Project Evaluation and Review Technique (PERT) Analysis in the renovation project of the Church of St. John the Evangelist, Jakarta

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Abstract. The renovation of the St. Yohanes Evangelist Church project located on 197, Melawai Street Kebayoran Baru, Jakarta with a building area about 1480.9 m2 was chosen as a research object because the Church Construction Committee wanted to accelerate the renovation project from 2 years 5 months targeted to 1 year 5 months. This is because the Church of St. John the Evangelist as a place of worship can be immediately used again. The PERT method can be used to manage projects more efficiently and effectively; to be able to know the possibility of accelerating the duration of the project carried out on activities in the critical path and the shortening of the duration of each work on each alternative is equalized. In this study, the critical path compression step of the network using Microsoft Project and the results of the Project Evaluation and Review Technique (PERT) method, obtained a probability of 99.88%, so the renovation project of Saint John Evangelist Church can be an accelerated project to 1 year 5 months.

Keywords: accelerated project, probability, PERT method.

1. Introduction
Many things can happen in the project development process, which can result in delays in project execution or cost overruns, such as changes in the situation of the project, the weather's changing factors, constraints of procurement of project materials, the architect errors, and human resource constraints. This delay can become an issue that often occurs as well as detrimental to the parties concerned both the contractor and the project owner itself. Many efforts can be made to overcome the delay of a project, namely by accelerating the duration of the project such as increasing the duration of work, adding the labour, and or changing work methods that are more efficient and effective [1].

The Church of Saint John the Evangelist will be renovated to increase and expand the capacity of people in religious activities and to repair the damage that occurs to improve the quality of the church building itself to be suitable for use and to provide comfort for the users. The area of the church is around 1480.9 m2, with a planned renovation duration of 2 years and 5 months. The acceleration of the project must be done because there is a special request from the church with the target of completing the project
in 1 year 5 months so that the church building can be used immediately. To know this, it is important to study the existing network and the relationship of dependency between activities and the relationship between time and cost. Therefore, it is necessary to conduct a PERT analysis to be able to find out the level of accuracy of the project schedule for each activity specified in the network by calculating the probability of the specified schedule and to be able to know the potential of possibility for project acceleration.

Analysis of critical and slack networks is performed using Microsoft Project. This analysis is used to be able to see activities other than critical networks that can be accelerated and analysed using the PERT method (Project Evaluation and Review Technique). PERT method is a method that has three estimated time in each project activity, namely the longest time (pessimistic), the optimal time and the fastest time (optimistic), the third value will be sought at the average exchange rate to improve the quality of project planning and control [2].

This analysis is expected to help renovate the Catholic Church of St. Yohanes Evangelist in Jakarta to develop new plans for the right targets so that they can provide input for human resource planning so that resources are ready at the specified time to accelerate the project.

2. Literature Review

2.1. Project Definition

The project is an activity to achieve goals and objectives. In the process, the project is limited by the time and resources required. In achieving its objectives, there are 3 constraints that must be met and all three are important measures during a project. These three constraints consist of the cost or budget that underlies the project, the schedule or time required, and the quality that must be met. These three limits are often referred to as triple constraints [3].

2.2. Critical network analysis

Network analysis aims to unite all elements into the main time plan to obtain an estimate of the expected time to complete the project. The work network within the project is used to plan and compile the project. A critical path is a path that is contained in a working network that contains components, has the oldest total time, and shows the shortest amount of activity to complete the project. The existence of critical pathways in a project is very important because the activity through this critical path will not experience a delay in the completion of the entire project [4].

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2.4. Project Evaluation and Review Technique (PERT)

The PERT method is an analytical technique whose activity time is a probability and is often used to plan and control the project [5]. The PERT method uses three estimated time in each project activity that is the longest time (pessimistic), the optimal time and the fastest time (optimistic) [6].

In time cost trade-off method, compressions are only performed on activities that are on the critical path. With the change of project completion time, it is also changed costs incurred. When the execution time is accelerated, the project's direct cost will increase while indirect costs will decrease and if the compression is done on activities that are not on the critical track, then the overall project completion time will remain.
3. Methods
This study was conducted using the literature review related to network analysis and slack. This is done so that in the process of collecting data up to making conclusions can be done effectively.

The research data analysis in this project divided into 2 types that are qualitative data analysis that given the result of the most effective network by using of Microsoft Project software and quantitative data analysis provides the result of the probability of the PERT method being a guideline for approving project acceleration.

