BAREKENG: Journal of Mathematics and Its Applications
March 2024 Volume 18 Issue 1 Page 0105–0116
P-ISSN: 1978-7227 E-ISSN: 2615-3017
https://doi.org/10.30598/barekengvol18iss1pp0105-0116

# SCHEDULING ANALYSIS BEDUGUL VILLA CONSTRUCTION PROJECT USING PERT AND CPM METHODS

**Kiswara Agung Santoso[1*], Ade Ratna Yusnita[2], Agustina Pradjaningsih[3]**

[1,2,3] *Department of Mathematics, Faculty of Mathematics and Natural Science, Jember University*
*Kalimantan Street No 37, Jember, 68121, Indonesia*

*Corresponding author's e-mail:* ***** ***kiswara.fmipa@unej.ac.id***

***Article History:***

*Received: 20th July 2023*
*Revised: 17th November 2023*
*Accepted: 18th December 2023*

***Keywords:***

*Construction Scheduling;*
*PERT;*
*CPM;*
*Optimum Duration.*

*ABSTRACT*

*Scheduling in construction projects is necessary so that the planned time to complete the project can be achieved on time. The methods used in optimizing project scheduling are the Project Evaluation Review Technique (PERT) and the Critical Path Method (CPM). Bedugul Villa is one of the projects that has been carried out with a work contract for 175 calendar days, the scheduling of which will be optimized in this study. The optimal duration for scheduling with the PERT method is 170 calendar days. The duration is 5 days faster than the existing schedule prepared by the project construction contractor, which is 175 calendar days. The probability of completion of the project is 87.7%. Calculations using the CPM method are 168 calendar days or 7 days earlier than the existing schedule made by the contractor.*



***How to cite this article:***

K. A. Santoso, A. R. Yusnita and A. Pradjaningsih., "SCHEDULING ANALYSIS BEDUGUL VILLA CONSTRUCTION PROJECT USING PERT AND CPM METHODS," *BAREKENG: J. Math. & App.*, vol. 18, iss. 1, pp. 0105-0116, March, 2024.


Journal homepage: *https://ojs3.unpatti.ac.id/index.php/barekeng/*
Journal e-mail: *barekeng.math@yahoo.com; barekeng.journal@mail.unpatti.ac.id*

**Research Article · Open Access**

## 1. INTRODUCTION

The construction project is an activity that has the goal of constructing a building, house, or other by maximizing various existing resources such as materials, tools, labor, and costs [1]. Planning and control are part of optimizing the construction of the project itself. Planning is closely related to construction projects [2]. Planning is done by analyzing time, cost, and quality so that the efficiency of a project can be achieved. In control, the goal to be achieved is to minimize various problems during the project so that the results do not deviate. One part of planning is scheduling. Scheduling is needed so that the planned time to complete the project can be achieved on time [3]. Used in optimizing project scheduling, namely the Project Evaluation Review Technique (PERT) method and the Critical Path Method (CPM) method [4], [5]. PERT is a method for determining the time required to complete a project that cannot be estimated with certainty and uses three-time estimates, while CPM is a method used to determine project completion time within one estimated time [6]. Villa Bedugul is one of the projects that has been carried out with a work contract for 174 calendar days and was completed on time. Based on the explanation above, the authors are interested in comparing the application of the PERT and CPM methods to analyze the scheduling of the Bedugul Villa construction project [7]. Completion assisted with QM for Windows software [8], [9].

## 2. RESEARCH METHODS

Data is a collection of facts that can be trusted to be accurate; the available data is often raw data that has not been compiled and has no information, so the data needs to be processed in such a way to get information. The following details the data needed: Activity data to complete the construction of Bedugul Villa, Sequence of each activity, and list of 3 estimated times for each activity. Data processing uses calculations using the PERT and CPM methods [10].

The steps for implementing the PERT method are as follows:

a. Record 3 types of estimated time required for PERT method calculations.

b. Calculating the effective duration of all activities on the project as in the following equation:

$$Te = \frac{a + 4m}{6} \tag{1}$$

where:

$Te$ : effective duration of activity

$a$ : optimistic time

$m$ : realistic time

c. Find the variance and standard deviation values of activities that are on the critical path using the equation below [10], [11]:

$$V(Te) = S^2 = \left[\frac{b - a}{6}\right]^2 \tag{2}$$

$$S = \left[\frac{b - a}{6}\right] \tag{3}$$

where:

$S$ : standard Deviation

$V$ : variance

$a$ : optimistic time

$b$ : pessimistic time

d. Calculating the probability of successful completion of the project on time using the following equation [12].

$$Z = \frac{T(d) - Te}{S} \quad (4)$$

where:

$Z$ : probability of the project being completed on time

$T(d)$: target completion duration of the project

$Te$ : effective duration of activity

$S$ : standard deviation

Next is the calculation using the CPM method:

a. Record the activities carried out on the project in accordance with the data provided by the contractor.

b. Sequencing activities is done by compiling activities according to the time the activities began.

c. Preparation of network planning or work networks from data on job sequences and the duration of each job so that the interrelationships of one job and another can be identified through the network.

d. Determine Activity Time for each activity.

