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PROJECT SCHEDULING EVALUATION USING THE PERT (PROGRAM EVALUATION AND REVIEW TECHNIQUE) METHOD FOR THE RECONSTRUCTION OF THE BUARENO – KEDUNGREJO ROAD IN BOJONEGORO

Slamet Widodo[1*], Hanie Teki Tjendani[2*], Erni Puspanantasari Putri[3]
[1,2,3]Department of CIvil Engineering, Universitas 17 Agustus 1945 Surabaya Indonesia, 60118
*Corresponding Author: swidodo1990@gmail.com, hanie@untag-sby.ac.id

ABSTRACT

The Program Evaluation and Review Technique (PERT) method is one of the project scheduling techniques designed to address the uncertainty of activity durations. In this study, PERT is used to analyze the probability of completing the reconstruction project of Jalan Baureno – Kadungrejo, Bojonegoro, which has experienced significant delays from the original schedule. PERT allows for the estimation of project completion time based on three main parameters: optimistic time, most likely time, and pessimistic time. Through this probabilistic approach, the estimated project completion time (expected time), standard deviation, and variance of the project's critical path are calculated. The analysis results show that the use of the PERT method provides important information regarding the possibility of project completion within a certain timeframe and helps in formulating strategies to mitigate the risk of delays. In addition, this method has also proven effective in rescheduling the project based on the level of confidence in its successful completion. The application of PERT in this research provides a realistic picture of the management of complex and dynamic project timelines, and supports more measurable managerial decision-making in construction projects.

Keyword: PERT, Project Scheduling, Time Uncertainty, Probability, Road Construction.

1. INTRODUCTION

Construction project planning is one of the main pillars in project management aimed at directing the execution of work to align with time, quality, and cost objectives. In practice, various obstacles and challenges often arise that cause project implementation not to always go according to plan (Artigues, 2025). Delays, uncertainty in activity durations, design changes, and dynamic field conditions present unique challenges for project implementers. In this context, the selection of the appropriate scheduling method is crucial for the success of a project, especially construction projects that have complex, non-repetitive characteristics and depend on many unpredictable variables (García et al., 2017).

One of the scheduling methods long known in project management is the Program

Evaluation and Review Technique (PERT). PERT was introduced in the late 1950s in the Polaris missile system development project by the United States Navy, which required the management of a highly complex schedule under conditions of full uncertainty (Moreno et al., 2020). Unlike deterministic methods such as the Critical Path Method (CPM), which only uses a single time estimate, PERT employs a probabilistic approach that takes into account the uncertainty in the execution of each project activity (Kokuryo et al., 2024). By using three types of time estimates—optimistic time, most likely time, and pessimistic time—PERT allows project managers to calculate the expected time for each activity, as well as variance and standard deviation as the basis for time risk (Moreno et al., 2025).

In construction projects, time uncertainty is a very common condition. Activities such as material procurement, structural work, and weather factors are often unpredictable (Grace & German, 2024). The PERT method provides an advantage in facing such uncertainties by modeling the likelihood of project completion based on probabilistic distribution. This allows planners and project controllers to formulate more flexible anticipation strategies, as they can estimate the probability of a project being completed within a certain timeframe, based on statistical calculations (Lee et al., 2017). In large projects, where delays directly impact cost overruns and reputation, the ability to predict the probability of completion is very important.

Another advantage of the PERT method lies in its ability to present a visualization of the interconnected project activity network (Chang et al., 2021). The PERT network diagram systematically illustrates the sequence of activities, their durations, and the interdependencies between them (Wenying & Xiaojun, 2011). Each activity is represented as an arrow, while the nodes indicate the start and end of an event or activity. Through this diagram, planners can identify the critical path—a series of activities with no slack (time flexibility)—which is the main determinant of the project's duration (Eddine et al., 2011). However, what distinguishes PERT from similar methods is its ability to calculate the project's standard deviation and estimate the probability of successful completion time using a statistical approach.

