Scheduling of Infrastructure Construction Projects Using the Manual-Program Evaluation and Review Technique (M-Pert) Method Case Study: Indonesian Sunda Strait Bridge

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Abstract. The idea to build the Sunda Strait Bridge, popularly known as Jembatan Selat Sunda (JSS), began in the government of Indonesia's first president, Sukarno, which connect two islands with the largest economy in Indonesia, Sumatra Island and Java Island. This ambitious project will become a single mega infrastructure project with the largest investment in Indonesia. The successful completion of a project can be associated to the completion of a project on time. Accurate calculation of project time duration estimation is the key to the success of an infrastructure project delivery on time. Many practitioners in construction industry nowadays are having difficulties to estimates project duration correctly. Choosing the appropriate method in scheduling planning is the key to the successful estimation of a project. This research proposes the use of the M-PERT scheduling method which is the development of the conventional PERT with a higher degree of accuracy. As a case study, this research uses the Suspension Bridge section, which is one part of the overall phase of the construction of the JSS infrastructure project. The results of this research produce estimates of the project duration using M-PERT is 2104.38 days. It gives the estimation error is less than 1% when compared with the Monte Carlo simulated curves. As a comparison, this research also calculates duration estimation using conventional PERT and it gives 2013 days with error more than 24% when compared with the Monte Carlo simulated curves. A step-by-step process to estimate project duration using M-PERT method are also include in supplemental data.

Keywords: *Jembatan Selat Sunda; M-PERT; PERT; Scheduling; Simulated Curves*

1 Introduction

The Sunda Strait Bridge or known as Jembatan Selat Sunda (JSS) is one of the major projects in the construction of bridges that cross the Sunda Strait as a link between Java Island and Sumatra Island. This bridge originated from the idea of

Prof. Sedyatmo , a professor at the Bandung Institute of Technology (ITB) in 1960 was called Tri Nusa Bimasakti which means a link between three islands; Sumatra Island, Java Island and Bali Island.

Then, in 1965 Sukarno as the first president of the Republic of Indonesia ordered ITB to conduct a trial design of the link in which the results of the experiment were in the form of a tunnel. From many articles that discuss JSS, there are only a few or even no one discussing planning scheduling in the construction phase of JSS development. A large-scale project such as the JSS mega project requires an appropriate scheduling plan. In the construction industry, scheduling plays an important role because it regulates the time and sequence of various activities, the interrelationships between one activity and other activities.

One method of scheduling that is quite extensive in use is the Program Evaluation and Review Technique (PERT). This PERT method is a scheduling method based on statistics and probabilities. However, despite the popular use of PERT, this method has several shortages. The original PERT significantly underestimated the duration average and overestimated the duration variance of real-life projects. Original PERT also stated that this method follows Beta distribution, which is not, in real-life project. To overcome this shortcoming, Ballesteros-Perez (2017) propose a new reformulated PERT, named M-PERT, Manual Program Evaluation and Review Technique.

The M-PERT method is much more accurate in determining the actual duration of the project and it is also easier and simpler because it does not require the assistance of certain simulation software in its calculations. To further emphasize the accuracy of this M-PERT method, this research compares it with the calculation of the estimated duration of the project using original PERT method. Furthermore, in this research, what was meant by JSS development work was narrowed down to the construction of a Suspension Bridge of the JSS.

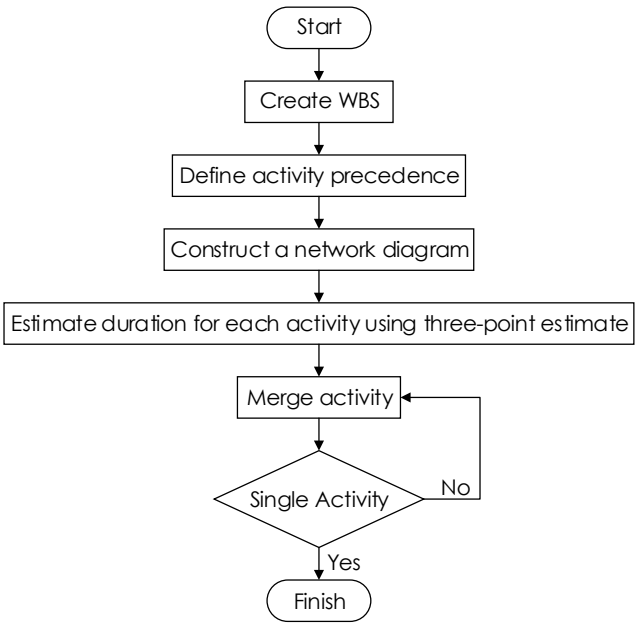

Figure 1 M-PERT procedures for JSS project.