4. Result
4.1. Network Diagram
To simplify the relationship between activities, it is made a grouping of works as stated to those listed on the project schedule and budget plan, while to determine the interrelationship between activities obtained from field observations and interviews with the parties involved to find out critical activities and slack between activities. A critical point in table 1 is obtained from a network diagram that is formed in Microsoft Project software. This critical point becomes a guideline for calculating slack from other activities.

Data collection on the description of work items and their relationship dependency obtained from field observations and interviews with the parties involved to find out critical activities. This study was conducted using the literature review related to network analysis and slack.

This combination of the network diagram and duration of activity can produce a Gantt Chart and a complete network diagram outline and in accordance with interviews with involved parties to produce a network diagram. Gantt Chart and network diagrams are used to get the critical network or critical path of a project. The results of network calculations based on Microsoft Project 2016 get the results of critical networks, it is shown in Tables 1 and 2 below.

### Table 1. Relationship Between Activities

| ITEM | DESCRIPTION | PREDECESSOR | CRITICAL PATH | SLACK |
|------|-------------|-------------|----------------|-------|
| 1    | PREPARATION WORK | - | YES | |
| 2    | CUT AND FILE WORK | - | YES | |
| 3    | BLOCK WORK, LCM | - | YES | |
| 4    | FENCE WALL WORK | III-1 | 396 days | |
| 5    | WOODEN FRAME AND DOOR WORK | IV | 396 days | |
| 6    | CEILING WORK | - | YES | |
| 7    | Brick Finish | III-2, IV | 486 days | |
| 8    | Text | III-2, IV | 486 days | |
| 9    | Laundry Tiled (men) | IV, V-8, VIII | 486 days | |
| 10   | Laundry Tiled (women) | IV, V-8, VIII | 486 days | |
| 11   | FLOOR WORK | III-1, IV | 568 days |  |
| 12   | The labor cost of installation of the ceramic at the back and side terrace | III-1, IV | 568 days | |
| 13   | The labor cost of installation of the ceramic | III-1, IV | 568 days | |
| 14   | The labor cost of installation of the ceramic at the outdoor patio | III-1, IV | 568 days | |
| 15   | Toilet Work | III-1, IV | 568 days | |
| 16   | SANITARY WALL AND FLOOR AND WALL CERAMICS | III-1, IV | 568 days | |
| 17   | The labor cost of installation of the ceramic, granite, ceramic tiles, and ceramics toilet | III-1, IV | 568 days | |
| 18   | The labor cost of installation of the ceramic, granite, ceramic tiles, and ceramics toilet (woman) | III-1, IV | 568 days | |
| 19   | Painting Work | IV, V-8, VIII | 486 days | |
| 20   | PLUMBING WORK | III-2, IV | 486 days | |
| 21   | ELECTRICAL WORK | III-3, IV | 486 days | |
| 22   | FENCE WORK | III-3 | 486 days | |
| 23   | Fence As.1 | - | YES | |
| 24   | Fence As.2 | - | YES | |
| 25   | Fence As.3 | - | YES | |
| 26   | Fence As.4 | - | YES | |
| 27   | Fence As.5 | - | YES | |
| 28   | Fence As.6 | - | YES | |
| 29   | Fence As.7 | - | YES | |
| 30   | Fence As.8 | - | YES | |
| 31   | Fence As.9 | - | YES | |
| 32   | Fence As.10 | - | YES | |
| 33   | Fence As.11 | - | YES | |
| 34   | Fence As.12 | - | YES | |
| 35   | Fence As.13 | - | YES | |
| 36   | Fence As.14 | - | YES | |
| 37   | Fence As.15 | - | YES | |
| 38   | Fence As.16 | - | YES | |
| 39   | Fence As.17 | - | YES | |
| 40   | Fence As.18 | - | YES | |
| 41   | Fence As.19 | - | YES | |
| 42   | Fence As.20 | - | YES | |
| 43   | Fence As.21 | - | YES | |
| 44   | Fence As.22 | - | YES | |
| 45   | Fence As.23 | - | YES | |
| 46   | Fence As.24 | - | YES | |
| 47   | Fence As.25 | - | YES | |
| 48   | Fence As.26 | - | YES | |
| 49   | Fence As.27 | - | YES | |
| 50   | Fence As.28 | - | YES | |
| 51   | Fence As.29 | - | YES | |
| 52   | Fence As.30 | - | YES | |
| 53   | Fence As.31 | - | YES | |
| 54   | Fence As.32 | - | YES | |
| 55   | Fence As.33 | - | YES | |
| 56   | Fence As.34 | - | YES | |
| 57   | Fence As.35 | - | YES | |
| 58   | Fence As.36 | - | YES | |