The period of activity or known as activity time is described as follows [13].

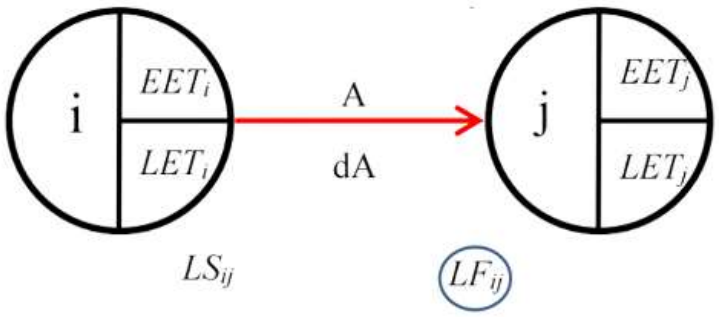


**Figure 1. Activity Time**

**Figure 1** shows a chart of the activity of job i followed by job j. The description of the alphabet above can be explained as follows:

$i \; in \; j$ : activity number

$A$ : activity symbol

$dA$ : period of activity

$EET_i$ : earliest start of activity i

$EET_j$ : earliest start of activity j

$LET_i$: $LF_{ij}$ : latest finish, the latest time the activity will finish

e. Forward and backward calculations are carried out as in. From the results of these calculations, it can be seen that the ES, EF, LS to LF of each activity.

The stages in calculating advanced calculations are [14]:

1) If the initial event is set on day zero then:

$$TE = 0$$

Where $TE$: Earliest time an event can finish.

2) If the initial event is carried out on day zero, it can be described as follows.

$$ES = TE = 0$$

$$EF = ES + t$$
$$= TE + t$$

where:

$ES$ : Earliest Start, the earliest activity start time

$TE$ : Earliest time an event can finish

$EF$ : Earliest Finish, the fastest ending time for activities

$t$ : Period of activity.

3) Activities that are preceded by more than two activities, then,

$$TE = \max\left(EF_{(1)}, EF_{(2)}, \ldots EF_{(3)}\right) \quad (5)$$

The steps to calculate the countdown are:

1) At the very last activity of the network or terminal event applies

$$TL = TE$$

where:

$TL$ : The last time the last activity ends

$TE$ : Earliest time an event can finish.

2) The latest time for an activity to start is equal to the latest time the activity can be completed minus the duration or period time of the activity **[15]**:

$$LF = TL \qquad where \quad TL = TE$$
$$\text{with} \quad LS = LF - t \qquad \text{so} \quad LS = TL - t$$

where:

$LS$ : the last time the activity starts

$LF$ : the last time the activity was completed

$t$ : duration or period of activity

$TL$ : the last time the last activity ends

$TE$ : earliest time an event can finish

3) Activities that are preceded by more than two activities, then

$$TL_i = \min\left(LS_{(1)}, LS_{(2)}, \ldots, LS_{(n)}\right)$$

where:

$TL$ : the last time the last activity ends

$LS$ : the last time the activity starts

f. Next is to find the Float value using the equation below.

$$TF = LS - ES - t$$
$$= LF - EF = LS - ES \quad (6)$$

where:

$TF$ : total floats

$LS$ : the last time the activity starts

$t$ : activity duration

$ES$ : earliest start time of activity

*LF* : the last time the activity was completed

*EF* : the fastest ending time of the activity

g. Determining the critical path is based on the Float value of each activity. The critical path is determined by activities that have a Float value of 0. To get the completion time with the CPM method, we add each activity duration that is included in the critical path.[16]

## 3. RESULTS AND DISCUSSION

Calculation of the optimal duration for the construction of the Villa Bedugul project using QM for Windows.

1. Calculations Using the PERT Method

Data processing begins with compiling data in the form of three-time estimates for each activity on the project. The three-time estimates are optimistic time (a), realistic time (m), and pessimistic time (b). Table 1 is the estimated time for each activity that has been described by the contractor according to the conditions in the field.

