The Project Performance Evaluation of Road Construction Project Using Earned Value Method

Zetta Rasullia Kamandang

Department of Civil Engineering, Engineering Faculty, University of Pembangunan Nasional “Veteran” Jawa Timur, Indonesia

*Corresponding author: zerasullia.ts@upnjatim.ac.id

Abstract
The fundamental goal of project management is to finish a facility building project on schedule and within budget while adhering to defined standards and specifications. No matter how great the construction project plan is, if frequent and timely reviews are not done throughout project execution, neither the project progress nor the plan's efficacy can be evaluated. The Earned Value Method (EVM) is one of the tools used in project management that integrates scope, cost and time or schedule measures and provide an accurate picture of current project state at the time of control. This research implements the EVM to road construction project to observe the project performance during its execution and to estimate the cost and the duration of the project completion. Based on the calculation, the project team has efficient performance in using their time and cost for week one until week three, but it decreased especially in time of execution (0,864 of SPI value). Further calculations predict the project needs to prepare Rp. 115.935.300,00 to finish with Rp. 264.828.113,00 of total cost while the TE value shows this project will be finished one week behind its initial planning if no corrective action is done.

Keywords: construction project performance, earned value method, project management, project performance evaluation, road construction project.

INTRODUCTION
Project is a time-limited activity that uses resources, such as money, materials, man power, and equipment to create a product, service, or outcome. A solid and precise project management is required to manage a project from the beginning to the end [1]. The fundamental goal of project management is to finish a facility building project on schedule and within budget while adhering to defined standards and specifications [2]. No matter how great the construction project plan is, if frequent and timely reviews are not done throughout project execution, neither the project progress nor the plan's efficacy can be evaluated [3]. Production in construction is indicated by powerful seasonal fluctuations. They form a cycle of recurring changes in approximately equal intervals of time, with comparable intensity. Their discovery and inclusion significantly improves forecast precision [4].

The Earned Value Method (EVM) is one of the tools used in project management that integrates scope, cost and time or schedule measures. The method could provide an accurate picture of current project state at the time of control. The implementation of the EVM to construction projects itself have been addressed by previous researchers [5]–[7]. EVM, according to Naderpour and Mofid [8], is a recognized system that gives quantitative metrics of project performance and combines them with cost and schedule. Furthermore, EVM is proven to be advantageous to the project team since it offers early notice of whether the project is behind time or over budget [3]. Most academics believe that EVM is reliable in assessing construction project status in terms of cost, time, and scope [9], [10]. EVM also allows exact and contemporaneous examination of a construction project's time and cost performance [11]. After being used on real-life projects, the use of EVM in project management was demonstrated to be a solid forecasting tool for project length [12], [13]. Another researcher [14] also verified the capacity of EVM to anticipate project progress in their study.

MATERIAL AND METHOD
A. Case Study
The case study of this research is an asphalt road construction project with a length of 831 meters and a width of 2.5 meters located in Sampang, East Java. This project has three stages of work: preparation work, construction work 1 (CW1) and construction work 2 (CW2). The preparation work consisted of equalization work and site cleaning, while CW1 (KM 0.000-0.500) and CW2 (KM 0.500-0.831) consisted of prime coat work, patching of telford work, 5% and 10% patching of layer penetration macadam (lapen)
work, and layer penetration work with Rp. 303,142,000,00 of contract price.

<table>
<thead>
<tr>
<th>NO</th>
<th>Work Item</th>
<th>As-as-planned Cost</th>
<th>Weight</th>
<th>Duration</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Location equalization work &amp; mobilization</td>
<td>Rp 775,500.00</td>
<td>0.28</td>
<td>Week 2</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>actual</td>
<td>0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Site clearing before construction work</td>
<td>Rp 775,500.00</td>
<td>0.28</td>
<td>Week 2</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>actual</td>
<td>0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Planning consultation</td>
<td>Rp 5,000,000.00</td>
<td>1.65</td>
<td>Week 6</td>
<td>1.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>actual</td>
<td>1.65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This project is supposed to be finished in six weeks, however, it faced delay starting in the fourth week. The purpose of this study is (1) to observe the project performance during its execution and (2) to estimate the cost and the duration of the project completion if the occurred conditions remain the same as during the inspection time, with no corrective actions.

