Evaluation of Warehouse Renovation Project Scheduling in Bojonegoro Regency

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Abstract. Project scheduling is the process of managing time and sequencing all the work in it so as not to experience delays. The purpose of this study was to determine, analyze and evaluate the scheduling of warehouse renovation projects in Bojonegoro. The respondent of this research is a company engaged in construction services, namely PT DS. The analysis method used is Program Evaluation Review Technique (PERT). The results showed that the project undertaken by the company was delayed from 365 days to 608 days, then with the analysis of work network planning using the Program Evaluation Review Technique (PERT) method, it was obtained that the completion time that should have been completed with normal time was 374 days with the same labor costs between companies which amounted to Rp. 2,803,236,079.70. Thus, work network planning using the PERT method can shorten the project work time so that the project can be carried out more effectively and efficiently.

Keywords: Scheduling, project management, time, cost, PERT

1 Introduction

Evidence of the science of project management dates back thousands of years. So that it becomes evidence of the existence of giant pyramids in the city of Egypt. History also records that Indonesia also has a glorious record in project management, one of which is the Borobudur Temple in Magelang Regency, Central Java. The construction of the pyramids and Borobudur would not have been able to run if there were no people planning, organizing, and mobilizing workers and evaluating the construction. Project management has been applied from the beginning of human civilization. In the 1900s, project management was already applied to complex engineering projects. Two phenomenal figures of project management are Henry Gantt and Henry Fayol. Henry Gantt is called the father of planning and control techniques who is famous for using the *Gantt Chart* as a project management tool. While Henry Fayol is famous for the science of management functions that form the basis of knowledge related to projects and project management [1].

Project scheduling has the purpose of knowing the series of project activities and the period of project activities to facilitate the preparation of project activities. Along with the times, running a

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project requires project management to facilitate the running of a project (Larson translated by [1]. A company in carrying out operational management requires detailed scheduling. The scheduling carried out by the company aims to smooth all activities so that there are no errors in carrying out all activities. Project scheduling helps show the relationship of each activity to other activities and to the overall project, identifies relationships that must take precedence among activities, and shows realistic time estimates for each activity [2]

The main goal of the project is to satisfy customer needs. Over time in running the project, project management is needed to smooth the running of a project (Larson translated by [1]. The success or failure of project implementation is often due to poor planning of project activities and ineffective control. Project delay itself is a very undesirable condition, because this can harm both parties both in terms of time and cost. Then in relation to production time and costs, the company must be efficient in using time in each activity or activity, so that costs can be minimized from the original plan [3].

The increasing number of construction projects in Indonesia, especially the construction of factory buildings carried out by the company, requires the company to be able to complete the project on time at a cost that is in accordance with the plan. So that it requires handling good work scheduling management, therefore it needs to be handled with careful and thorough calculations. PT DS is a company engaged in construction services located on Jalan Raya Margorejo Surabaya, East Java. Project management is often ineffective in terms of project implementation time and completion targets are not as planned. The start time of the project is delayed, so it does not match the design required for construction, lack of equipment, availability of raw materials is not available and additional development items.

Table 1. Data on Warehouse Renovation Projects That Experience Delays in Completion Time

Project Name	Start Date	Duration	Date Completed	EOT	Length of Delay
Warehouse A Renovation	April 6, 2014	183 Days	October 5, 2014	November 14, 2014	40 Days
Warehouse B Renovation	June 14, 2014	365 Days	June 13, 2015	December 12, 2015	180 Days
Warehouse C Renovation	June 14, 2014	274 Days	March 14, 2015	April 28, 2015	45 Days
Warehouse D Renovation	August 28, 2014	274 Days	May 28, 2015	August 22, 2015	86 Days
Warehouse Renovation E	August 29, 2014	365 Days	August 28, 2015	November 30, 2015	94 Days

Source: PT DS (2014)

In the data above, it proves that the Warehouse renovation project is experiencing delays in its completion time. Based on the description of the background above, to overcome this, proper project management must be carried out with one of the methods in project management. The use of methods can help companies to manage projects more effectively and efficiently. Project management management can be calculated using the PERT (*Project Evaluation and Review Technique*) method. The purpose of this method is to find out when the project is completed. So research is needed to find out and analyze how long the project can be completed and the amount of cost required.