**Table 1. PERT Time Estimates**

| Work Description | a (days) | m (days) | b (days) | Work Description | a (days) | m (days) | b (days) |
|---|---|---|---|---|---|---|---|
| Setting out Bowplank | 3 | 7 | 8 | Concrete Slabs and beams | 18 | 21 | 25 |
| Excavate the footplate | 7 | 14 | 16 | Ladder | 5 | 7 | 9 |
| Foot plate concrete | 4 | 7 | 8 | Practical wall + column work (brick, plaster) | 26 | 28 | 35 |
| Pedestal column | 4 | 7 | 8 | Timber and roofing work | 27 | 28 | 40 |
| Continuous foundation excavation | 4 | 7 | 8 | Wood wall and sill work | 14 | 21 | 23 |
| Backfill Sand Under Foundation | 4 | 7 | 8 | Doors and windows and railing work | 12 | 14 | 17 |
| Redeployment Jobs | 4 | 7 | 8 | Furniture (kitchen) | 20 | 21 | 27 |
| Scrap the floor | 4 | 7 | 8 | Wall and floor finishing work | 27 | 28 | 40 |
| Workshop floor | 4 | 7 | 9 | Ceiling work | 16 | 21 | 22 |
| Empty masonry installation | 4 | 7 | 9 | Wood finishing work | 12 | 14 | 16 |
| Stone Foundation | 8 | 14 | 16 | Electrical sparing work | 10 | 14 | 15 |
| Selof Concrete Work/ Ground beam | 10 | 14 | 17 | Electrical Installation and Plumbing Panel Work | 13 | 14 | 20 |
| Floor concrete | 4 | 7 | 9 | Electrical accessories work | 15 | 21 | 22 |
| Concrete Column Structure | 14 | 21 | 23 | Sanitary work | 4 | 7 | 8 |

The next step is to determine the effective duration of activities on the project. Determining the effective duration of activities can be calculated using Equation (1). Table 2 below is the effective duration (Te) of activities in the Bedugul Villa construction project.

**Table 2. Test Value**

| Code | Work description | a (days) | m (days) | b (days) | Te (days) |
|---|---|---|---|---|---|
| A | Setting out Bowplank | 3 | 7 | 8 | 6.5 |
| B | Excavate the footplate | 7 | 14 | 16 | 13.17 |
| C | Foot plate concrete | 4 | 7 | 8 | 6.67 |
| D | Pedestal column | 4 | 7 | 8 | 6.67 |
| E | Continuous foundation excavation | 4 | 7 | 8 | 6.67 |
| F | Backfill Sand Under Foundation | 4 | 7 | 8 | 6.67 |
| G | Redeployment Jobs | 4 | 7 | 8 | 6.67 |

| Code | Work description | a (days) | m (days) | b (days) | Te (days) |
|---|---|---|---|---|---|
| H | Scrap the floor | 4 | 7 | 8 | 6.67 |
| I | Workshop floor | 4 | 7 | 9 | 6.83 |
| J | Empty masonry installation | 4 | 7 | 9 | 6.83 |
| K | Stone Foundation | 8 | 14 | 16 | 13.33 |
| L | Selof Concrete Work / Ground beam | 10 | 14 | 17 | 13.83 |
| M | Floor concrete | 4 | 7 | 9 | 6.83 |
| N | Concrete Column Structure | 14 | 21 | 23 | 20.17 |
| *O* | Concrete Slabs and beams | 18 | 21 | 25 | 21.17 |
| *P* | Ladder | 5 | 7 | 9 | 7 |
| Q | Practical wall + column work (brick, plaster) | 26 | 28 | 35 | 28.83 |
| R | Timber and roofing work | 27 | 28 | 40 | 29.83 |
| S | Wood wall and sill work | 14 | 21 | 23 | 20.17 |
| T | Doors and windows and railing work | 12 | 14 | 17 | 14.17 |
| U | Furniture (Kitchen) | 20 | 21 | 27 | 21.83 |
| V | Wall and floor finishing work | 27 | 28 | 40 | 29.83 |
| W | Ceiling Work | 16 | 21 | 22 | 20.33 |
| *X* | Wood finishing work | 12 | 14 | 16 | 14 |
| Y | Electrical Sparing Work | 10 | 14 | 15 | 13.5 |
| Z | Electrical Installation and Plumbing Panel Work | 13 | 14 | 20 | 14.83 |
| AA | Electrical Accessories Work | 15 | 21 | 22 | 20.17 |
| AB | Sanitary work | 4 | 7 | 8 | 6.67 |

The next step is to calculate the variance and standard deviation of each activity in the Bedugul Villa Construction Project. Activity variance can be calculated using **Equation (2)** and **Equation (3)**. The variance (V) and standard deviation (S) values of all project activities can be seen in **Table 3.**

