*Article*

# Implementation Of Program Evaluation And Review Technique (Pert) To Optimize Shophouse Development Projects

Irma Ayu Kartini[1], Tasya Aspiranti[1], Asni Mustika Rani[1, *]

[1]Prodi Manajemen Fakultas Ekonomi dan Bisnis, Universitas Islam Bandung 40116 Indonesia
email: irma_10090317274@unisba.ac.id; tasya@unisba.ac.id
*Correspondence: email: asnimustika@unisba.ac.id

**Abstract:** Construction development in Indonesia is being intensively carried out as a characteristic that Indonesia is a developing country. CV. X is a construction company that has a project in the form of ten shophouses with three floors. The project is planned to start in August 2020 and be completed in December 2021 or for 68 weeks. The change of seasons becomes an obstacle in the work of the project that causes delays. Progress expected by CV. X in 2 months of project work is 8%, but the reality on the project progress field is only 6%. Therefore, this study aims to optimize existing work time so that the delay can be overcome. The method used in this study is Program Evaluation and Review Technique (PERT) with rainfall as the probability. The results of the study found that the project work time can be optimized by 3% and delays can be overcome because the project completion time becomes 66 weeks. The project is still ongoing, so there is still a possibility of error, therefore effective project management must still be considered. Usually in similar studies the probability of time or cost, while in this study use rainfall as the probability.

**Keywords:** *Project Management, PERT, Optimization*

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## 1. Introduction

In developing countries such as Indonesia, continuous development has been performed extensively, especially infrastructure development such as toll roads, bridges, hospitals, schools, airports. South Sumatra Province is a province that does quite many project development in Indonesia. Based on data from the Regional Research and Development Agency of South Sumatra Province in 2015-2018, more than 125 projects were conducted. Meanwhile, for 2019-2020, the South Sumatran government will focus on the Trans Sumatra Toll Road (JTTS) construction project.

* Corresponding author.


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As one of the construction companies in South Sumatra, CV. X is currently working on constructing ten shophouses with three floors built on an area of 900 m2. The project was started in August 2020 and is estimated to be completed within 68 weeks or completed in December 2021. According to the planned schedule, this project should have worked within two months of project progress; due to delays in the project, the actual performance of the new project was up to 6% only. Table 1 shows the planning and actual performance of the ten three-floor shophouse construction project is as follows:

**Table** 1 Project Planning and Actual Performance

| Month | Planning | Actual |
|---|---|---|
| Aug-20 | 6% | 4% |
| Sep-20 | 8% | 6% |
| Oct-20 | 16% | - |
| Nov-20 | 19% | - |
| Dec-20 | 20% | - |
| Jan-21 | 28% | - |
| Feb-21 | 35% | - |
| Mar-21 | 41% | - |
| Apr-21 | 42% | - |
| May-21 | 44% | - |
| Jun-21 | 52% | - |
| Jul-21 | 63% | - |
| Aug-21 | 67% | - |
| Sep-21 | 68% | - |
| Oct-21 | 74% | - |
| Nov-21 | 96% | - |
| Dec-21 | 100% | - |

Actual performance that is slower than planned in Table 1. will have harmful effects if it continues and is not controlled. However, the projects that experienced delays or failures had many impacts, such as additional project costs for the construction company as the party working on the project [1]. Therefore, departing from these problems, in this study, the author analyzes this project which aims to optimize the working time of the shophouse construction project.

Therefore, this study uses the PERT method with rainfall as a probability. So, it is estimated for high, normal, and low rainfall the same which is 33.3% because rainfall is an uncertainty. Then each project activity is sorted from the project starting until the project is completed to be further used as a calculation on the PERT method. From the results of this research, project work time can be more optimal by increasing the working time of employees and adding a little project funds for employee overtime costs. By using PERT, the project work time becomes faster, and several project activities can be done simultaneously to save time.

## 2. Literature

Project management is included in the ten strategic operations management decisions because, in project management, there are decisions to design projects, manage project quality, design raw materials and project capacity, determine strategic project locations, develop project layouts, recruit employees according to job descriptions. manage the supply chain of project raw materials, manage inventory, create a schedule for each project activity from start to finish, and maintain existing facilities [2].