2 Literature Review

Heizer & Render [4] explain that planning activities are used to determine when and where each operation should be carried out. Scheduling is done to manage limited resources. Effective project scheduling can result in cost savings and increased productivity. In addition, effective scheduling can produce other benefits [5]. According to [6] in the book Project Management [1] that projects are temporary efforts to produce unique products or services. Then according to [7] in the book Project Management [1], projects are complex, non-routine activities and one-time efforts limited by time, budget, resources, and performance specifications designed to meet customer needs. The schedule is prepared to serve as a reference for project implementation as well as a basis for monitoring the implementation of the project in question. The earliest form of schedule applied in project management is the *Gantt Chart* [8]. Projects require control tools such as *Gantt charts* or PERT *charts* are needed in a project to measure and control [6] in the book Project Management written by [1].

According to [7] in Dimyati & Nurjaman's Project Management Boo, the main goal of a project is to satisfy customer needs. Similarities aside, the characteristics of a project can help distinguish it

from others in an organization. The main characteristics of projects are goal setting, a defined lifespan from start to finish, involving several departments and professionals, doing something that has never been done before, time and cost are specific requirements.

Schwalbe translated by [1] that every project is limited by *scope*, *time*, and *cost*. These limits are often used in project management as the three main limits. For the project to be successful, the project manager must consider the following. First, what scope of work will be performed as part of the project, as well as what products and services or results the customer (sponsor) wants the project to deliver. Second, the time required to complete a project. Third, the cost required to complete a project.

The following are some of the main characteristics of projects including (1) having a clear goal; (2) being temporary; (3) being unique and non-recurring; (4) having limitations (scope, time, cost, and quality); (5) involving various resources; (6) being risky and having uncertainty; (7) requiring project management; (8) can involve many stakeholders. According to [1] project planning methods include scheduling methods with beam diagrams, work network methods, PERT (*Program Evaluation Review Technique*), CPM (*critical path method*), scheduling methods using the precedent diagram method (PDM) [9].

The following is a framework that will be raised in the problem, as written in the picture below.

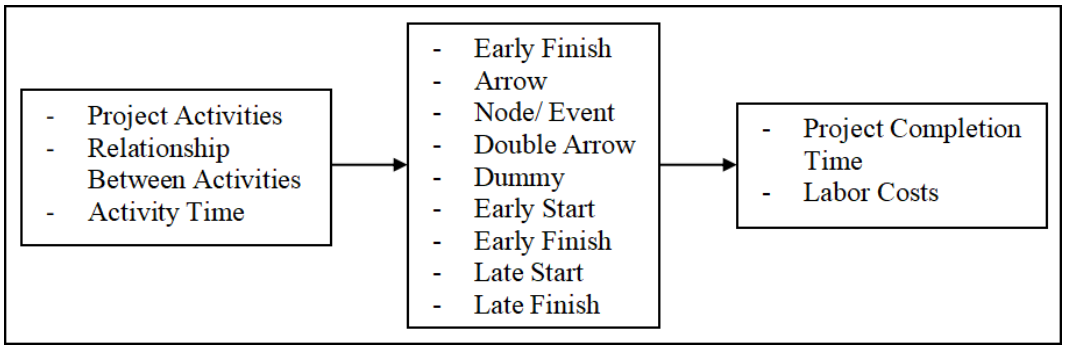


Figure 1. Framework

Source: [10]

From the framework above, it is explained that the research process that starts from input, process, and output can be developed in indicator points. Starting from the input in the form of activities, relationships between activities and activity time, which in scheduling requires the three indicators to achieve goals. Furthermore, in the process section that activities, relationships between activities and activity time are indicators in project scheduling. At input and the process is expected to get output in the project. The expected output is in the form of project completion time and project labor costs.

3 Research Method

This research was conducted at PT DS using the documentation study data collection method. The type of research used in this study is to use model applications. Model application is a type of research that emphasizes practical problem solving directed at answering specific questions in determining certain performance policies (Indriantoro & Supomo, 2013). The operational definition of variables in this study is adjusted to the research framework. The framework in this study are project activities, relationships between activities, activity time, *Network Planning*, project completion time and labor costs.