2 Materials and Methods

In making this M-PERT method, it still requires the same working steps as for making the PERT method, with some additional variations. The first step in making project scheduling is to develop the list of tasks to create what is known as a work breakdown structure (WBS). Each activity in the construction process above is related to each other. For each activity, it is necessary to know whether there are other activities that must be done before starting the activity (predecessor). In the construction of this JSS, relationships between activities are described in table form. Project network diagrams are graphical representations of all activities contained in WBS and workflows for a project. This diagram looks like a chart with a series of boxes and arrows that are used to map the schedule and sequence of work of a project, and track its progress through each stage, up to and including completion.

MS-Project software and MS-Visio software are used to assist making a network diagram for construction phase in this JSS project. At this stage, the information needed is to estimate the duration of each activity, in this case is to estimate the duration of each activity of the JSS construction phase. In addition to calculating the duration of each activity, this stage also calculates the standard deviation or

standard deviation of each of these activities as well. Basically, the M-PERT method is a method for combining two or more activities into only a single activity. This process is done repeatedly until there is only one activity left, which represents the total duration of the project. There are four merge operations in M-PERT, (1) Merge for Serial Activities, (2) Merge for Probabilistic (alternative) paths, (3) Self-loops, and (4) (maximum or minimum) Parallel paths. The procedure for making JSS project scheduling using the M-PERT method in the form of a flow diagram can be seen in Figure 1.

3 Result and discussion

The WBS on the JSS project was made to find out what activities are involved in the construction of suspension bridges at JSS and made up to level four. This level is sufficient for flexibility and ease of scheduling, not too detailed but also not too few. In JSS development work, activity precedence is divided into each level three and the precedence type would be Finish-to-Start (FS). In this research the type of network diagram used is Activity-On-Node (A-O-N) where a node represents an activity. The estimated calculation of the duration of each JSS development activity is carried out by a bridge construction expert. M-PERT merge activity for JSS work applied in serial and (maxima) parallel path. Seven steps were used to reduce all activity into one merge activity, with four steps of serial activity merge and three (maxima) parallel path merge activity. For comparison, in this research the accuracy of the M-PERT scheduling method was compared with the original PERT scheduling method. From the calculation results, the estimated duration of construction of the JSS suspension bridge by the PERT method is 2013 days with a standard deviation of 39.14 days, while the M-PERT method is 2103.76 days, and the standard deviation is 25.9 days. The average (project duration) of simulated distribution is 2098.08 days and this simulated distribution used as reference. The JSS project duration mean using M-PERT method when compared to simulated distribution mean gives estimation error less than 1% (0.14%) while compare project duration mean using PERT method with simulated distribution mean gives estimation error 27.59% (see figure 2).

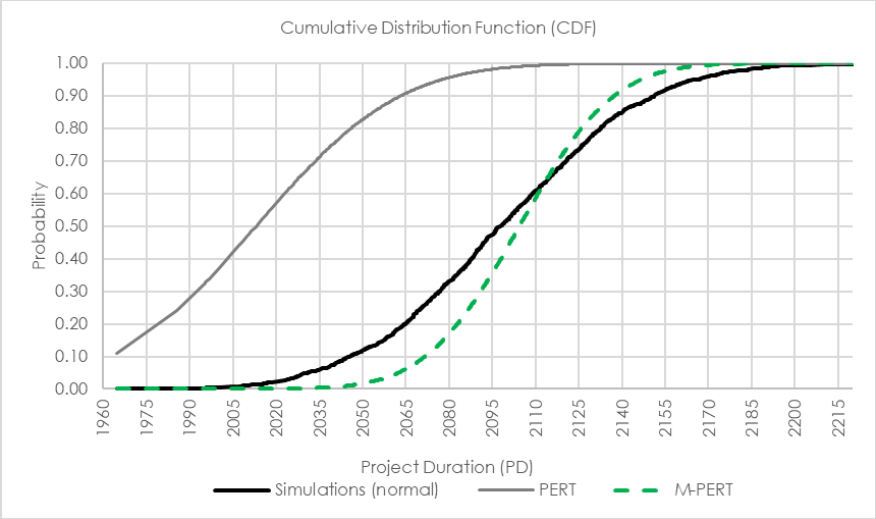

Figure 2 Comparison of project duration estimation accuracy between PERT and M-PERT for JSS project.

4 Conclusion

The construction of infrastructure projects in the Sunda Strait Bridge (Jembatan Selat Sunda, JSS) requires an accurate time estimation plan. The original PERT method cannot afford it because it only focuses on the critical path, ignores other activity, underestimated project duration and overestimated variance. The development of PERT method into M-PERT is done to overcome this. The estimation error of the M-PERT method for estimating the duration of construction of the Sunda Strait Suspension Bridge is less than 1% compared to the original PERT method which is above 27% proves that the M-PERT method successfully overcomes the shortcoming of the PERT method. The M-PERT method is also quite simple in its calculations so it is enough just to use spreadsheet software without special software for calculating the duration of the project.

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