

Performance Index Analysis on the Construction of Probolinggo - Banyuwangi Toll Road Package 3

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ARTICLE INFO	ABSTRACT
Keywords: earned value method; time performance; cost performance.	<i>This study analyzes the performance index of the Probolinggo-Banyuwangi Toll Road Package 3 construction project using the Earned Value Method (EVM) to evaluate time and cost performance. Infrastructure projects, particularly toll roads, play a vital role in enhancing regional connectivity and economic growth. However, large-scale construction projects frequently face challenges such as cost overruns and delays. The Earned Value Method provides a comprehensive framework for measuring project performance by comparing planned costs, actual expenditures, and completed work. This research employs key performance indicators, including Budgeted Cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP), and Actual Cost of Work Performed (ACWP), to determine the Schedule Performance Index (SPI) and Cost Performance Index (CPI). The findings reveal that the project experienced schedule delays, with an SPI of 0.93, indicating that work progress was behind the planned schedule. However, the project maintained cost efficiency, as shown by a CPI of 1.06, reflecting lower actual costs than budgeted. The study highlights the importance of continuous performance monitoring using EVM to identify potential risks, optimize resource allocation, and support timely decision-making. The results provide valuable insights for project managers to improve efficiency and ensure project success in large-scale infrastructure developments.</i>

INTRODUCTION

Infrastructure is the entire structure as well as basic facilities, both physical and social such as buildings, electricity supply, irrigation, roads, bridges and so on that are needed for the operation of community and company activities. Physical and social infrastructure can be defined as the basic physical needs of organizing the structural system necessary for the economic security of the public sector and the private sector as the services and facilities needed for the economy to function properly. This term generally refers to technical or physical infrastructure that supports structural networks such as facilities such as roads, railways, clean water, airports, canals, reservoirs, dikes, waste management, electricity, telecommunications, ports functionally, infrastructure in addition to facilitation but can also support the smooth economic activity of the community, the distribution of the flow of production of goods and services as an example that the road can facilitate the transportation of raw materials to the factory and then for distribution to the market until it reaches the community. In some sense, the term infrastructure also includes social infrastructure in the form of basic needs, including schools and hospitals. Infrastructure can refer to information technology, formal and informal communication channels and software development tools, socio-political networks or trust in certain groups of society. In conceptual terms, the idea of an organizing structure is the provision of infrastructure and support for systems or for organizational services such as in a city, country, company, or collection of people with common interests. Infrastructure is the same as infrastructure, which is everything that is the main support for the implementation of a process.

Toll roads are one type of infrastructure that can improve connectivity and the regional economy. Toll road is a road that aims to shorten the distance and travel time from one place to another. The objectives of organizing toll roads include facilitating traffic in developed areas, improving distribution services for goods and services to support economic growth, increasing equitable distribution of development results and justice and easing the burden of government funds through road user participation. While the benefits of toll roads are influencing regional development and economic improvement, increasing mobility and accessibility of people and goods, toll road users will benefit in the form of savings in vehicle operating costs (BOK) and time compared to when passing non-toll roads and Business Entities get a return on investment through toll revenues that depend on the certainty of toll rates.

Indonesia has many islands, one of which is Java. Java is the 13th largest island in the world and has the world's most populous population of nearly 170 million people. There are many cities in Java that have experienced an increase in the industrial sector. This increase is strongly supported by the existence of facilities for mobility. One of them is the city of Probolinggo and Banyuwangi. To facilitate road access so that the time traveled is more efficient, toll road construction is needed. The construction of the Probolinggo - Banyuwangi Toll Road is part of the government's efforts to improve transportation infrastructure in Indonesia, especially on the island of Java. This toll road is expected to improve connectivity between regions in East Java, connecting Probolinggo with Banyuwangi, which is the gateway to Bali, can accelerate the distribution of goods and services, which in turn can support regional economic growth, can reduce congestion that often occurs on the main routes, thereby facilitating traffic flow, Banyuwangi is known as an area with great tourism potential so with good infrastructure it can attract more tourists and facilitate access to various destinations, with better transportation access, the quality of life of the community is also expected to improve, including access to health services, education, and employment, projects involving cooperation between the government and the private sector are expected to encourage further investment and infrastructure development.