In its practical implementation, the PERT method is very useful for projects that have high uncertainty in execution time, such as road infrastructure projects, high-rise building construction, mechanical-electrical installations, and other projects involving many parties, stages, and risks (Hashemin et al., 2012). For example, in a road reconstruction project that involves a lot of fieldwork, weather dependence, and heavy equipment mobilization, the duration of each activity is very difficult to predict with certainty (Ren & Li, 2023). If we only rely on a single time estimate, it is highly likely that the planning results will not reflect the actual field conditions. With

PERT, that uncertainty can be accommodated in a more realistic estimate, making project scheduling more adaptive to changing situations (Pregina, 2024).

Technically, the application of the PERT method is carried out by first identifying all activities in the project, determining the relationships between activities, and estimating the duration of each activity with three time values: optimistic time (a), most likely time (m), and pessimistic time (b) (Mazlum et al., 2015). From these three values, the average time is calculated.

Then, to determine the extent of uncertainty in the estimate, variance and standard deviation are calculated. After that, the critical path is identified, and the total standard deviation of that path is determined. Using the cumulative normal distribution (Z-score), the probability of project completion within a certain timeframe can be calculated, which serves as the basis for management decision-making (Sackey & Kim, 2019).

In the context of academia and professional practice, the application of the PERT method has proven to enhance the accuracy of scheduling and project control. Several previous studies have shown that projects planned using the PERT approach tend to have higher accuracy in estimating completion times, while also being able to identify potential delay risks at an earlier stage (Bergantiños et al., 2018). In the highly competitive construction industry, this advantage becomes an important asset for both project implementers and project owners, as it provides a more logical and data-driven basis for decision-making (Mishakova et al., 2016).

Furthermore, the integration of the PERT method with software technologies such as POM-QM, Microsoft Project, or Primavera provides additional ease in compiling and analyzing project schedules quantitatively. This software simplifies the process of calculating time estimates, variances, and project completion probabilities, while also providing visualizations of the critical path and alternative schedule scenarios (Carlos et al., 2023). This application is also highly relevant in the era of project management digitalization, where accuracy, efficiency, and transparency are the main demands.

Therefore, this research focuses on the use of the PERT method in evaluating construction project scheduling, particularly in road reconstruction projects. By utilizing the probabilistic approach offered by PERT, it is expected to obtain a more realistic picture of the likelihood of project completion within the planned timeframe, as well as to formulate mitigation strategies for potential delays. This is important so that the project implementation runs more efficiently, on time, and in accordance with the planned resources.

Overall, the PERT method is not just a technical aid in scheduling, but also a systematic approach to dealing with project uncertainties. Its ability to project possible outcomes in various scenarios makes it a highly relevant method for the dynamic modern construction industry. With the application of PERT, project time management is no longer rigid and static, but becomes more responsive and adaptive to unexpected changes.

2. RESEARCH METHOD

This research uses a descriptive quantitative approach with a project scheduling analysis method based on probabilistic techniques, namely the Program Evaluation and Review Technique (PERT). The choice of this method is based on the high level of uncertainty in the execution of construction projects, particularly related to the duration of completing each activity. By using the PERT method, project scheduling analysis does not only focus on a single fixed time estimate but considers three time parameters to describe the possible variation in activity durations, which are then used to calculate the average time estimate, variance, and standard deviation as the basis for evaluating the likelihood of timely project completion.

2.1 Types and Approaches to Research

This research falls under the category of descriptive quantitative research with a case study approach. The study was conducted on the Baureno – Kadungrejo road reconstruction project in Bojonegoro Regency. This project was chosen because there is evidence of actual delays in the project implementation based on weekly progress reports and the S-Curve. Using a case study approach, this research explores in detail the application of the PERT method on a real project with original field data.

2.2 Sources and Types of Data

The data used in this research consists of:

a. Primary data, which is the duration data of project activities obtained from interviews and project documents such as time schedules, weekly reports, and as-built drawings.
b. Secondary data, which includes literature, scientific journals, and book references that support the theoretical analysis and application of the PERT method.