**Table 3. V And S Value**

| Code | Work description | a (days) | m (days) | b (days) | V | S |
|---|---|---|---|---|---|---|
| A | Setting out Bowplank | 3 | 7 | 8 | 0.69 | 0.83 |
| B | Excavate the footplate | 7 | 14 | 16 | 2.25 | 1.5 |
| C | Foot plate concrete | 4 | 7 | 8 | 0.44 | 0.67 |
| D | Pedestal column | 4 | 7 | 8 | 0.44 | 0.67 |
| E | Continuous foundation excavation | 4 | 7 | 8 | 0.44 | 0.67 |
| F | Backfill Sand Under Foundation | 4 | 7 | 8 | 0.44 | 0.67 |
| G | Redeployment Jobs | 4 | 7 | 8 | 0.44 | 0.67 |
| H | Scrap the floor | 4 | 7 | 8 | 0.44 | 0.67 |
| I | Worksjop floor | 4 | 7 | 9 | 0.69 | 0.83 |
| J | Empty masonry installation | 4 | 7 | 9 | 0.69 | 0.83 |
| K | Stone Foundation | 8 | 14 | 16 | 1.78 | 1.33 |
| L | Selof Concrete Work / Ground beam | 10 | 14 | 17 | 1.36 | 1.17 |
| M | Floor concrete | 4 | 7 | 9 | 0.69 | 0.83 |
| N | Concrete Column Structure | 14 | 21 | 23 | 2.25 | 1.5 |
| *O* | Concrete Slabs and beams | 18 | 21 | 25 | 1.36 | 1.17 |
| *P* | Ladder | 5 | 7 | 9 | 0.44 | 0.67 |
| Q | Practical wall + column work (brick, plaster) | 26 | 28 | 35 | 2.25 | 1.5 |
| R | Timber and roofing work | 27 | 28 | 40 | 4.69 | 2.17 |
| S | Wood wall and sill work | 14 | 21 | 23 | 2.25 | 1.5 |
| T | Doors and windows and railing work | 12 | 14 | 17 | 0.69 | 0.83 |
| U | Furniture (Kitchen) | 20 | 21 | 27 | 1.36 | 1.17 |
| V | Wall and floor finishing work | 27 | 28 | 40 | 4.69 | 2.17 |
| W | Ceiling Work | 16 | 21 | 22 | 1 | 1 |
| *X* | Wood finishing work | 12 | 14 | 16 | 0.44 | 0.67 |
| Y | Electrical Sparing Work | 10 | 14 | 15 | 0.69 | 0.83 |
| Z | Electrical Installation and Plumbing Panel Work | 13 | 14 | 20 | 1.36 | 1.17 |
| AA | Electrical Accessories Work | 15 | 21 | 22 | 1.36 | 1.17 |
| AB | Sanitary work | 4 | 7 | 8 | 0.44 | 0.67 |

Determining the optimal duration of the PERT method is by adding up the effective duration of activities that enter the critical path. Jobs that enter the critical path are 12 jobs with the help of Windows QM software. From **Table 3**, the optimal duration is 175 calendar days.

The next step is to determine the probability of completion of the project on target. The determination of probability requires the standard deviation value of the critical path in its calculations where the standard deviation value is obtained by taking the square root of the variance value on the critical path. The calculation of the critical path variance is as follows:

Critical V = V(A) + V(C)+ V(E) + V(I) + V(K) + V(L) + V(M) + V(O) + V(R) + V(V) + V(AB) +V(U)

= 0.69 +0.44 + 0.44 +0.69 + 1.78 + 1.36 + 0.69 + 1.36 + 4.69 + 4.69 + 0.44 + 1.36

= 18.63

The calculation of the standard deviation of the critical path is as follows:

$$\text{Critical S} = \sqrt{18.63} = 4.31$$

The percentage to know the project is completed at that duration is as follows

$$Z = \frac{175-174}{4{,}31} = 1.16$$

The Z value that has been calculated will be adjusted to the Z normal distribution table to get the probability of success. The Z value obtained is 1.16. This value if adjusted with the normal Z distribution **Table 3** is 0.8770. This result means that the percentage of the Bedugul Villa construction project can be carried out according to the target which for 175 days is 87.7%.

2. Calculations Using the CPM Method

Data processing begins with compiling data types and relationship activities on the project. In **Table 4** it can be seen the number and type and relationship of project activities and their duration.