Work completion time plays a very important role in project implementation. Work completion time can be influenced by the method of work implementation used, the distribution of human resources (HR), as well as the estimation of material stock scheduling in proper and appropriate implementation. In recent years, the construction industry has become increasingly competitive as contractors seek solutions to complete projects successfully. Common problems such as cost overruns and time delays are common in this industry. Therefore, an effective construction management system is required to control work productivity and costs. In the implementation of project work, it is not uncommon to find obstacles that are not in accordance with planning. Planning is the initial stage to achieve efficiency and effectiveness of resources that will be used during the implementation of project activities. Planning that has been made, can be a reference to achieve the expected goals. To avoid the bigger problems that arise, so that it is realized according to plan, supervision of work and control of project implementation can be carried out using the earned *value* concept method to determine the performance of the activities carried out and increase effectiveness in monitoring project activities (Abdel-Wahab et al., 2019; Amaral & Watu, 2021; Nurhayati et al., 2021; Pratiwi et al., 2018; Satrio et al., 2021).

The *earned value* method is applied to project management that focuses on cost and time issues to measure project performance based on budget and time constraints. The *earned value* method provides estimates and early warnings of problems in the project, allowing contractors to take timely corrective action. The *earned value* method is a project management technique for measuring project performance and progress (Aditama & Winarto, 2021). The *earned value* method has the ability to combine the measurement of the project management triangle of scope, time, and cost. In general, the concept of *earned value* is to compare the cost and schedule plan with the realization that occurs in the field.

In an integrated system, the *earned value* method is able to provide accurate estimates of project performance problems, which is an important aspect of project management. *Earned value* is one of the appropriate project management methods used as project performance control because it can control the cost and time aspects required for project completion, and prevent the risk of cost losses by the implementing contractor (Fitri et al., 2022). There are three basic indicators that become a reference in analyzing the performance of a project based on the *earned value* concept. The three indicators are ACWP (*Actual Cost of Work Performance*), BCWP (*Budgeted Cost of Work Performance*) and BCWS (*Budgeted Cost of Work Scheduled*).

ACWP (*Actual Cost of Work Performance*), is the actual amount of expenditure or funds used to carry out work in a certain period of time. This cost is obtained from project financial data on the reporting date. While BCWP (*Budgeted Cost of Work Performance*), is the amount of costs that should be incurred for work that has been carried out during a certain period according to planning. The third is BCWS (*Budgeted Cost of Work Scheduled*), which is the budget of a work package that is compiled and linked to the implementation schedule. So that there is a relationship between cost, schedule and scope of work where each part of the work has been given an allocation of time and cost which becomes a benchmark in the implementation of the work (Ajeng et al., 2023).

Performance analysis is used to determine the efficient use of resources, this analysis is obtained based on BCWS, BCWP, and ACWP calculations made from previous calculations. Performance analysis consists of *Schedule Performance Index* (SPI) and *Cost Performance Index* (CPI). *Schedule Performance Index* (SPI) is an efficient performance factor in completing work can be shown by the comparison between the value of work that has been physically completed (BCWP) with the planned cost expenditure incurred based on the work plan (BCWS). Meanwhile, the *Cost Performance Index* (CPI) is a cost efficiency factor that has been incurred that can be seen by comparing the value of work that has been physically completed (BCWP) with the costs that have been incurred in the same period (ACWP) (Kusumo et al., 2020).

With the *earned value* method, it is expected to be able to measure project performance objectively. By comparing the *earned value* with the plan and actual cost, management can get a clear picture of the project status. In addition, for large infrastructure projects such as toll roads often face unexpected cost and schedule risks, the *earned value* method helps in identifying deviations early, so that corrective actions can be taken on time. The use of *earned value* method is expected to increase transparency in reporting project performance to stakeholders.

This is important to maintain accountability among all parties involved. With continuous performance analysis, the project team can identify areas for improvement, both in the use of resources and in work processes, to improve overall project efficiency. The *earned value* method also serves in risk management by providing relevant information to anticipate problems that may arise during project execution. The data obtained from the *earned value* method analysis can be a solid basis for management in making strategic decisions, including resource re-allocation or plan revision. Through the *earned value* method, the project can be compared with similar projects, thus providing insight into best practices and areas for further development (Atin Nori Cahyana, 2017).

In large-scale construction projects such as toll road developments, the proper management of time and cost is essential for project success. The Probolinggo-Banyuwangi Toll Road, which aims to enhance connectivity and stimulate economic growth in East Java, faces significant challenges, particularly in maintaining schedule and cost efficiency. Delays and budget overruns are common issues in the construction industry and can undermine the benefits of such infrastructure projects if not managed effectively. The Earned Value Method (EVM) has been widely adopted as an effective tool for monitoring project performance by measuring the variances between planned and actual costs and schedules (Kerthajaya, 2014). By comparing the Budgeted Cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP), and Actual Cost of Work Performed (ACWP), project managers can gain early insights into performance and take corrective actions promptly.