### Table 2. Relationship Between Activities

| ITEM | DESCRIPTION | PREDECESSOR | CRITICAL PATH | SLACK |
|------|-------------|-------------|----------------|-------|
| 10   | Fence As.11 | - | YES | |
| 11   | Fence As.12 | - | YES | |
| 12   | Fence As.13 | - | YES | |
| 13   | Fence As.14 | - | YES | |
| 14   | Fence As.15 | - | YES | |
| 15   | Fence As.15 | - | YES | |
| 16   | Fence As.20 | - | YES | |
| 17   | Fence As.21 | - | YES | |
| 18   | Fence As.22 | - | YES | |
| 19   | Fence As.23 | - | YES | |
| 20   | Fence As.24 | - | YES | |
| 21   | Fence As.25 | - | YES | |
| 22   | Fence As.26 | - | YES | |
| 23   | Fence As.27 | - | YES | |
| 24   | Fence As.28 | - | YES | |
| 25   | Fence As.29 | - | YES | |
| 26   | Fence As.30 | - | YES | |
| 27   | Fence As.31 | - | YES | |
| 28   | Fence As.32 | - | YES | |
| 29   | Fence As.33 | - | YES | |
| 30   | Fence As.34 | - | YES | |
| 31   | Fence As.35 | - | YES | |
| 32   | Fence As.36 | - | YES | |

4.1. Network Diagram

[XIV ELECTRICAL WORK AT THE FENCE] XI-1 252 days

[XIV RENOVATION WORK OF PRODIAGO AND PASTORS’ ROOM] VIII 4 396 days

[2] Brick Wall Work XIV 1 396 days

[3] Ceiling Work XIV 2 396 days

[XV CERAMIC WORK] XIV 3 406 days

[XVI ELECTRICAL WORK IN THE INTERIOR SPACE] XIV 2 396 days

XV RENOVATION WORK OF ALTAR AREA

[XVI ELECTRICAL WORK IN THE INTERIOR SPACE] XIV 2 396 days
The calculation for the expected time (te) of all activities based on the network diagram; this is because the preparatory work is always present in each project activity. Estimates of optimistic, realistic, and pessimistic time will be used to obtain the expected time (te), standard deviations, and variances from the time of each project activity. The calculation for the expected time (te) for the 4th activity i.e. brick wall work is as follows:

$$t_{e n} = \frac{a_n + 4m_n + b_n}{6} = \frac{7 + 4 \times 14 + 16}{6} = 13.17$$

$$t_{e n} = \text{Expected duration on the } n\text{-th activity}$$

$$a_n = \text{Optimistic time value}$$

$$m_n = \text{Realistic (optimal) time value}$$

$$b_n = \text{Pessimistic time value}$$

Meanwhile, to calculate the standard deviation (S) for the 4th activity is as below:

$$S_n = \frac{b_n - a_n}{6} = \frac{16 - 7}{6} = 1.5$$

$$S_n = \text{Standard deviation of } n\text{-th activity}$$

$$a_n = \text{Optimistic time value}$$

$$b_n = \text{Pessimistic time value}$$

Table 2. Relationship Between Activities

| ITEM | DESCRIPTION | PREDECESSOR | CRITICAL PATH | SLACK |
|------|-------------|-------------|---------------|-------|
| XVII | AIR CONDITIONING INSTALLATION AT PROHOKAN ROOM | XIX 5 | 650 days | |
| XIX  | EXTERIOR WORK IN THE FRONT TERRACE | | | |
| 1    | Gut and Hill Work | XII 1 | 40 days | |
| 2    | Concrete Work | XII 1 | 40 days | |
| 3    | Steel Work & Merchant Roof | XII 2 | 40 days | |
| 4    | Porch Cover | | | |
| 5    | Installation Ceramics | XIX 2, XIX 3 | 40 days | |
| 6    | Columns & Steel Beam Covers | XIX 3 | 48 days | |
| XX   | EXTERIOR WORK OF TERRACE & ROOF SIDE | | | |
| 1    | Front & Side Terraces | XIX 5 | YES | |
| 2    | Ceiling Work | XIX 3 | YES | |
| 3    | Concrete Roof Work | XIX 3 | YES | |
| 4    | Column & Steel Beam Covers | XIX 5 | YES | |