**Table 4. Activity Relationship**

| Code | Work Description | Predecessor | Duration (Days) |
|---|---|---|---|
| A | Setting out Bowplank | - | 7 |
| B | Excavate the footplate | A | 14 |
| C | Foot plate concrete | A | 7 |
| D | Pedestal column | C | 7 |
| E | Continuous foundation excavation | C | 7 |
| F | Backfill Sand Under Foundation | E | 7 |
| G | Redeployment Jobs | M | 7 |
| H | Scrap the floor | G | 7 |
| I | Workshop floor | E | 7 |
| J | Empty masonry installation | I | 7 |
| K | Stone Foundation | I, B, D | 14 |
| L | Selof Concrete Work / Ground beam | K | 14 |
| M | Floor concrete | L, F | 7 |
| N | Concrete Column Structure | M, J | 21 |
| *O* | Concrete Slabs and beams | M | 21 |
| *P* | Ladder | O | 7 |
| Q | Practical wall + column work (brick, plaster) | O, H | 28 |
| R | Timber and roofing work | O | 28 |
| S | Wood wall and sill work | R | 21 |
| T | Doors and windows and railing work | R | 14 |
| U | Furniture (Kitchen) | S, Q, T, AB, X, AA | 28 |
| V | Wall and floor finishing work | R | 28 |
| W | Ceiling Work | Y, Z | 7 |
| *X* | Wood finishing work | R | 21 |
| Y | Electrical Sparing Work | N | 14 |
| Z | Electrical Installation and Plumbing Panel Work | O | 14 |
| AA | Electrical Accessories Work | W | 21 |
| AB | Sanitary work | V, P | 7 |

Furthermore, the relationship between activities in project scheduling, the relationship between activities can be visualized using a network. Researchers use the QM for Windows in making network planning. From the data in **Table 4**. above, the Bedugul Villa Construction project network can be described as follows:

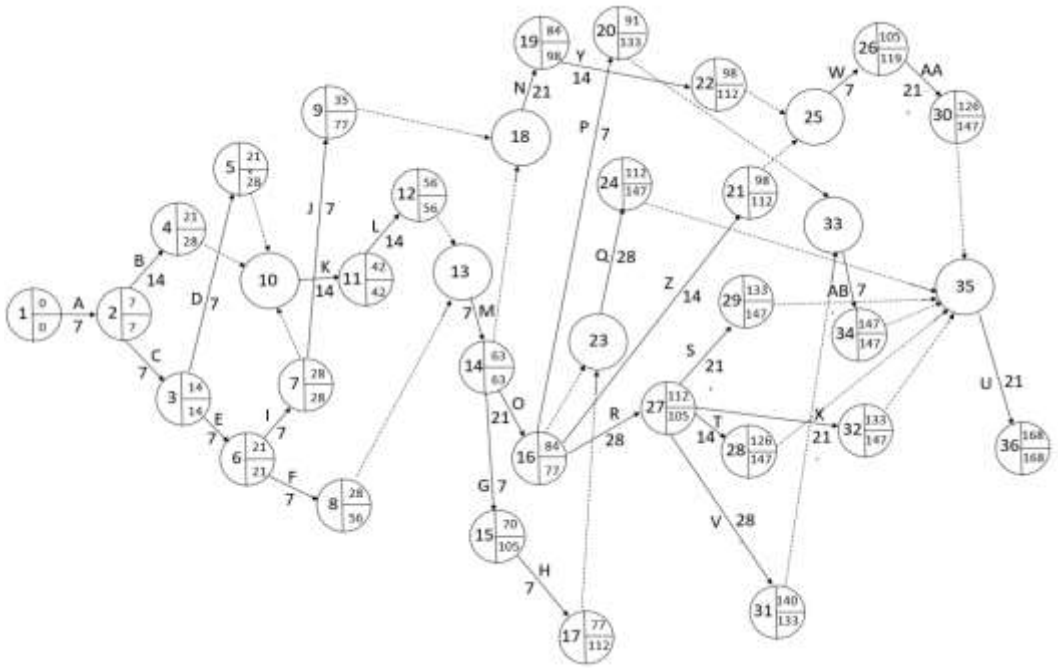

**Figure 2. Network Planning**

The Network is created after performing forward and backward calculations. With this calculation, the activity time or Early Start, Early Finish, Latest Start, and Latest Finish for each activity can be known. ES, EF, LS, and LF of each activity can be seen in **Table 5**.