The data analysis used in this research is PERT (*Program Evaluation Review Technique*), according to [10] the steps in *Network Planning* are (1) inventorying activities, (2) compiling inter-activity relationships, (3) setting the time for each activity [8], (4) compiling a *network* diagram that connects all activities in this step, (5) identifying *critical paths* on the *network* diagram, and (6) conducting time-cost and resource analysis.

Working time can be divided into three categories of time symbolized by symbols, namely optimistic time (α), pessimistic time (b), Most Likely time (m). The approach used to determine the processing time is the *expected time* method which is called PERT (*Program Evaluation Review Technique*) [12]:

$$expected\ time\ (t_{e=\frac{\alpha+4m+b}{6}})$$

Where:
α = optimization time
b = pessimistic time
m = most likely time

4 Result and Discussion

Analyzing the data required steps in the Warehouse renovation project schedule series. The first step is to outline the project activities (shown in table 2). The second step creates relationships between activities. It can be seen which activities can be preceded and which activities can precede other activities (shown in table 3).

The activity relationship of all project activities is explained. It can be seen that combining the same activities can reduce the length of time. In addition, using the relationship between activities is also able to determine the activity network which will be explained in the next section [11]. Activity relationships explain the various activities such as activity A followed by activities B and C, activities B and C followed by activity D, activity D followed by activities E and F, activities E and F followed by activities G and H, activities G and H followed by activities I, J, K and so on as explained in the table above. The relationship between the above activities can be concluded that the interconnected activities provide a link that can affect the performance of the activity, this activity can also speed up the activity by calculating the time in the next section [13].

The third step is to create activity times (shown in table 4). The renovation project activities have been determined by PT DS for each activity. So that it will become a reference for the company in working on the project. Warehouse renovations are determined by the actual time of the company and the time made using the PERT (*Program Evaluation Review Technique*) method. The estimated completion value of each activity (t_e) is transferred to the corresponding diagram. On a PERT diagram, the activity symbol is written above the arrow line and the activity time is written below it.

The fourth step is to create a work network. The work network is drawn through the *predecessor* that has been connected from the previous activity. The merged activities will form an event that can find out the longest activity in an activity.

In the explanation from figure 2 and figure 3, the stage continues with the creation of a *network diagram of* work network planning can be seen in the picture above. The picture above explains that the AOA image and its time. The work network in the picture above is useful for knowing which work should take precedence and which work should wait for the completion of other activities. As previously stated, activity A in the picture above is followed by activities B and C, activities B and C are followed by activity D, activity D is followed by activities E and F, activities E and F are followed by activities G and H, activities G and H are followed by activities I, J, K and so on as explained above.

In the Gantt Diagram (shown in figure 4), it can be interpreted that by using a Gantt diagram, it can be seen that time games are being played. As in activities B and C, both activities can be done simultaneously. As with activities E and F then activities I, J and K, activities G and H, activities I, J and K, activities L and M, activities N, O, P and Q, activities R and S, then activities V and W.

These activities can be done simultaneously using different colors will greatly help workers to analyze [14].

The fifth step determines the critical path of the activity (shown in table 5). PERT method will be applied to the Warehouse renovation project, this method is used to determine the critical path. The critical path can be done by knowing the ES, EF, LS and LF values of an activity.

From table 5, it can be seen that by using ES, EF, LS, LF, the values of each activity can be known. The longest time is found in activity B which is 20 days, activity E is 21 days, activity G is 6 days, activity I is 3 days, activity K is 20 days, activity M is 9 days, activity N is 7 days, activity Q is 24 days, activity S is 27 days and activity V is 3 days. This delays each activity which can cause various activities to be delayed, not only that activity but also other activities which result in losing their extension time.

From the results of the critical path calculation, it can be seen that the critical path crosses the activity (A - C - D - F - H - J - L - O - P - R - T - U - W - X - Y). The amount of time required in the renovation project using the PERT method is 374 days, it can be seen in the Warehouse renovation design work network diagram in the following figure. While the time required by the company in the renovation project is 608 days.