| ITEM | DESCRIPTION | PREDECESSOR | CRITICAL PATH | SLACK |
|------|-------------|-------------|---------------|-------|
| XXI  | CARPORT FOR PARKING AREA | XIX 3 | 280 days | |
| XXII | PIA MARIA | XIX 3, XIX 4 | 110 days | |
| XXIV | GETHSEMANI LANDSCAPE AREA | XIX 3 | 250 days | |
| 1    | Gethsemani Landscape & Children Playground | XIX 4 | 250 days | |
| 2    | Finishing Gethsemani Landscape & Children Playground | XIX 5 | 250 days | |
| 3    | Steel Work | XIX 3 | 250 days | |
| 4    | Column of Saint Joseph | XIX 3 | 250 days | |
| 5    | Gethsemani Landscape & Children Playground | XIX 3 | 250 days | |
| 6    | Finishing Gethsemani Landscape & Children Playground | XIX 3 | 250 days | |
| XXV | STATUE OF ST. JOHN’S WORK | XIX 3 | 270 days | |
| XXVI | RAINWATER PIPE INSTALLATION | XIX 3 | 260 days | |
| XXVII| CHURCH’S EXTERIOR RENOVATION | | | |

4.2. Project Evaluation and Review Technique (PERT) Analysis

Approximate duration of project execution namely the fastest execution time (optimistic time) and the longest execution time (pessimistic time) is needed to get a more accurate prediction of overall project duration. The approximate A and B values are described in table 2 where data is derived from the estimate of the project manager. The duration of the preparatory work activities follows the total duration of all activities based on the network diagram; this is because the preparatory work activities are always present in each project activity. Estimates of optimistic, realistic, and pessimistic time will be used to obtain the expected time (te), standard deviations, and variances from the time of each project activity. The calculation for the expected time (te) for the 4th activity i.e. brick wall work is as follows:

$$t_{e n} = \frac{a_n + 4m_n + b_n}{6} = \frac{7 + 4 \times 14 + 16}{6} = 13.17$$

$$t_{e n} = \text{Expected duration on the } n\text{-th activity}$$

$$a_n = \text{Optimistic time value}$$

$$m_n = \text{Realistic (optimal) time value}$$

$$b_n = \text{Pessimistic time value}$$

Meanwhile, to calculate the standard deviation (S) for the 4th activity is as below:

$$S_n = \frac{b_n - a_n}{6} = \frac{16 - 7}{6} = 1.5$$

$$S_n = \text{Standard deviation of } n\text{-th activity}$$

$$a_n = \text{Optimistic time value}$$

$$b_n = \text{Pessimistic time value}$$
The method for calculating variants (V (te)) for the 4th activity i.e., brick wall work is as below:

\[ V_{te_n} = (S_{n})^2 = (S_{P})^2 - (1.5)^2 = 2.25 \]

\[ S_n \] = Standard deviation of n-th activity
\[ V_{te_n} \] = variants of n-th activity

The S and Vte data for each activity calculated in table 1 is used to get the total S and Vte as a whole. The previous step needs to be selected for the largest S and Vte values in each sub-activity so that the values of S and Vte for each of the 40 main activities.