Project management is an activity that has a starting time and a completion time which, in practice, the parties who do it, whether organizations, teams, or individuals, involve innovation so that project goals can be achieved following the available resources such as budgeted costs, time allotted, and labor [3].

The purpose of project management must be clear and identified in advance so that the parties working on it can organize activities according to their goals [4]. In project management, planning, organizing, directing, and controlling company resources have previously explicitly been prepared [5]. These steps are taken as a stepping stone because usually, in the field, the project experiences unexpected obstacles, so a decision must be made [6].

In project management practice, time is often seen as something that can be managed, while resources are owned to achieve predetermined goals [7]. Therefore, the success of the project depends on these independent variables [8]. As the person responsible for the project being carried out, the project manager must know the priorities set for the project [9]. In addition, risks in projects must continually be monitored because risks can always appear as indicators at various stages of a project's life cycle [10].

It can be concluded that project management is a company or organization activity that includes planning, scheduling, and controlling its resources. Whether it is the people involved, the budgeted costs, and the time determined to be managed optimally, the project goals are successful regardless of the risks. In the PMBOK book [11], it is stated that effective project management helps individuals, groups, and organizations, as well as institutions, to meet business goals, meet stakeholder interests, increase chances of success, respond to risks, solve problems, optimize available resources, and manage constraints.

Several methods can be used for project management, but almost all methods focus on managing project time and costs [12]. The critical path method (CPM) is a project management method that identifies the longest path and finds a critical path that can be shortened to faster the project completion time [13]. In shortening the project completion time, additional resources are needed or transferring from the non-critical path to the critical path [14]. The minimum project completion time is shorter than the expected time if there is no delay [15].

The other project management method is crashing, a way to speed up the expected time of project activities in a network by shortening the duration on the critical path [2]. Although costs must be sacrificed, efforts are made to use these costs as optimally as possible and do not reduce other resources [16].

Program Evaluation and Review Technique (PERT). The PERT method is a project management method that uses three-time estimates for each [17]. The following are three-time estimates [2], including:

1. Optimistic time is symbolized by (A)

The time activity would take if things went according to plan. There is only a tiny probability in estimating this value, for example, 1/100 where the activity time is < to.

2. Pessimistic time is symbolized by (B)

The time that an activity will take by assuming unfavorable conditions. In estimating this value, there is only a tiny probability, also 1/100, that the activity time is > tp.

3. The most likely time is symbolized by (M)
The most realistic estimate of the time required to complete an activity can be calculated using the formula below.

$$te = \frac{A + (4 \times M) + B}{6}$$

In addition to the calculation of time expected (te) and variance (V), there is also a calculation for the standard deviation (σ) of the duration of the execution time of each activity, which can be calculated using the following formula:

$$\sigma = \frac{(B - A)}{6}$$

After getting the expected time (te), using a normal distribution, the probability of the project being completed within a specific time (Td) can be calculated as follows:

$$Z = \frac{T(d) - te}{\sigma}$$

Information :
Z = the probability that the target will be achieved
T(d) = project completion time target
te = earliest time for project completion
σ = standard deviation

In addition to the three-time estimates, PERT also includes the average duration of time expected (te), standard deviation (σ), and variance ($\sigma 2$). Each activity's standard deviation and variance are calculated to get the average time duration or better known as the expected time (te) [18]. Several terms must be known in PERT, namely as follows:

1. Earliest start – ES: The earliest time an activity can start, assuming all predecessor activities have been completed.
2. Earliest finish (EF): The earliest time at which an activity can be completed.
3. The latest start (LS): The latest time at which an activity starts so as not to delay the completion time of the entire project.
4. Latest finish (LF): The latest time at which an activity must be completed so as not to delay the completion time of the entire project.