The sixth step analyzes time-cost and resources. Analyze the time-cost and resources available in the Warehouse renovation project as shown in table 6. Based on the above calculations, the project implemented by PT DS for 608 days costs Rp. 7,219,518,358.40. If the project is implemented using the PERT (*Program Evaluation Review Technique*) method, it will be completed in 374 days. This affects the use of human resources which will reduce the completion time of the Warehouse renovation. In a project that lasts for 608 days requires labor costs of Rp 2,803,236,079.70 or 38.83% of the project cost. While using the PERT method there is no difference in cost due to the system of giving wages based on *volume.*

Table 2. Project Activity Description

No.	Activity Code	Activity Name
Preparation		
1.	A	Preparation of Manpower, Experts and Heavy Equipment
Warehouse		
2.	B	Window Removal, Brick Wall, Plaster Aci Work
Mess and Kitchen		
3.	C	Litplank Work
Office		
4.	D	Listplank Work
Warehouse		
5.	E	Roof Work
Mess and Kitchen		
6.	F	Gutter Work
Office		
7.	G	Gutter Work
Mess and Kitchen		
8.	H	Ceiling Work
Office		
9.	I	Ceiling Work
Warehouse		
10.	J	Wall Acian Work
Office		
11.	K	Acian Work
Mess and Kitchen		
12.	L	Ceramic Work
Office		
13.	M	Ceramic Work
Mess and Kitchen		
14.	N	Paint Job
Office		
15.	O	Paint Job
Warehouse		
16.	P	Exterior wall paint job
17.	Q	Exterior Wall Paint Work of Warehouse
Mess and Kitchen		
18.	R	Termite Proof Work
Office		
19.	S	Termite Proof Work
Utility		
20.	T	New Guard Post Work
21.	U	Existing Guard Post Work
22.	V	Parking Lot Work

No.	Activity Code	Activity Name
Infrastructure		
23.	W	Kansteen's work
Warehouse		
24.	X	External Steel Paint Job & Fence
Infrastructure		
25.	Y	Aspalt Road Work

Source: PT DS (2016)

Table 3. Relationship between Activities

Activity Code	Activity Description	Duration	Predecessor
Preparation			
A	Preparation of Manpower, Experts and Heavy Equipment	7 Days	-
Warehouse			
B	Window Removal, Brick Wall, Plaster Aci Work	19 Days	A
Mess and Kitchen			
C	Litplank Work	39 Days	A
Office			
D	Listplank Work	18 Days	B,C
Warehouse			
E	Roof Work	15 Days	D
Mess and Kitchen			
F	Gutter Work	36 Days	D
Office			
G	Gutter Work	9 Days	E,F
Mess and Kitchen			
H	Ceiling Work	15 Days	E,F
Office			
I	Ceiling Work	36 Days	G,H
Warehouse			
J	Wall Acian Work	39 Days	G,H
Office			
K	Acian work	19 Days	G,H
Mess and Kitchen			
L	Ceramic Work	18 Days	I,J,K
Office			
M	Ceramic Work	9 Days	I,J,K
Mess and Kitchen			
N	Paint Job	27 Days	L,M
Office			
O	Paint Job	34 Days	L,M
Warehouse			
P	Exterior wall paint job	30 Days	L,M
Q	Exterior Wall Paint Work of Warehouse	24 Days	L.M
Mess and Kitchen			
R	Termite Proof Work	54 Days	P,Q

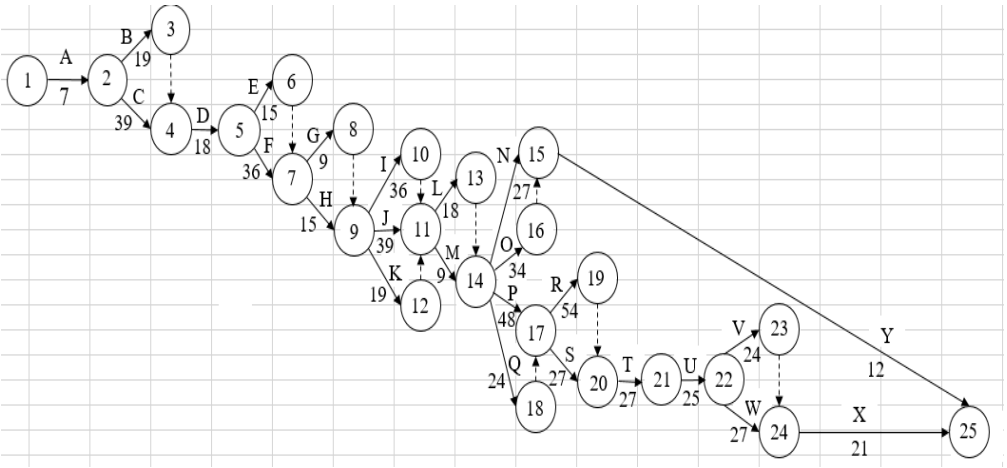
Activity Code	Activity Description	Duration	Predecessor
Office			
S	Termite Proof Work	27 Days	P,Q
Utility			
T	New Guard Post Work	27 Days	R,S
U	Existing Guard Post Work	25 Days	T
V	Parking Lot Work	24 Days	U
Infrastructure			
W	Kansteen's work	27 Days	U
Warehouse			
X	External Steel Paint Job & Fence	21 Days	V,W
Infrastructure			
Y	Aspalt Road Work	12 Days	N,O