**Table 5. Activity Time**

| Code | Work Description | ES | EF | LS | LF |
|---|---|---|---|---|---|
| A | Setting out Bowplank | 0 | 7 | 0 | 7 |
| B | Excavate the footplate | 7 | 21 | 14 | 28 |
| C | Foot plate concrete | 7 | 14 | 7 | 14 |
| D | Pedestal column | 14 | 21 | 21 | 28 |
| E | Continuous foundation excavation | 14 | 21 | 14 | 21 |
| F | Backfill Sand Under Foundation | 21 | 28 | 49 | 56 |
| G | Redeployment Jobs | 63 | 70 | 105 | 112 |
| H | Scrap the floor | 70 | 77 | 112 | 119 |
| I | Workshop floor | 21 | 28 | 21 | 28 |
| J | Empty masonry installation | 28 | 35 | 77 | 84 |
| K | Stone Foundation | 28 | 42 | 28 | 42 |
| L | Selof Concrete Work / Ground beam | 42 | 56 | 42 | 56 |
| M | Floor concrete | 56 | 63 | 56 | 63 |
| N | Concrete Column Structure | 63 | 84 | 84 | 105 |
| *O* | Concrete Slabs and beams | 63 | 84 | 63 | 84 |
| *P* | Ladder | 84 | 91 | 133 | 140 |
| Q | Practical wall + column work (brick, plaster) | 84 | 112 | 119 | 147 |
| R | Timber and roofing work | 84 | 112 | 84 | 112 |
| S | Wood wall and sill work | 112 | 133 | 126 | 147 |
| T | Doors and windows and railing work | 112 | 126 | 133 | 147 |
| U | Furniture (Kitchen) | 147 | 168 | 147 | 168 |
| V | Wall and floor finishing work | 112 | 140 | 112 | 140 |
| W | Ceiling Work | 98 | 105 | 119 | 116 |
| *X* | Wood finishing work | 112 | 133 | 126 | 147 |
| Y | Electrical Sparing Work | 84 | 98 | 105 | 119 |
| Z | Electrical Installation and Plumbing Panel Work | 84 | 98 | 105 | 119 |
| AA | Electrical Accessories Work | 105 | 126 | 126 | 147 |
| AB | Sanitary work | 140 | 147 | 140 | 147 |

The next step after the network has been completed is to determine the critical path on the network. Determination of the critical path is to find the value of TF or Total Float which is zero using Equation (6). The TF value of the Bedugul Villa construction project can be seen in **Table 6**.

**Table 6. TF Value**

| Code | Work Description | D (Days) | ES | EF | LS | LF | TF (Days) |
|---|---|---|---|---|---|---|---|
| A | Setting out Bowplank | 7 | 0 | 7 | 0 | 7 | 0 |
| B | Excavate the footplate | 14 | 7 | 21 | 14 | 28 | 7 |
| C | Foot plate concrete | 7 | 7 | 14 | 7 | 14 | 0 |
| D | Pedestal column | 7 | 14 | 21 | 21 | 28 | 7 |
| E | Continuous foundation excavation | 7 | 14 | 21 | 14 | 21 | 0 |
| F | Backfill Sand Under Foundation | 7 | 21 | 28 | 49 | 56 | 28 |
| G | Redeployment Jobs | 7 | 63 | 70 | 105 | 112 | 42 |
| H | Scrap the floor | 7 | 70 | 77 | 112 | 119 | 42 |
| I | Workshop floor | 7 | 21 | 28 | 21 | 28 | 0 |
| J | Empty masonry installation | 7 | 28 | 35 | 77 | 84 | 49 |
| K | Stone Foundation | 14 | 28 | 42 | 28 | 42 | 0 |
| L | Selof Concrete Work / Ground beam | 14 | 42 | 56 | 42 | 56 | 0 |
| M | Floor concrete | 7 | 56 | 63 | 56 | 63 | 0 |
| N | Concrete Column Structure | 21 | 63 | 84 | 84 | 105 | 21 |
| *O* | Concrete Slabs and beams | 21 | 63 | 84 | 63 | 84 | 0 |
| *P* | Ladder | 7 | 84 | 91 | 133 | 140 | 49 |
| Q | Practical wall + column work (brick, plaster) | 28 | 84 | 112 | 119 | 147 | 35 |
| R | Timber and roofing work | 28 | 84 | 112 | 84 | 112 | 0 |
| S | Wood wall and sill work | 21 | 112 | 133 | 126 | 147 | 14 |
| T | Doors and windows and railing work | 14 | 112 | 126 | 133 | 147 | 21 |
| U | Furniture (Kitchen) | 21 | 147 | 168 | 147 | 168 | 0 |
| V | Wall and floor finishing work | 28 | 112 | 140 | 112 | 140 | 0 |
| W | Ceiling Work | 21 | 98 | 105 | 119 | 116 | 21 |
| *X* | Wood finishing work | 21 | 112 | 133 | 126 | 147 | 14 |
| Y | Electrical Sparing Work | 14 | 84 | 98 | 105 | 119 | 21 |
| Z | Electrical Installation and Plumbing Panel Work | 14 | 84 | 98 | 105 | 119 | 21 |
| AA | Electrical Accessories Work | 21 | 105 | 126 | 126 | 147 | 21 |
| AB | Sanitary work | 7 | 140 | 147 | 140 | 147 | 0 |

In **Table 6**, it can be seen that the 12 jobs have a float value of 0. Because the float value of the 12 works is 0, the work above is part of the critical path. **Figure 3** below shows the critical path in the Bedugul Bali Villa construction project network.