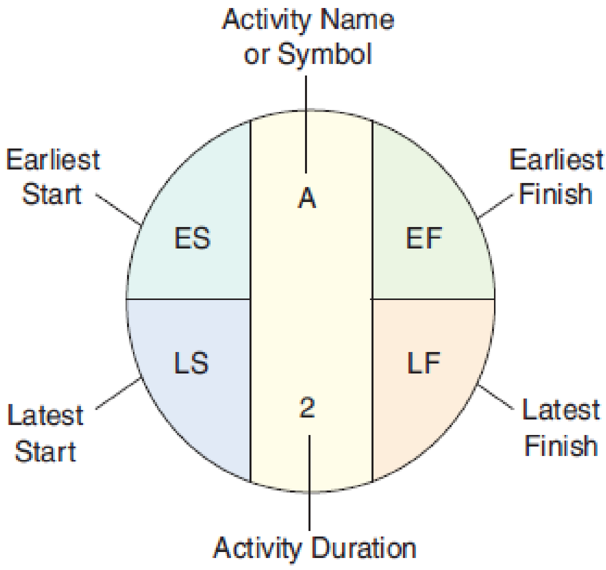
Using a two-pass process (two-way cross) that contains the front and backtracks to determine the schedule for each activity. The faster start (ES) and finish (EF) times are determined during the forward pass, namely:

EF = ES + Activity Time

Meanwhile, the start time (LS) and the slowest time (LF) are determined during the backtrack, namely:

LS = LF – Activity time

In addition to having two methods in project management, there is also an approach to describe a project network diagram, namely Activity On Node (AON), where activities are at node points [18]. The examples of AON images are as follows:




Source: *Heizer et al* (2017:67)

## 3. Method

This research uses descriptive qualitative research methods, namely research that describes existing phenomena to obtain data and present a complete picture of current events. The data was taken in September 2020 using a technique in the form of interviews with project forepersons in the field to find out the actual project situation.

Observations were made on the object of research. Aside from interviews, the observations were explicitly built to investigate the current condition of the project, how it was running, and the constraints faced. The order of the work of this research is as follows:

1. Start.
2. Looking for project planning data.
3. Applying the PERT. Method
    a. Create a sequence of activities.
    b. Calculate the expected time.
    c. Calculates forward pass (ES = Max EF).
    d. Counting backward passes.
    e. Calculate slack and determine the critical path.
4. Optimizing working time.
5. Finish.

## 4. Result and Discussion

This project consists of 3 main stages: the first stage of preparation, the second stage of development, and the third stage of completion. The preparation stage consists of the following activities: (1) Land surveying, (2) Land clearing, (3) Mowing grass, and (4) Leveling the soil. These activities are carried out so that they can be used to build shophouses.

The construction phase consists of the following activities: (1) Installing boplank, (2) Site plan, (3) Excavating the site, (4) Foundation, (5) Installing seloof beams, (6) Formwork/formwork, (7) Installing ring beams, (8) Casting, (9) Installation of trasram, (10) Making walls, (11) Installing frames, windows, doors (12) Making 2nd floor, (13) Hoarding, (14) Ceiling frames, (15) Gypsum ceilings, (16) Easel installation, (17) Roof frame, (18) Lisplank, and (19) Asbestos installation. However, activities 1 to 15 at the construction stage are repeated for the 2nd and 3rd floor of shophouses. The completion stage consists of the following activities: (1) Melting, (2) Melting, (3) Installing ceramics, (4) Painting, and (5) Cleaning the building. In this study, an analysis of all activities in the three stages was used.

This project started in August 2020 and is estimated by CV. X will be completed in December 2021 or completed in 68 weeks. In every month CV. X provides a value for project progress to measure project performance as expected or not. In this project CV. X grouped workers into two, namely foreman and handyman, who were expected to help each other and make work easier. At the beginning of the project, only 16 workers consisted of 8 forepersons and eight artisans.

When the casting activity is carried out, the workers are added to 45, consisting of 15 forepersons and 30 artisans. So the number of workers until the project is completed 45 people. To control costs CV. X makes a draft budget (RAB) consisting of various costs needed such as worker salaries, materials, wood, and others. The total cost budgeted by CV. X for this project from the start of the project to completion is Rp. 4,500,000.

Applying the PERT method to this project requires a predecessor or determines which activities can be carried out if the previous activity has been completed. In addition to predecessors, the PERT method also uses three-time estimates, namely optimistic time (A), pessimistic time (B), and most likely time (M), which will later be used to calculate the expected time (te). Both A, B, and M scores were obtained from the interviews where A was the most optimistic time or the fastest time the activity could be completed, B was the most pessimistic or longest time for the activity to be completed, and M was the average time the activity could be completed. The result of the PERT calculation by entering the value of each time estimate in the formula is depicted in Table 2.