Each activity in the project is evaluated based on three time estimates:

a. a (optimistic time): The fastest time that might occur if everything goes smoothly.
b. m (most likely time): The most realistic time under normal conditions.
c. b (pessimistic time): The longest time that might occur if there are many obstacles

2.3 Location and Research Object

This research was conducted on a road construction project in the Baureno District, Bojonegoro Regency, carried out by the local government agency. This project has a planning duration of 120 calendar days with a project value of Rp 11,659,850,785.00. However, in its implementation, the project experienced significant delays, highlighting the importance of conducting a thorough scheduling evaluation.

2.4 Steps of PERT Analysis

The stages in the analysis using the PERT method are as follows:

1. Identification of Project Activities and Their Interrelationships

The initial step is to identify all the main activities in the project, determine the sequence and dependencies between the activities. Each activity is systematically coded, arranged in the form of a network diagram, and assigned estimated duration values.

2. Collection of Time Estimates (a, m, b)

For each activity, three types of time estimates are determined based on field data, interviews with project implementers, and document reviews. These three estimates are used to calculate the expected time and variance values.

3. Calculation of Expected Time (Te)

The expected time for each activity is calculated using the formula:

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

This calculation provides the expected average duration for each activity while considering the possibility of variation.

4. Calculation of Variance and Standard Deviation

Each activity has a time variance calculated as follows:

$$Variance = (\frac{b - a}{6})^2$$

Then, the project standard deviation is calculated from the sum of the variances along the critical path. This value is useful for calculating the probability of project completion.

5. Determination of the Critical Path

From the network diagram, the project's critical path is identified, which is the sequence of activities with a total slack (time flexibility) equal to zero. The critical path is the sequence of activities that determines the overall project completion time.

6. Calculation of Project Completion Probability

By knowing the total expected time of the critical path and its standard deviation, the probability of project completion within a certain time (for example, as planned) is calculated using the normal distribution as follows:

$$Z = \frac{Z - \mu}{\sigma}$$

Where:

Z = Z-score value (converted to probability)

X = target project completion time (for example, 120 days)

μ = project expected time (total Te on the critical path)

σ = standard deviation of the project (square root of the sum of variances on the critical path)

The Z value is then converted into a probability percentage through the cumulative normal distribution table.

2.5 Analysis Tools

To support systematic calculations and reduce manual errors, this research uses the POM-QM for Windows software, which provides comprehensive features for project network analysis using the PERT method. This application is used to calculate expected time, critical path, and project completion probability more quickly and accurately..

2.6 Validation and Evaluation

To ensure the validity of the calculation results, validation is carried out by comparing the PERT results with the actual project realization and evaluating the S-curve. This evaluation provides an overview of the accuracy of the PERT method in predicting project completion time and to what extent this method can be used to assist in decision-making for project time control in the field.

3. RESULTS AND DISCUSSION

3.1 Description of PERT Data

The PERT method is used in this study to analyze the estimated completion time of the delayed Baureno – Kadungrejo road reconstruction project. The data used includes a list of project activities, the sequence of activities, and the estimated duration of each activity based on three main parameters: optimistic time (a), most likely time (m), and pessimistic time (b). The time estimates were obtained from project documents, interviews with field implementers, and weekly progress reports.

As many as 7 main activities were analyzed using the PERT method. Each activity was identified for its interconnections, allowing them to be arranged in a work network. Then, the expected time (Te), variance, and standard deviation for each activity were calculated.

Table 1. Time Estimate.

Activity Code	Activity	Optimistic Time (a)	Most Likely Time (m)	Pessimistic Time (b)
A	General	2	4	6
B	Construction Safety Management System (CSMS)	6	9	12
C	Earthworks and Geosynthetics	6	9	12
D	Granular Pavement and Cement Concrete Pavement	4	7	10
E	Asphalt Pavement Work	1	3	4
F	Structural Work	12	16	20
G	Daily Tasks and Other Tasks	2	5	8

Self-efficacy is judgement of a person to his capabilities to plan and implement the action to reach certain goals (Mukhid, 2009). In an academic context, self-efficacy reflects how confident students are in performing specific tasks (Perez & Ye, 2013). Self-efficacy plays a role in academic motivation and learning motivation (especially students' ability to manage their learning activities), and resistance to learning (Zimmerman, 2000). Self-efficacy has three dimensions that are magnitude, the level of task difficulty a person believes she can attain; strength, the conviction regarding magnitude as strong or weak; and generality, the degree to which the expectation is generalized across situations (Lunenburg, 2011).