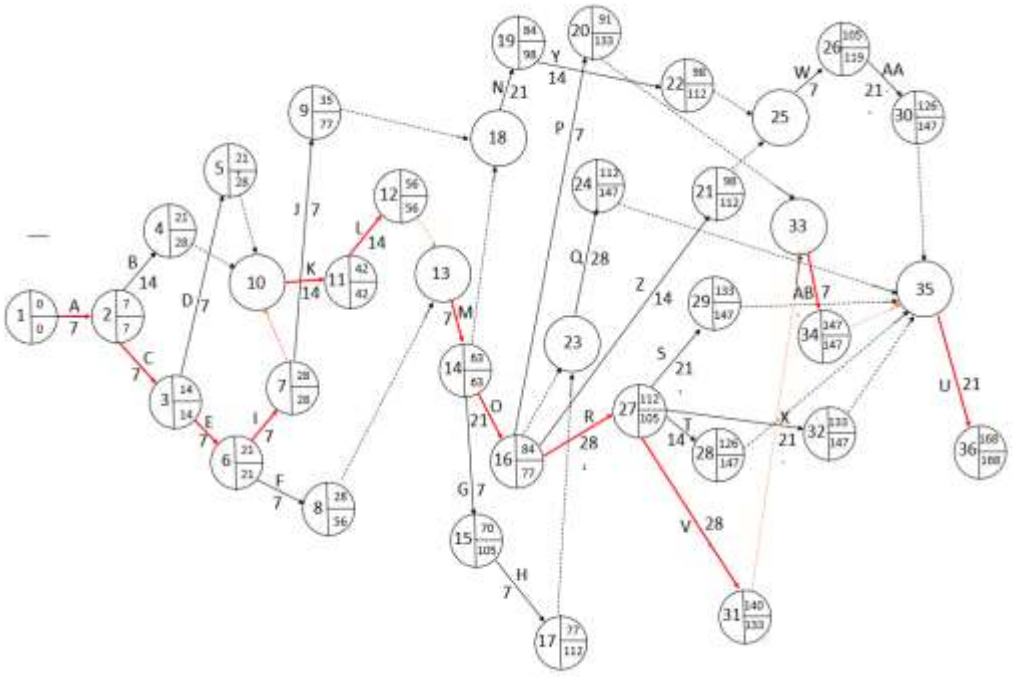

**Figure 3. Critical Path**

The sum of the jobs that enter the critical path is as follows:

Optimal Duration = D (A) + D (C) + D (E) + D (I) + D (K) + D (L) + D (M) + D (O) + D (R) + D (V) + D (AB) + D (U)
= 7 + 7 + 7 + 7 + 14 + 14 + 7 + 21 + 28 + 28 + 7 + 21
= 168 days

The results of applying the CPM method and work diagrams show clear and specific job dependencies. The result of applying the CPM method to the Bedugul Villa construction project is 168 calendar days. This result is 7 days faster than scheduled by the contractor, which is 175 calendar days.

## 3. CONCLUSIONS

The optimal duration for scheduling with the PERT method for scheduling the same project is to produce an optimal duration of 170 calendar days. The duration is 5 days faster than the existing schedule prepared by the project construction contractor, which is 175 calendar days. The probability of completion of the project is 87.7%. Calculations using the CPM method are 168 calendar days or 7 days earlier than the existing schedule made by the contractor.

## REFERENCES


[1] F. S. Wijaya and H. Sulistio, "PENERAPAN METODE MONTE CARLO PADA PENJADWALAN PROYEK SERPONG GARDEN APARTMENT," *JMTS: Jurnal Mitra Teknik Sipil*, vol. 2, no. 3, p. 189, Oct. 2019, doi: 10.24912/jmts.v2i3.5828.

[2] S. Ilham, I. Revo, and P. Pingkan, "Optimasi Penjadwalan Menggunakan Algoritma Genetika Pada Proyek Rehabilitasi Puskesmas Minanga," *Jurnal Sipil Statik*, vol. 7, no. 12, Dec. 2019, Accessed: Aug. 05, 2023. [Online]. Available: https://ejournal.unsrat.ac.id/v3//index.php/jss/article/view/26145

[3] T. Hamdy, *Operations Research An Introduction*. Pearson Education Limited , 2017. Accessed: Aug. 05, 2023. [Online]. Available: http://zalamsyah.staff.unja.ac.id/wp-content/uploads/sites/286/2019/11/9-Operations-Research-An-Introduction-10th-Ed.-Hamdy-A-Taha.pdf

[4] R. Sinaga, P. Simanjuntak, and Setiyadi, "ANALISIS DAN PENERAPAN METODE LINE OF BALANCE PADA PROYEK REPETITIF," *Jurnal Rekayasa Teknik Sipil dan Lingkungan - CENTECH*, vol. 2, no. 2, pp. 82–89, Nov. 2021, doi: 10.33541/cen.v2i2.3466.