Based on the Table 2, it can be seen the expected time for each activity. Besides that, there is also a forward pass calculation for this project regarding the early start time of project activities and the early finish time of project activities. The early start time for project activities is week 0 in activity A, while the early finish time for project activities is day 389.5 of week 65 inactivity AZ. Meanwhile, for the backward pass calculation in this project, the project activity late starts time and project activity late finish time. The late start time for project activities is week 0 in activity A, while the late finish time for project activities is day 396 of week 66 in activity AZ.

**Table 2**. Program Evaluation and Review Technique Calculation

| No | Activity | Duration (week) | Code | *Predecessor* | | | | *ET* | *ES* | *EF* | LS | LF | Slack | *Critical Path* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | | | | | | | |
| 1 | Land measurement | 6 | A | | | | | 6,5 | 0 | 6,5 | 0 | 6,5 | 0 | Yes |
| 2 | Clearing the land | 12 | B | A | | | | 12 | 6,5 | 18,5 | 6,5 | 18,5 | 0 | Yes |
| 3 | Mow the lawn | 6 | C | A | | | | 6,5 | 6,5 | 13 | 12 | 18,5 | 5,5 | No |
| 4 | Leveling the ground | 6 | D | B | C | | | 6,5 | 18,5 | 25 | 18,5 | 25 | 0 | Yes |
| 5 | Installing wooden board | 6 | E | D | | | | 6,5 | 25 | 31,5 | 25 | 31,5 | 0 | Yes |
| 6 | site plan | 6 | F | D | | | | 6,5 | 25 | 31,5 | 25 | 31,5 | 0 | Yes |
| 7 | Digging tapas | 18 | G | E | F | | | 17 | 31,5 | 48,5 | 31,5 | 48,5 | 0 | Yes |
| 8 | Foundation | 12 | H | G | | | | 12 | 48,5 | 60,5 | 79,5 | 91,5 | 31 | No |
| 9 | Installing the tie beam | 12 | I | G | | | | 12 | 48,5 | 60,5 | 48,5 | 60,5 | 0 | Yes |
| 10 | Formwork | 24 | J | H | | | | 23 | 60,5 | 83,5 | 91,5 | 114,5 | 31 | No |
| 11 | Installing the beam ring | 6 | K | H | | | | 6,5 | 60,5 | 67 | 108 | 114,5 | 47,5 | No |
| 12 | Casting | 18 | L | I | | | | 19 | 60,5 | 79,5 | 60,5 | 79,5 | 0 | Yes |
| 13 | Waterproof plaster installation | 12 | M | J | K | | | 12 | 83,5 | 95,5 | 114,5 | 126,5 | 31 | No |
| 14 | Making walls | 60 | N | L | | | | 60 | 79,5 | 139,5 | 79,5 | 139,5 | 0 | Yes |
| 15 | Installing frames, windows, doors | 12 | O | M | | | | 13 | 95,5 | 108,5 | 126,5 | 139,5 | 31 | No |
| 16 | 2nd floor construction (dak) | 12 | P | N | O | | | 13 | 139,5 | 152,5 | 139,5 | 152,5 | 0 | Yes |
| 17 | hoard | 6 | Q | P | | | | 6,5 | 152,5 | 159 | 152,5 | 159 | 0 | Yes |
| 18 | Ceiling frame | 6 | R | P | | | | 6,5 | 152,5 | 159 | 152,5 | 159 | 0 | Yes |
| 19 | Gypsum ceiling | 6 | S | P | | | | 6,5 | 152,5 | 159 | 152,5 | 159 | 0 | Yes |
| 20 | Installing wooden board | 6 | T | P | | | | 6,5 | 152,5 | 159 | 152,5 | 159 | 0 | Yes |
| 21 | site plan | 6 | U | Q | R | S | T | 6,5 | 159 | 165,5 | 159 | 165,5 | 0 | Yes |
| 22 | Installing the tie beam | 12 | V | U | | | | 12 | 165,5 | 177,5 | 165,5 | 177,5 | 0 | Yes |
| 23 | Installing the beam ring | 6 | W | U | | | | 6,5 | 165,5 | 172 | 171 | 177,5 | 5,5 | No |
| 24 | Casting | 18 | X | U | | | | 19 | 165,5 | 184,5 | 170,5 | 189,5 | 5 | No |
| 25 | Waterproof plaster installation | 12 | Y | V | W | | | 12 | 177,5 | 189,5 | 177,5 | 189,5 | 0 | Yes |
| 26 | Making walls | 60 | Z | X | Y | | | 60 | 189,5 | 249,5 | 189,5 | 249,5 | 0 | Yes |
| 27 | Installing frames, windows, doors | 12 | AA | Y | | | | 13 | 189,5 | 202,5 | 220 | 233 | 30,5 | No |
| 28 | 3rd floor construction | 24 | AB | AA | | | | 13 | 202,5 | 225,5 | 233 | 256 | 30,5 | No |
| 29 | Hoard | 6 | AC | Z | | | | 6,5 | 249,5 | 256 | 249,5 | 256 | 0 | Yes |