Self-efficacy in mathematics is described as an individual's mathematics self-efficacy is his or her confidence about completing a variety of tasks, from understanding concepts to solving problems, in mathematics (May, 2009). High mathematics self-efficacy will encourage the achievement of good learning outcomes, and when students have good learning outcomes, they will be more motivated in the learning process. Higher self-efficacy expectations can lead to better results and therefore increase the motivation for learning mathematics (Zimmermann, et al, 2011). Based on the description above, it can be concluded that mathematics self-efficacy is a belief or self-assessment of the student's ability in overcoming certain mathematical problems and tasks related to mathematics in the three dimensions that are magnitude, strength and generality. The dimension of magnitude refers to the students' self-confidence in their ability in overcoming the mathematical problems and tasks at different levels of difficulty.

3.2 Calculation of Expected Time (Te), Standard Deviation, and Variance

The expected time for each activity is calculated using the formula:

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

$$Te = \frac{2 + 4(4) + 6}{6}$$

$$Te = \frac{24}{6}$$

$$Te = 4$$

This calculation yields an estimated average duration that considers a time variation of 4. Meanwhile, the standard deviation uses the formula:

$$S = \frac{(b - a)}{6}$$

$$S = \frac{(6 - 2)}{6}$$

$$S = \frac{4}{6}$$

$$S = 0.67$$

Then the result of the standard deviation is used to find the variance of the activity. The calculation of the variance of activity A was obtained:

$$V(te) = s^2 = 0.67^2 = 0.44$$

The results of the three calculations are then displayed in Table 2 below.

Table 2. Value of te, standart deviation dan variance

Activity Code	Activity	(a)	(m)	(b)	te	S	V(te)
A	General	2	4	6	4	0.67	0.44
B	Construction Safety Management System (CSMS)	10	14	18	9	1	1
C	Earthworks and Geosynthetics	15	17	20	9	1	1
D	Granular Pavement and Cement Concrete Pavement	9	13	7	12.67	1	1
E	Asphalt Pavement Work	1	3	2.83	3.17	0.5	0.25
F	Structural Work	18	20	16	20.17	1.33	1.78
G	Daily Tasks and Other Tasks	4	6	5	6.17	1	1

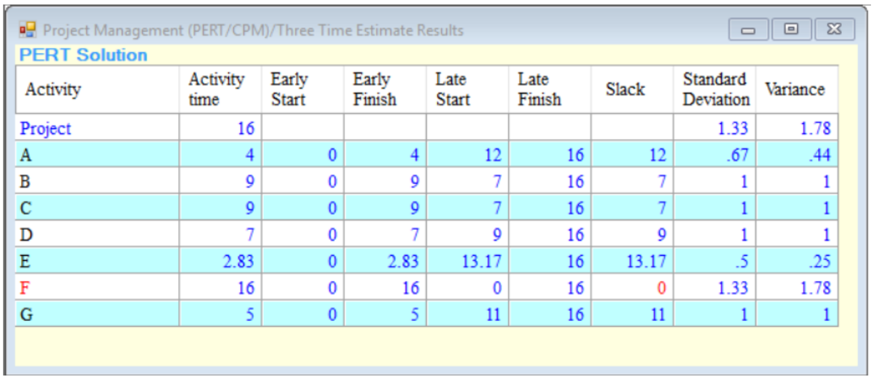
The results of expected time, standard deviation, and variance are used to determine the critical path. The critical path is the sequence of activities that have a slack value of 0, so a delay in any of the activities on this path will directly impact the entire project.