B. Data
The main required data that collected from the project are the bill of quantity (BoQ), as-planned and actual work progress, S-curve, and actual cost for each week of construction works. Figure 1 shows the information summary of the data, where the blue line shows the as-planned cumulative progress and the red one represents the actual progress.

C. Methodology
This research started by collecting the required data from the project. The data later will be processed to obtain the three key variables representing the fundamental of EVM analysis; Budgeted Cost of Work Scheduled (BCWS) or Planned Value (PV), Budgeted Cost of Work Performed (BCWP) or Earned Value (EV), and Actual Cost of Work Performed (ACWP). Figure 2 depicts the principle of the EVM. The figure shows that the BCWS is determined during the planning phase of the project with a final value namely BAC (Budget at Completion) [15], the BCWP shows how much the work performed as planned costs, so that, the data of work progress is required to calculate the value of BCWP, and ACWP is the real costs incurred.

From those three key variables, a calculation covering EVM indicators; cost variance (CV), schedule variance (SV), cost performance index (CPI) and schedule performance index (SPI) has to be done before obtaining the value of estimate to complete (ETC), estimate at completion (EAC), and time estimate (TE) using these following equations:

\[ CV = BCWP - ACWP \]  
\[ SV = BCWP - BCWS \]  
\[ CPI = \frac{BCWP}{ACWP} \]  
\[ SPI = \frac{BCWP}{BCWS} \]  

and,

\[ ETC = \frac{(BAC - BCWP)}{CPI} \]  

Figure 1. The information summary of the data  
(Source: Author)

Figure 2. The principle of EVM  
(Source: Author)
\[ EAC = ACWP + ETC \]  
(6)

\[ TE = ATE + \frac{OD - (ATE \times SPI)}{SPI} \]  
(7)

where ATE is the actual duration of performed works and OD is the as-planned total duration of the project. Furthermore, figure 3 presents the flowchart of this research.

RESULTS AND DISCUSSIONS

A. Budgeted Cost of Work Scheduled (BCWS)

The BCWS value is calculated for each work of each week by multiplying the as-planned cost with the as-planned work progress. For example, in the first week, the BCWS value of prime coat work is Rp. 9.006.951,00 which obtained by multiplying Rp. 45.034.756,00 with 20%. While in the second week for the same work, the BCWS value is Rp. 18.013.903,00 with 40% of as-planned work progress. After calculating the BCWS value of each work, the total BCWS value of each week must be calculated.

B. Budgeted Cost of Work Performed (BCWP)

If the BCWS value is calculated by multiplying the as-planned cost with the as-planned work progress, BCWP value uses the actual progress and ignoring the planning progress. For example, the BCWS value of prime coat work in the fourth week is Rp. 36.027.805,00 while the BCWP value is Rp. 31.524.329,00. The total BCWP value has to be calculated for each week.

C. Actual Cost of Work Performed (ACWP)

The ACWP value is the real cost that spent by the contractor for each work in each week. For example, the real cost spent for prime coat work for 20% of as-planned and actual progress is Rp. 7.655.909,00, while the BCWS and BCWP are showing the same value (due to the as-planned and actual progress), Rp. 9.006.951,00.

Table 1 shows the result of BCWS, BCWP, and ACWP of the project for the first week until the fourth week, when the S-curve starting to indicate the delay.

<table>
<thead>
<tr>
<th>Week</th>
<th>Total of (Rp)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BCWS</td>
</tr>
<tr>
<td>1</td>
<td>15.557.951</td>
</tr>
<tr>
<td>2</td>
<td>77.508.431</td>
</tr>
<tr>
<td>3</td>
<td>139.458.911</td>
</tr>
<tr>
<td>4</td>
<td>201.409.392</td>
</tr>
</tbody>
</table>

D. Cost and Schedule Variance

By implementing equations (1) and (2), the results of the cost and schedule variance are obtained as shown in Table 2 below.