**Table 3. Data regarding 3 estimated time, standard deviations, and variants of each project activity.**

| ITEM | DESCRIPTION | OPTIMISTIC TIME (a) | OPTIMAL TIME (m) | PESSIMISTIC TIME (b) | EXPECTED TIME (te) | STANDARDS OF DEVIATION (S) | VARIANS (V(te)) |
|------|-------------|---------------------|------------------|----------------------|--------------------|--------------------------|---------------|
| 1    | PREPARATION WORK | 279 | 558 | 649 |
| 2    | CUT AND FILL WORK | 5 | 10 | 14 |
| 3    | CONCRETE WORK | 21 | 42 | 45 |
| 4    | BRICK WALL WORK | 7 | 14 | 16 |
| 5    | WOODEN FRAME AND DOOR WORK | 4 | 8 | 10 |
| 6    | CEILING WORK | 5 | 10 | 12 |
| 7    | FLOOR WORK | 2 | 4 | 7 |
| 8    | TOILET WORK (SANITARY, FLOOR AND WALL CERAMICS) | 8 | 16 | 20 |
| 9    | PAINTING WORK | 4 | 8 | 10 |
| 10   | PLUMBING WORK | 5 | 16 | 18 |
| 11   | ELECTRICAL WORK | 5 | 10 | 12 |
| 12   | FENCE WORK | 5 | 10 | 12 |
| 13   | ELECTRICAL WORK AT THE FENCE | 28 | 56 | 60 |
| 14   | RENOVATION WORK OF PRODIKAKON AND PASTOR'S ROOM | 7 | 14 | 17 |
| 15   | RENOVATION WORK OF ALTAR AREA | 14 | 28 | 32 |
| 16   | ELECTRICAL WORK IN THE INTERIOR SPACE | 7 | 14 | 16 |
| 17   | AIR CONDITIONING INSTALLATION AT PRODIKAKON ROOM | 4 | 8 | 9 |
| 18   | EXTERIOR WORK IN THE FRONT TERRACE | 14 | 28 | 32 |
| 19   | EXTERIOR WORK OF TERRACE & ROOF SIDE | 15 | 30 | 34 |
| 20   | CARPORT FOR PARKING AREA | 21 | 42 | 45 |
| 21   | FISHPOND WORK | 28 | 56 | 60 |
| 22   | PIETA MARIA | 28 | 56 | 60 |
| 23   | GETSEMANI LANDSCAPE AREA | 14 | 28 | 30 |
| 24   | STATUE OF ST. JOHN'S WORK | 5 | 10 | 14 |
| 25   | RAINWATER PIPE INSTALLATION | 20 | 40 | 42 |
| 26   | CHURCH'S INTERIOR RENOVATION | 20 | 40 | 45 |
| 27   | ELECTRICAL WORK AT CONGREGATION ROOM | 21 | 42 | 45 |
| 28   | BALCONY'S WORK | 10 | 20 | 24 |
| 29   | CEILING WORK IN THE CONGREGATION ROOM | 14 | 28 | 32 |
| 30   | WOODEN FRAME AND DOOR WORK | 7 | 14 | 16 |
| 31   | BRICK WALL WORK | 7 | 14 | 20 |
| 32   | WATERPROOFING WORK ON CONCRETE ROOF | 7 | 14 | 18 |
| 33   | PAINTING WORK | 7 | 14 | 16 |
| 34   | BOX FOR AIR CONDITIONING PROTECTION | 7 | 14 | 16 |
| 35   | AIR CONDITIONING INSTALLATION AT CONGREGATION ROOM | 7 | 14 | 21 |
| 36   | SOUND SYSTEM INSTALLATION | 7 | 14 | 16 |
| 37   | LIFT INSTALLATION | 7 | 14 | 16 |
| 38   | LANDSCAPE WORK | 7 | 14 | 21 |
| 39   | ELECTRICAL WORK AT LANDSCAPE AREA | 7 | 14 | 18 |
| 40   | EXTERIOR WORK AT LANDSCAPE AREA | 7 | 14 | 18 |

| TOTAL | 91.33 | 273.31 |

The formula for calculating the target probability number \(Z_{Value}\) is as follows:

\[ Z_{Value} = \frac{T_d - T_e}{Total\ S} = \frac{558 - 279}{91.33} = 3.05474 \]

\[ Z_{Value} \] = probability number
\[ T_d \] = project planning duration
\[ T_e \] = accelerated target time
\[ Total\ S \] = The total deviation of the activity
$Z_{\text{Value}}$ is connected by using the normal $Z$-distribution curve for the number $Z_{\text{Value}} = 3.05474$, hence the probability number of 0.99886 or 99.88%. This indicates that the probability of the project being completed at the target time of 279 days has a 99.88% chance.

5. Summary
The critical network of the project consists of preparatory work activities, excavation work activities, K-250 concrete structure work activities, fence work activities, outdoor patio work activities, congregation renovation activities, electrical work in church interiors, and ceiling spaces for congregations. The shortest total slack value is in the eaves work sub-activity of 4 days and the longest slack value is in the terrace and stairs ceramic work sub-activity of 508 days. The optimistic time of the project duration is 279 days, the realistic time of the project is 558 days, and the pessimistic time of the project is 649 days.

The results of the PERT methodology indicate that the likelihood of project opportunities can be accelerated using the calculated $Z$ formula obtained at 3.05744. This calculated $Z$ value is used as a guideline to look for results in table $Z$ to see the probability value. The result obtained in the $Z$ table value is 0.99886 or 99.88% which indicates that this project is feasible to be accelerated.

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