**Table 2**. Program Evaluation and Review Technique Calculation (Cont.)

| No | Activity | Duration (week) | Code | *Predecessor* | | | | *ET* | *ES* | *EF* | LS | LF | Slack | *Critical Path* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | | | | | | | |
| 30 | Ceiling frame | 6 | AD | Z | | | | 6,5 | 249,5 | 256 | 249,5 | 256 | 0 | Yes |
| 31 | Gypsum ceiling | 6 | AE | Z | | | | 6,5 | 249,5 | 256 | 249,5 | 256 | 0 | Yes |
| 32 | Installing wooden board | 6 | AF | AB | AC | AD | AE | 6,5 | 256 | 262,5 | 256 | 262,5 | 0 | Yes |
| 33 | Site plan | 6 | AG | AB | AC | AD | AE | 6,5 | 256 | 262,5 | 256 | 262,5 | 0 | Yes |
| 34 | Installing the tie of beam | 12 | AH | AB | AC | AD | AE | 12 | 256 | 268 | 294,5 | 306,5 | 38,5 | No |
| 35 | Installing the beam ring | 6 | AI | AF | AG | | | 6,5 | 262,5 | 269 | 300 | 306,5 | 37,5 | No |
| 36 | Casting | 18 | AJ | AF | AG | | | 19 | 262,5 | 281,5 | 262,5 | 281,5 | 0 | Yes |
| 37 | Waterproof plaster installation | 12 | AK | AH | AI | | | 12 | 269 | 281 | 306,5 | 318,5 | 37,5 | No |
| 38 | Making walls | 60 | AL | AJ | | | | 60 | 281,5 | 341,5 | 281,5 | 341,5 | 0 | Yes |
| 39 | Installing frames, windows, doors | 12 | AM | AK | | | | 13 | 281 | 294 | 323,5 | 336,5 | 42,5 | No |
| 40 | Making dak | 24 | AN | AM | | | | 23 | 294 | 317 | 336,5 | 359,5 | 42,5 | No |
| 41 | hoard | 6 | AO | AL | | | | 6,5 | 341,5 | 348 | 353 | 359,5 | 11,05 | No |
| 42 | Ceiling frame | 6 | AP | AL | | | | 6,5 | 341,5 | 348 | 389,5 | 396 | 48 | No |
| 43 | Gypsum ceiling | 6 | AQ | AL | | | | 6,5 | 341,5 | 348 | 353 | 359,5 | 11,5 | No |
| 44 | Installation of the horses | 18 | AR | AL | | | | 18 | 341,5 | 359,5 | 341,5 | 359,5 | 0 | Yes |
| 45 | Roof truss | 18 | AS | AN | AO | AR | AQ | 18 | 359,5 | 377,5 | 359,5 | 377,5 | 0 | Yes |
| 46 | List plank | 12 | AT | AR | | | | 12 | 359,5 | 371,5 | 365,5 | 377,5 | 6 | No |
| 47 | Asbestos installation | 12 | AU | AS | AT | | | 12 | 377,5 | 389,5 | 377,5 | 389,5 | 0 | Yes |
| 48 | Plaster | 48 | AV | AK | | | | 48 | 281 | 329 | 318,5 | 366,5 | 37,5 | No |
| 49 | Melamine | 24 | AW | AM | | | | 23 | 294 | 317 | 343,5 | 366,5 | 49,5 | No |
| 50 | Installing ceramics | 18 | AX | AM | | | | 17 | 294 | 311 | 379 | 396 | 85 | No |
| 51 | Paint | 24 | AY | AV | AW | | | 23 | 329 | 352 | 366,5 | 389,5 | 37,5 | No |
| 52 | Cleaning the building | 6 | AZ | AU | AY | | | 6,5 | 389,5 | 396 | 389,5 | 396 | 0 | Yes |

