the completion time of each project activity item into 3 types of time estimates, namely optimistic time (a), most likely or realistic time (m) and pessimistic time (b):

By using the te value (expected time duration), a network diagram is made where the principle of making a network is the same as the CPM method.

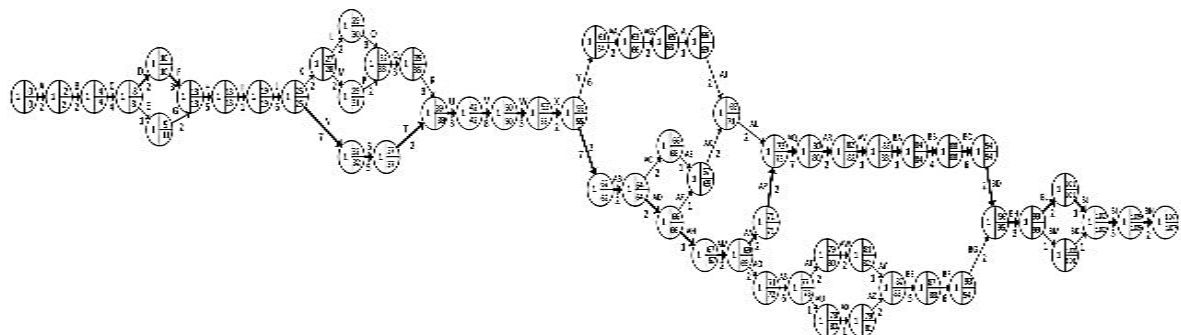


Figure 3. PERT Network

In the network diagram there is an activity path with the longest duration or an activity with slack 0, namely:

ABCDFHIJNSTUVWXZ-AB-AD-AH-AM-AN-AP-AQ-AR-AV-BA-BB-BC-BD-BH-BI-BJ-BL-BN

$$= (2+2+4+2+3+5+1+6+7+5+2+3+8+3+2+7+2+2+1+2+2+2+7+2+1+1+4+6+2+3+3+1+2+2) \\ = 107 \text{ days}$$

Based on the critical path that has been obtained, then determine the standard deviation value, activity variance and standard deviation. From the results of these calculations, the standard deviation values.

Furthermore, we can calculate the uncertainty if it is measured in accordance with the Expected Time (TE) of critical activities of 107 days. The possibility or uncertainty of reaching the schedule target on the PERT method is expressed by z. to calculate the normal value of z, it takes the desired completion time T(d) and Expected Time (TE) for critical activities. The desired turnaround time is 101 days(CPM real time critical path), then the normal value of z is:

$$z = \frac{T(d) - TE}{S} = \frac{101 - 107}{2,40} = -2.50$$

By using the normal distribution table (can be seen in the attachment) with a value of $z = -2.50$, the result is 0.0062. This means that the probability of the project being completed within 107 days is around 0.62%. If we calculate that we are looking for a 99 percent probability with a value in the normal distribution table of 0.99 or equal to $z = 3.49$, the completion of the project falls on:

$$z = \frac{T(d) - TE}{S}$$

$$3,49 = \frac{T(d) - 107}{2,40}$$

$$T(d) = (3.49 \times 2.40) + 107$$

$$T(d) = 115.376 = 116 \text{ days}$$

Crashing Project

Based on data and calculations using the CPM method, the critical path is obtained ABCDFHIJNSTUVWXZ-AB-AD-AH-AM-AN-AP-AQ-AR-AV-BA-BB-BC-BD-BH-

BI-BJ-BL-BN. It is these jobs that can be crashing because the critical path is an activity that affects the next activity. However, in this critical path there is a critical path that cannot be crashed because there is no additional overtime hours as in the DI-AB-AH-AP-AR-AV-BA-BJ-BN activities so that the path that can be crashed is ABCFHJNSTUVWXZ-AD -AM-AN-AQ-BB-BC-BD-BH-BI-BL.

The results of calculating daily productivity, hourly productivity, productivity after crash and crash duration with the addition of 3 hours of overtime work in full.

With the addition of working time, the cost for labor will increase from the normal cost of labor. In this calculation will be carried out with the addition of 3 hours on the critical path. The results of the calculations performed to determine

The results of the calculation of Cost Slope costs (added direct costs to speed up an activity per unit of time) are as follows:

Table 1. Cost Slopes

Activity Code	Time (Days)		Cost (IDR)		Cost Slopes (IDR)
	Normal	Added 3 Hours	Normal	Added 3 Hours	
A	2	1.89	6,000,000	6,853,050	7,755,000
B	2	1.89	2,649,900	3,026,657	3,425,064
C	4	3.60	8,186,778	8,701,839	1,287,653
D	1	1	1,801,932	1,801,932	0
E	1	1	5,511,792	5,511,792	0
F	3	2.70	14,137,746	15,969,373	6,105,423
G	2	2	13,249,500	13,249,500	0
H	5	4.66	10,472,405	11,954,028	4,357,715
I	1	1	3,611,814	3,611,814	0
J	6	5.33	8,479,680	9,283,265	1,199,381
K	1	1	7,066,400	7,066,400	0
L	2	2	2,685,232	2,685,232	0
M	2	2	2,826,560	2,826,560	0
N	7	6.28	17,411,610	19,654,629	3,115,304
O	3	3	16,535,367	16,535,367	0
P	2	2	1,882,489	1,882,489	0
Q	3	3	9,014,960	9,014,960	0
R	3	3	5,723,784	5,723,784	0
S	5	4.54	34,194,309	37,484,656	7,152,928
Q	2	1.59	1,831,611	2,005,712	424,637
U	3	2.70	16,280,986	18,392,432	7,038,153
V	8	7.20	28,572,042	31,624,733	3,815,864
W	3	2.70	23,252,880	24,926,921	5,580,137
X	2	1.80	19,138,950	20,023,515	4,422,825
Y	6	6	16,959,396	16,959,396	0
Z	7	6.30	26,832,281	29,615,220	3,975,627
A A	2	2	3,561,466	3,561,466	0

Activity Code	Time (Days)		Cost (IDR)		<i>Cost Slopes</i> (IDR)
	Normal	Added 3 Hours	Normal	Added 3 Hours	
AB	1	1	4,504,830	4,504,830	0
AC	2	2	1,297,391	1,297,391	0
AD	2	1.79	3,693,864	4,132,606	2,089,248
AE	1	1	847,968	847,968	0
AF	1	1	3,533,200	3,533,200	0
AG	2	2	2,119,920	2,119,920	0
AH	1	1	777,304	777,304	0
AI	1	1	706,640	706,640	0
AJ	2	2	5,829,780	5,829,780	0
AK	1	1	2,252,415	2,252,415	0
AL	1	1	1,469,811	1,469,811	0
AM	2	1.80	3,179,880	3,318,926	695,230
AN	2	1.80	7,949,700	7,974,587	124,435
AO	1	1	750,805	750,805	0
AP	1	1	2,148,186	2,148,186	0
I	7	6.30	13,646,063	15,062,811	2,023,926
AR	1	1	4,974,746	4,974,746	0
US	6	6	10,104,952	10,104,952	0
AT	1	1	618,310	618,310	0
AU	1	1	3,815,856	3,815,856	0
AV	1	1	17,666,000	17,666,000	0
AW	2	2	28,936,908	28,936,908	0
AX	1	1	780,000	780,000	0
Vv	1	1	7,066,400	7,066,400	0
AZ	1	1	4,239,840	4,239,840	0
BA	1	1	3,533,200	3,533,200	0
BB	4	3.60	3,072,000	3,470,400	996,000
BC	5	4.50	2,016,000	2,205,513	379,026
BD	2	1.80	1,180,000	1,333,155	765,775
BE	4	4	6,000,000	6,000,000	0
BF	6	6	4,166,688	4,166,688	0
BG	2	2	1,300,000	1,300,000	0
BH	3	2.71	5,299,800	5,991,895	2,386,534
BI	3	2.68	4,239,840	4,780,443	1,689,384
BJ	1	1	565,312	565,312	0
BK	1	1	1,483,944	1,483,944	0
Bl	2	1.80	3,674,528	4,151,081	2,382,765
BM	1	1	777,304	777,304	0
BN	1	1	1,978,592	1,978,592	0
Total	167	158	480,068,572	506,613,766	73,188,034

Source: Research data, 2022

CONCLUSION

Based on the description and discussion that has been done in the previous chapter, the conclusions that can be drawn in this study are:. Scheduling the completion of the Tangerang Two Residential Shophouse Development Project using the CPM method at the planning duration obtained the critical path which is located in the activities ABCDFHIJNSTUVWXZ-AB-AD-AH-AM-AN-AP-AQ-AR-AV-BA-BB-BC-BD- BH-BI-BJ-BL-BN with a duration of completion of 91 days from the initial planning duration of 154 days. Whereas using the CPM method on the duration of reality, the critical path is obtained which lies in the activities ABCDFHIJNSTUVWXZ-AB-AD-AH-AM-AN-AP-AQ-AR-AV-BA-BB-BC-BD-BH-BI-BJ-BL -BN with a completion duration of 101 days from the initial reality duration of 167 days;

Scheduling the completion of the Tangerang Two Residential Shophouse Development Project using the PERT method to obtain a critical path located in the activities ABCDFHIJNSTUVWXZ-AB-AD-AH-AM-AN-AP-AQ-AR-AV-BA-BB-BC-BD-BH-BI -BJ-BL-BN with a completion duration of 107 days out of the expected total time (te) of 181 days and has a completion probability of 0.62 percent. For a 99 percent Probability of falling on the 116th day; With the planning duration, the total final cost was Rp. 470,408,633 with a duration of 154 days. Whereas in the reality duration, the final total cost was recorded at IDR 480,068,572 with a duration of 167 days, after being accelerated by 9 days using a crashing project the resulting cost increased by IDR 26,545,194 with a completion time of 158 days and a final total cost of IDR 506,613,766.

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