Source: PT DS (2016)

Table 4. Project Activity Time with PERT Method

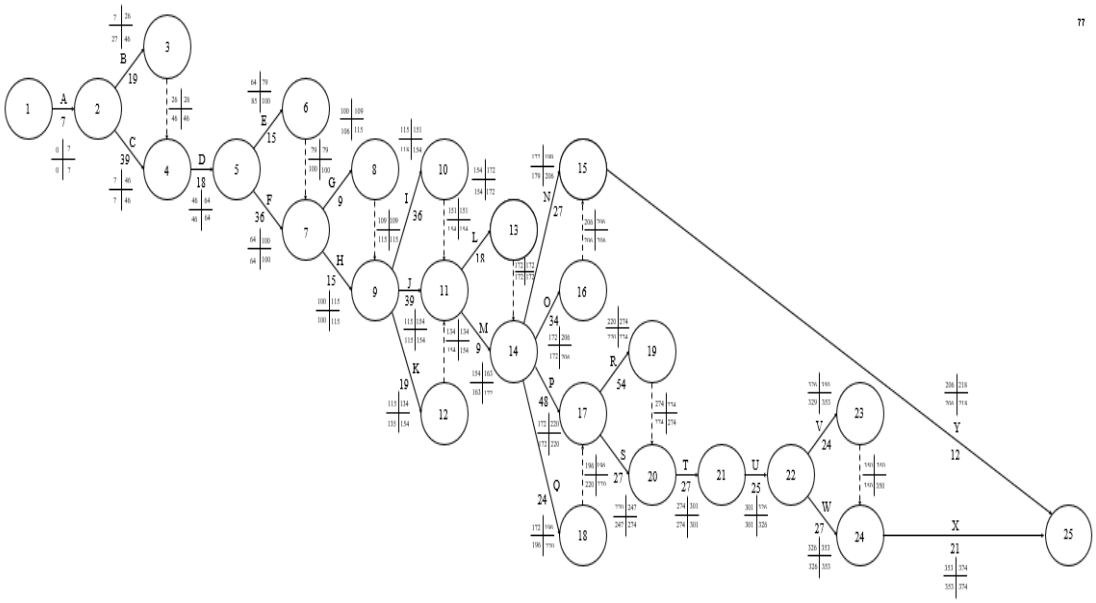
Activities	Completion Time (Days)			Expected Time $t_e = \alpha + 4m + b)/6$
	α	M	b	
A	6	7	8	7
B	18	19	20	19
C	38	39	40	39
D	17	18	19	18
E	14	15	16	15
F	35	36	37	36
G	8	9	10	9
H	14	15	16	15
I	35	36	37	36
J	38	39	40	39
K	18	19	20	19
L	17	18	19	18
M	8	9	10	9
N	26	27	28	27
O	33	34	35	34
P	47	48	49	48
Q	23	24	25	24
R	53	54	55	54
S	26	27	28	27
T	26	27	28	27
U	24	25	26	25
V	23	24	25	24
W	26	27	28	27
X	20	21	22	21
Y	11	12	13	12

Source: PT DS (2016)