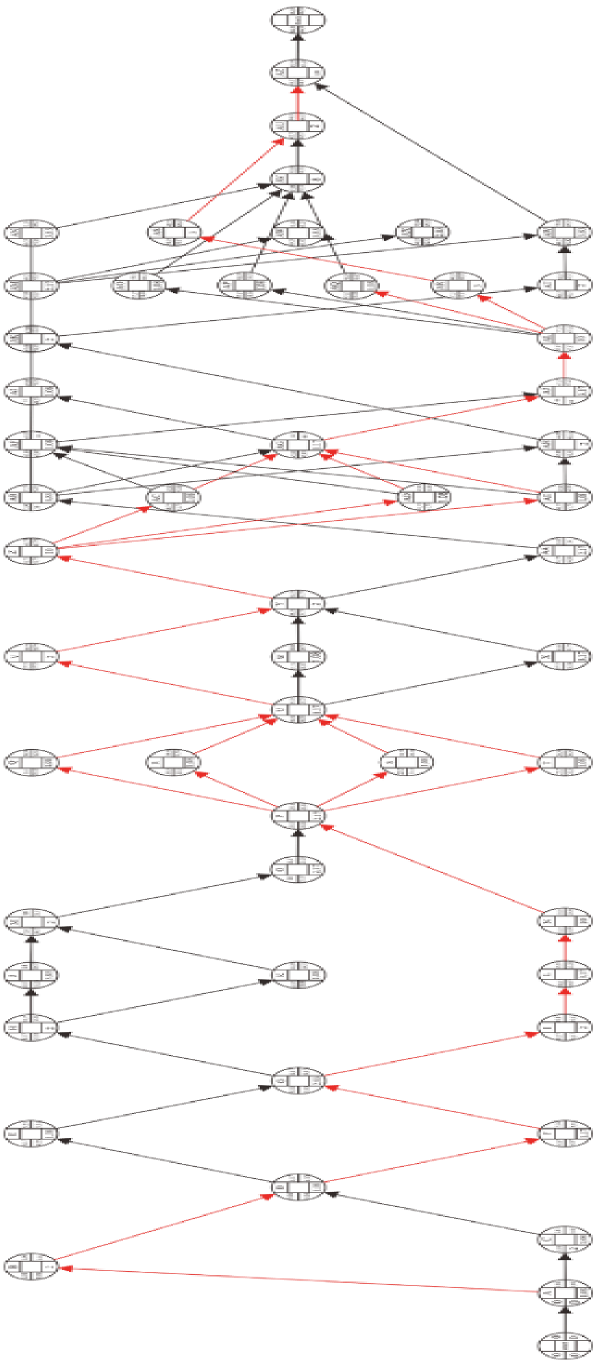


**Figure 2**. Activity on Node

Activities on the critical path itself are determined from the results of the slack calculation. If the results of the slack calculation are 0, then the activity is on the critical path. So from the ten shophouses project with three floors carried out by CV. X 29 activities are on the critical path, namely A, B, D, E, F, G, I, L, N, P, Q, R, S, T, U, V, Y, Z, AC, AD, AE, AF, AG, AJ, AL, AR, US, AU, and AZ. Then we got the AON drawings for the ten shophouses to project with three floors carried out by CV. X as depicted at Figure 2.