<table>
<thead>
<tr>
<th>Week</th>
<th>Total of (Rp)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CV</td>
</tr>
<tr>
<td>1</td>
<td>1.351.042,69</td>
</tr>
<tr>
<td>2</td>
<td>9.427.161,37</td>
</tr>
<tr>
<td>3</td>
<td>17.503.280,04</td>
</tr>
<tr>
<td>4</td>
<td>21.541.339,38</td>
</tr>
</tbody>
</table>

A positive value of CV indicates the cost incurred is lower than the planned budget, while the negatives indicate the opposite. For SV, the negative values mean that the project construction time was delayed from its initial planning. Based on the result shown in Table 2, at the first week until week three, the project was completed on schedule with a profit of Rp.
17.503.280,00, but at the fourth week, despite the fact that the project increased profits by up to Rp. 21.541.339,00, it took longer to finish than the planned.

E. Cost and Schedule Performance index

In order to obtain the value of CPI and SPI, the equations (3) and (4) are implemented to the data which is shows in this following table.

Table 3. The value of CPI and SPI

<table>
<thead>
<tr>
<th>Week</th>
<th>Value of CPI</th>
<th>Value of SPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,10</td>
<td>1,00</td>
</tr>
<tr>
<td>2</td>
<td>1,14</td>
<td>1,00</td>
</tr>
<tr>
<td>3</td>
<td>1,14</td>
<td>1,00</td>
</tr>
<tr>
<td>4</td>
<td>1,14</td>
<td>0,846</td>
</tr>
</tbody>
</table>

The CPI and SPI values indicates the efficiency of the project team using its resources and its time. The 1,00 of performance value indicates that the execution is on target, more than 1,00 indicates the excellency, less than 1,00 indicates inefficiency. Overall, the variances and indices are gauges of previous behavior that, if no corrective steps are made, are used to forecast the project’s eventual cost and duration [16]. Therefore, based on the results presented in table 3, the team has efficiency in running the project for the first three weeks, but it started to decreasing the performance at week four especially in term of time.

F. Estimate to Complete (ETC)

The value of ETC is calculated using equation (5) as shown below.

\[
ETC = \frac{(BAC - BCWP)}{CPI}
\]

\[
ETC = \frac{(303.142.603,00 - 170.434.152,00)}{1,14}
\]

= Rp. 115.935.300,00

The ETC result shows that Rp. 115.935.300,00 is the required cost for the project to complete the execution.

G. Estimate at Completion (EAC)

The value of EAC is calculated using equation (6) as shown below.

\[
EAC = ACWP + ETC
\]

= Rp. 148.892.812,00 + Rp. 115.935.300,00

= Rp. 264.828.113,00

The obtained value of EAC based on the calculation above represents the amount of cost that will be absorbed until the project 100% complete, which is Rp. 264.828.113,00.

H. Time Estimate (TE)

To calculate the TE value, the equation (7) is implemented to the data which the results is shown below.

\[
TE = ATE + \frac{OD - (ATE \times SPI)}{SPI}
\]

\[
TE = 4 + \frac{6 - (4 \times 0,864)}{0,846}
\]

= 7 weeks = 49 days

Form the calculation above, if no corrective actions such as increasing the number of workers, implementing the overtime hours, or another, the project will be finished in 49 days or 7 weeks.

CONCLUSION

This research has two purposes, (1) to observe the project performance during its execution and (2) to estimate the cost and the duration of the project completion if the occurred conditions remain the same as during the inspection time, with no corrective actions. So, based on the calculation, the project team has efficient performance in using their time and cost for week one until week three, but when the project entered its fourth week, the team has decreasing performance especially in time of execution (0,864 of SPI value). Further calculations predict the project needs to prepare Rp. 115.935.300,00 to finish its execution with Rp. 264.828.113,00 of total cost. Since this EVM predicts the cost and time of project completion with no corrective actions, even though the cost performance of this project is considered excellent, the time is the opposite. The TE value shows this project is one week behind its initial planning and predicted to complete the execution in 7 weeks.

REFERENCES

[3] L. L. Cleland, D.I. and Ireland, Project Management: Strategic Design and