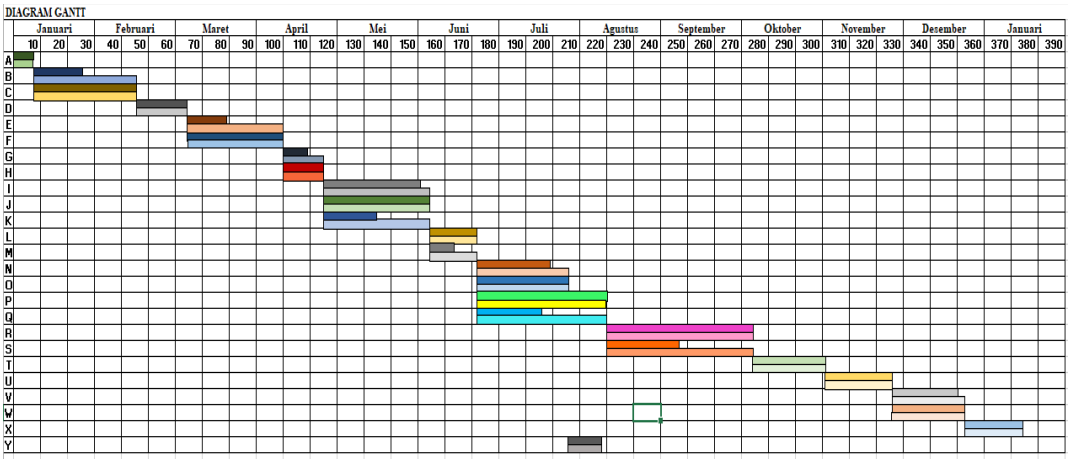
Source: PT DS (2016)

Figure 2. PERT diagram of renovation project



Source: PT DS (2016)

Figure 3. Calculation of Activity Completion Time and Overall Project



Source: PT DS (2016)

Figure 4. Gantt diagram

Table 5. Longest Time Path

Activities	ES Early Start Time	Early Finish Time EF	LS Latest Start Time	LF Latest Finish Time	Longest Time LS - ES	Critical Path
A	0	7	0	7	0	Yes
B	7	26	27	46	20	No
C	7	46	7	46	0	Yes
D	46	64	46	64	0	Yes
E	64	79	85	100	21	No
F	64	100	64	100	0	Yes
G	100	109	106	115	6	No
H	100	115	100	115	0	Yes
I	115	151	118	154	3	No
J	115	154	115	154	0	Yes
K	115	134	135	154	20	No
L	154	172	154	172	0	Yes
M	154	163	163	172	9	No
N	172	199	179	206	7	No
O	172	206	172	206	0	Yes
P	172	220	172	220	0	Yes
Q	172	196	196	220	24	No
R	220	274	220	274	0	Yes
S	220	247	247	274	27	No
T	274	301	274	301	0	Yes
U	301	326	301	326	0	Yes

Activities	ES Early Start Time	Early Finish Time EF	LS Latest Start Time	LF Latest Finish Time	Longest Time LS - ES	Critical Path
V	326	350	329	353	3	No
W	326	353	326	353	0	Yes
X	353	374	353	374	0	Yes
Y	206	218	206	218	0	No

Source: PT DS (2016)