Figure 2 above is an AON image that shows all activities and their completion times. The critical path is depicted with a red node, and inside the circle, there are values for an early start, late start, early finish, and late finish. Based on the results, we can stated that the project of ten shophouses with three floors that was carried out by CV. X, if using the PERT method, can be completed within 66 weeks or two weeks faster than before

## 5. Conclusion and Recommendation

The construction project of ten shop houses with three floors was carried out by CV. X. When using the PERT method, the construction project can be completed within 66 weeks or 396 days. Using the PERT method, the project can be completed 3% faster with a time efficiency of 12 days or two weeks than planned by CV. X.

However, it should be noted that if using this method, employees must work overtime and funds for the project will increase slightly to pay employees who are overtime. It never hurts to hire employees on an overtime basis and increases a little project funding so that the project can be completed faster and avoid delays.

In carrying out project management, especially with the PERT method, CV. X must always pay attention to environmental, climatic, and social conditions. Anticipation of delays in project completion need to be carried out, including budget projections using crash programming.

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**References**

1. Andrews et al., 2018. Public policy failure: 'How often' and 'what is failure, anyway'? A study of World Bank project performance. Harvard University Center for International Development Paper No. 344. https://www.hks.harvard.edu/centers/cid/publications/faculty-working-papers/public-policy-failure
2. Heizer, J., and Rander, B., 2017. Operation Management: Sustainability and Supply Chain Management,12th Edition. USA: Pearson Education.
3. Allan., 2017. Business Models: A Strategic Management Approach. New York: Mc Graw-Hill.
4. Schelle et al., 2017. Dimensions of project management: Salient Management Company. Springer-Verlag Berlin Heidelberg.

5. Kerzner, 2017. Using the Project Management Maturity Model: Strategic Planning for Project Management 3rd Edition. New Jersey: John Wiley & Sons, Inc.
6. Lalevee, 2020. The Interest of An Evolution of Value Management Methodology in Complex Technical Project for Improving Project Management. https://doi.org/10.1016/j.procir.2020.01.108
7. Delisle, 2019. Uncovering Temporal Underspinnings of Project Management Standards. https://doi.org/10.1016/j.ijproman.2019.09.005
8. Unegbu, 2020. An investigation of the relationship between project performance measures and project management practices of construction projects for the construction industry in Nigeria. Journal of King Saud University - Engineering Sciences. https://doi.org/10.1016/j.jksues.2020.10.001
9. Stanitsas, 2020. Integrating sustainability indicators into project management: The Case of Construction Industry. Journal of Cleaner Production, Volume 279, 2021, 123774. ISSN 0959-6526. https://doi.org/10.1016/j.jclepro.2020.123774
10. Kesk, 2018. Special studies in management of construction project risks, risk concept, plan building, risk quantitative and qualitative analysis, risk response strategies. Alexandria Engineering Journal, Volume 57, Issue 4, Pages 3179-3187. ISSN 1110-0168. https://doi.org/10.1016/j.aej.2017.12.003
11. Project Management Institute (2017), Guide to the Project Management Body of Knowledge PMBOK Guide 6th Edition.
12. Troussier, 2020. The interest of an evolution of value management methodology in complex technical projects for improving project management. Procedia CIRP, Volume 90, Pages 411-415. ISSN 2212-8271. https://doi.org/10.1016/j.procir.2020.01.108
13. Takakura, 2019. Application of critical path method to stochastic processes with historical operation data. Chemical Engineering Research and Design, Volume 149, Pages 195-208. ISSN 0263-8762. https://doi.org/10.1016/j.cherd.2019.06.027
14. Bordley, 2019. Managing projects with uncertain deadlines. European Journal of Operational Research, 274(1), 291-302. https://doi.org/10.1002/j.2334-5837.2019.00610.x
15. Zareei, S., 2018, Project scheduling for constructing biogas plant using critical path method, Renewable and Sustainable Energy Reviews, Vol. 81, pp 756-759.
16. Feylizadeh, 2018. Project crashing using a fuzzy multi-objective model considering time, cost, quality and risk under fast tracking technique: A case study. Journal of Intelligent and Fuzzy Systems 35(11):-1-19. DOI:10.3233/JIFS-18171
17. Nigel, 2014. Managing Risk in Constructure Project 3rd Edition. United Kingdom: John Wiley & Sons, Inc.
18. Fitzsimon, 2014. Service Management: Operations, Strategy, and Information Technology. Mc Graw-Hill: 11th edition.