Table 3. Variance and standard deviation of the project on the critical path

Activity Code	Activity	te	V(te)
A	General	4	0.44
B	Construction Safety Management System (CSMS)	9	1
C	Earthworks and Geosynthetics	9	1
D	Granular Pavement and Cement Concrete Pavement	7	1
E	Asphalt Pavement Work	2.83	0.25
F	Structural Work	16	1.78
G	Daily Tasks and Other Tasks	5	1
Project Variance Σ V(te) total time on the critical path		1.78	
Deviasi Standart Proyek		1.33	

3.2 PERT Calculation Using POM-QM

The results of the PERT calculation using the POM-QM support application are presented in Figure 1.



Project Management (PERT/CPM)/Three Time Estimate Results

PERT Solution

Activity	Activity time	Early Start	Early Finish	Late Start	Late Finish	Slack	Standard Deviation	Variance
Project	16						1.33	1.78
A	4	0	4	12	16	12	.67	.44
B	9	0	9	7	16	7	1	1
C	9	0	9	7	16	7	1	1
D	7	0	7	9	16	9	1	1
E	2.83	0	2.83	13.17	16	13.17	.5	.25
F	16	0	16	0	16	0	1.33	1.78
G	5	0	5	11	16	11	1	1

Fig. 1. PERT calculation with the POM-QM application

From the calculations above, it has been determined that the critical path in the PERT method lies in activities A, C, D, E, F with a total duration of 25 days. The probability/uncertainty of meeting the schedule target in the PERT method is expressed with z, and the probability of the project being completed on time can be determined using the formula.

$$Z = \frac{Z - \mu}{\sigma}$$

$$Z = \frac{25 - 16}{1.33}$$

$$Z = 0.68$$

The next step is to look at the z-normal distribution table presented in Appendix 1, where the z-value of 0.68 corresponds to 0.751. This means the probability of the project being completed in 25 days is 75%. The complete analysis is presented in Table 4 below.

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Table 4. Target for potential project completion

No	Target Penyelesaian	Deviasi Z	Tabel Distribusi	Probabilitas Proyek Dapat

	(harian)		Normal	diselesaikan (%)
1	16	0.00	0.500	50
2	25	0.68	0.751	75
3	50	2.56	0.995	99

From the analysis above, it can be concluded that:

1. The probability of the project being completed in 16 days is 50%.
2. The probability of the project being completed within an additional 25 days is 75%.
3. The probability of the project being completed within an additional 50 days is 99%.

The results of the PERT method calculations show that the expected project duration is 55 days, faster than the planned time. This indicates that probabilistically, the project has a high chance of being completed on time or even earlier at 99%.
These findings are very useful in project planning and control, especially in anticipating the risk of delays. In project conditions full of uncertainty, the PERT method provides flexibility by considering various possible implementation time scenarios. This method not only predicts the project's completion time realistically but also informs the likelihood of timely completion, which is crucial in managerial decision-making.

The advantage of the PERT method over deterministic methods like CPM lies in its approach that uses multiple time estimates and statistical analysis. Thus, project planners can identify activities that have the potential to cause delays and design mitigation strategies, such as adding resources to critical activities with high deviations.

However, the application of the PERT method also has limitations. The accuracy of the results heavily depends on the quality of the time estimates used. If the time estimation is unrealistic, then the analysis results will deviate from reality. Therefore, the collection of time estimation data needs to involve various sources, including records of similar projects, field experience, and expert technical opinions.

In the context of the Baureno – Kadungrejo Road reconstruction project, the results of the PERT method provide a positive recommendation that with proper control, the project can be completed without the need for additional overtime or massive acceleration. However, planning must remain vigilant towards activities with high variance, as fluctuations in execution time for these activities can significantly affect the overall project deviation.

4. CONCLUSION

The PERT method is capable of accommodating the uncertainty of project activity durations by using three time estimates: optimistic (a), most likely (m), and pessimistic (b). With this approach, PERT provides more realistic results compared to deterministic methods, especially for projects with high variability in field conditions. Based on the PERT (Program Evaluation and Review Technique) analysis in the normal distribution list Z, if the z-value result = 0.68 yields 0.751, it means the probability of the project being completed in 25 days is 75%. If the z-value result = 2.56 yields 0.995, it means the probability of the project being completed in 50 days is 99%.

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