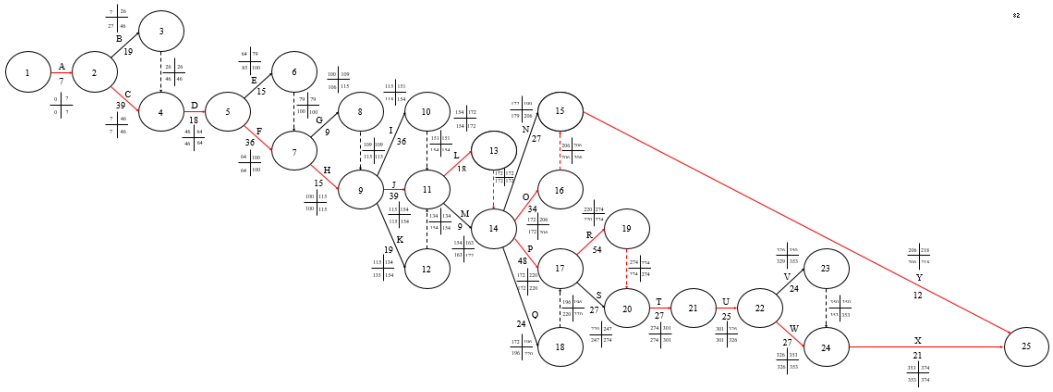


Figure 5. Critical Path

Table 6. Renovation Project Cost

Job Code	Job Description	Duration (Days)	Material Quantity (Area m²)	Material Cost	Number of Workers	Labor Cost	Total Cost
1	**Preparation**						
1.1	Preparation of labor, experts, and heavy equipment	7				820,073,000.00	820,073,000.00
2	**Mess hall and kitchen**						
2.1	Mess and Kitchen	19	200.00	27,400,976.25	4	8,190,175.00	35,591,151.25
2.2	Ceramic Works	27	675.27	28,605,902.93	19	19,761,265.09	48,367,167.93
2.3	Painting Works	36	17.8	15,642,000.00	2	9,849,930.00	25,491,930.00
2.4	Gutter Works	15	442.00	23,590,500.00	9	8,085,285.00	31,675,785.00
2.5	Ceiling Works	39	56.64	2,526,634.28	1	2,095,680.00	4,622,314.28
2.6	Listplank Works	54	371.20	9,187,200.00			9,187,200.00

Job Code	Job Description	Duration (Days)	Material Quantity (Area m²)	Material Cost	Number of Workers	Labor Cost	Total Cost
3	**Office**						
3.2	Anti-Termite Works	36	1,797.26	45,227,420.45	11	21,738,314.45	66,965,734.90
3.2	Office	18	74.37	50,879,424.62	8	14,292,240.80	65,171,665.42
3.5	Gutter Works	9	281.63	30,032,700.00	49	35,568,154.53	65,600,854.53
3.6	Anti-Termite Works	27	999.30	24,732,576.00			24,732,576.00
3.7	Plastering Works (Warehouse)	19					
4	**Warehouse**						
4.1	Exterior Wall Painting Works	48	7,802.18	348,044,763.67	70	288,680,660.00	636,725,423.67
4.2	Dismantling of Windows, Brick Walls, and Plaster Works	19	1,505.86	266,681,540.99	109	180,658,909.87	447,340,450.86
4.3	Warehouse Exterior Wall Painting Works	24	385.31	17,188,339.68	7	14,256,618.00	31,444,957.68
4.4	Roof Works	15	17,404.00	1,318,862,092.80	153	204,855,000.00	1,523,717,092.80
4.5	Exterior Steel and Fence Painting Works	21	9.00	378,989,444.03	181	514,029,322.09	893,018,766.12
4.6	Wall Plastering Works	39	1,505.86				
5	**Infrastructure Works**						
5.1	Curb Work	27	2,695.28	261,740,986.28	65	153,202,798.40	414,943,784.68
5.2	Asphalt Road Work	12	29,228.00	1,369,771,500.00	21	424,770,250.00	1,794,541,750.00
6	**Utility Works**						
6.1	Car Parking Area Work	24	240.00	7,836,000.00	14	26,410,000.00	34,246,000.00
6.2	New Guard Post Work	27	30.00	90,000,000.00	-	-	90,000,000.00
6.3	Existing Guard Post Work	25	131.70	5,874,736.95	2	4,872,715.00	10,747,451.95
Total Duration : 608 Days						2,803,236,079.70	7,219,518,358.40

Source: PT DS (2016)

5 Concluison and Recommendation

The results of the research that has been done can be concluded that PT DS in carrying out warehouse renovations with the aim of facilitating warehouse operational activities in Kedungbondo Bojonegoro. The renovation is planned to be completed for 365 days but at the time of implementation there was a delay of 243 days so that the project was completed in 608 days. While using the PERT (*Program Evaluation Review Technique*) method, the time required for warehouse renovations is 374 days. So it can be proven that the difference obtained is 234 days from the project carried out by the company. Labor costs at the time of planning amounted to Rp. 2,803,236,079.70 and at the time of work until completion of labor costs have not changed. While labor costs using the *Program Evaluatuon Review Technique* (PERT) method are the same as those carried out by the company of Rp. 2,803,236,079.70. This is because the calculation of labor costs uses *volume* calculations.

Based on the results of the research and the results of the analysis using the PERT (*Prohram Evaluation Review Technique*) method, namely (1) PT. DS in compiling the linkage of activities with one another must be more careful because it is very important to the length of the project, so that it can determine the completion of the project as a whole. As well as the level of linkage between one activity and another makes the linkage relationship require more understanding so that there are no errors in making the project work network, (2) For further researchers, it is expected to conduct research on more than one project location of the same type and use operational costs.

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