[5] S. A. Purba, "Analisis Jaringan Kerja dengan Metode Critical Path Method (CPM) dan Model Program Linier," *Jurnal Absis: Jurnal Pendidikan Matematika dan Matematika*, vol. 4, no. 1, pp. 429–438, Oct. 2021, doi: 10.30606/absis.v4i1.993.

[6] M. Nur'aini and K. Ikhsani, "Perencanaan dan Pengendalian Proyek dengan Metode CPM di PT Ghani Sejahtera Abadi," *SCIENTIFIC TIMELINE*, vol. 1, no. 2, Sep. 2021, Accessed: Aug. 05, 2023. [Online].

[7] M. Amiruddin, "PENGENDALIAN WAKTU PADA PROYEK PEMBANGUNAN LOS PASAR IKAN SEGAR GOTO KOTA TIDORE KEPULAUAN," *AKRAB JUARA*, vol. 4, no. 4, pp. 40–55, May 2019, Accessed: Aug. 05, 2023. [Online]. Available: https://akrabjuara.com/index.php/akrabjuara/article/view/774

[8] I. Mahapatni, *METODE PERENCANAAN DAN PENGENDALIAN PROYEK KONSTRUKSI*. Unhi Press, 2019. Accessed: Aug. 05, 2023. [Online]. Available: http://repo.unhi.ac.id/jspui/handle/123456789/186

[9] A. Lubis, E. Suhendar, and P. Suharmanto, "OPTIMASI PENJADWALAN PROYEK PEMBANGUNAN JALAN TOL BECAKAYU SEKSI 1BC DENGAN MENGGUNAKAN METODE CPM DAN PERT," *Sustainable Environmental and Optimizing Industry Journal*, vol. 3, no. 2, pp. 75–89, Sep. 2021, doi: 10.36441/seoi.v3i2.461.

[10] L. Muzdalifah, E. Fitri Kurniawati, E. Deise Ulul, and K. Gular Pamitra, "PENJADWALAN PROYEK PERUMAHAN DENGAN OPTIMASI WAKTU DAN BIAYA HARIAN," *Jurnal Riset dan Aplikasi Matematika (JRAM)*, vol. 3, no. 2, p. 78, Oct. 2019, doi: 10.26740/jram.v3n2.p78-87.

[11] V. Y. I. Ilwaru, D. L. Rahakbauw, and J. Tetimelay, "PENJADWALAN WAKTU PROYEK PEMBANGUNAN RUMAH DENGAN MENGGUNAKAN CPM (CRITICAL PATH METHOD)," *BAREKENG: JURNAL ILMU MATEMATIKA DAN TERAPAN*, vol. 12, no. 2, pp. 061–068, Dec. 2018, doi: 10.30598/vol12iss2pp061-068ar617.

[12] H. Jay and R. Barry, *Manajemen Operasi*, 11th ed. Jakarta: Salemba Empat., 2014. Accessed: Aug. 05, 2023. [Online]. Available: https://api.penerbitsalemba.com/book/books/02-0302/contents/703c3330-4f78-498e-b9f2-99d1dfc021cb.pdf

[13] H. Malayu and Estu Rahayu, *Manajemen Sumber Daya Manusia*. Jakarta: PT Bumi Aksara, 2014.

[14] E. Larson and C. Gray, *Project Management: The Managerial Process*, 8th ed. McGraw Hill eBook, 2021. Accessed: Aug. 05, 2023. [Online]. Available: https://www.mheducation.com/highered/product/project-management-managerial-process-larson-gray/M9781260238860.html

[15] N. M. Astari, A. M. Subagyo, and K. Kusnadi, "PERENCANAAN MANAJEMEN PROYEK DENGAN METODE CPM (CRITICAL PATH METHOD) DAN PERT (PROGRAM EVALUATION AND REVIEW TECHNIQUE)," *Konstruksia*, vol. 13, no. 1, p. 164, Dec. 2022, doi: 10.24853/jk.13.1.164-180.

[16] A. Angelin and S. Ariyanti, "ANALISIS PENJADWALAN PROYEK NEW PRODUCT DEVELOPMENT MENGGUNAKAN METODE PERT DAN CPM," *Jurnal Ilmiah Teknik Industri*, vol. 6, no. 1, Feb. 2019, doi: 10.24912/jitiuntar.v6i1.3025.