The implementation of EVM in this study allows for an objective performance analysis of the Probolinggo-Banyuwangi Toll Road Package 3 construction project, highlighting potential risks and inefficiencies early in the process. Research on toll road projects, such as those by (Purnomo et al., 2022), has shown the critical role of EVM in managing large infrastructure projects, emphasizing its ability to track project progress against established schedules and budgets. By focusing on the Schedule Performance Index (SPI) and Cost Performance Index (CPI), this study provides valuable insights into the project's status and identifies areas where adjustments are needed to meet the planned goals, thus optimizing resource allocation and ensuring successful project completion.

As of July 21, 2024, the progress of the work plan according to the S curve is 46.60%, while the progress of the work realization is 39.16%. There is a deviation between the work plan and realization of -7.44%. The minus deviation can be interpreted that the work is experiencing delays in implementation. In order to prevent further cost overruns in project implementation and prevent further minus deviations, a project performance analysis is required. The performance analysis that matches the above problems is to use the *earned value* method, because this method focuses on cost and time analysis. This method is very suitable to support project managers in making strategic decisions to be able to restore the condition of work progress so that there is no minus deviation. This method also helps project managers to reallocate resources or changes in the project approach because it provides sufficiently in-depth information. It is expected that the analysis of project performance using the *earned value* method can provide significant benefits in managing and succeeding the construction of the Probolinggo - Banyuwangi Package 3 Toll Road so that the level of success and effectiveness in project implementation can be achieved.

Several studies have explored the use of the Earned Value Method (EVM) in evaluating the performance of large-scale construction projects. (Castellani, 2024) analyzed time and cost performance using EVM in apartment projects, highlighting the method's ability to detect cost inefficiencies and schedule delays early in the project lifecycle. Similarly, (Indramanik et al., 2022) applied EVM to a school construction project, demonstrating that continuous monitoring using performance indices like SPI and CPI could significantly reduce project delays. (Susanti et al., 2019) studied the application of EVM in the Kayuagung-Palembang-Betung Toll Road construction and found that despite achieving cost efficiency, the project faced persistent scheduling issues, underscoring the need for more adaptive project management strategies. While these studies validate EVM as an effective tool for construction management, there is limited research focusing specifically on toll road projects in Indonesia, particularly in the context of long-distance, multi-package toll road developments like the Probolinggo-Banyuwangi Toll Road.

Although prior research has extensively applied the Earned Value Method to construction projects, there remains a notable gap in its application to large-scale infrastructure projects, specifically toll roads spanning vast distances and involving complex stakeholder coordination. Most studies have focused on isolated building projects or shorter road segments, leaving a lack of comprehensive analysis of the cumulative cost and time performance in multi-package toll road developments. Furthermore, few studies have examined the strategic decision-making processes influenced by EVM findings, such as resource reallocation or schedule adjustments in response to project deviations. This research addresses these gaps by applying EVM to the Probolinggo-Banyuwangi Toll Road Package 3, offering an in-depth evaluation of its cost and time performance while providing strategic insights for future large-scale infrastructure projects.

The novelty of this study lies in its focused application of the Earned Value Method on a multi-package toll road project, specifically the Probolinggo-Banyuwangi Toll Road Package 3. Unlike previous studies that primarily analyze short-term projects or single-building constructions, this research examines a long-distance infrastructure project, providing a broader perspective on the cumulative impact of cost and time deviations over an extended period. The study introduces a refined approach to EVM analysis by incorporating a detailed

breakdown of indirect costs and project-specific variables, enhancing the accuracy of performance indices like SPI and CPI. Additionally, the research offers actionable recommendations for managing project risks and optimizing resource allocation based on real-time performance data.

This study aims to evaluate the cost and time performance of the Probolinggo-Banyuwangi Toll Road Package 3 using the Earned Value Method, focusing on identifying deviations from the planned schedule and budget. The primary objective is to provide a comprehensive analysis that supports project managers in making informed decisions regarding resource allocation, risk management, and schedule optimization. The findings are expected to offer practical benefits, including early detection of potential project delays, improved cost efficiency, and enhanced transparency in project reporting. By applying EVM to a large-scale infrastructure project, this research contributes valuable insights to the field of construction management, serving as a reference for future toll road developments and other complex infrastructure projects in Indonesia.

This study aims to analyze the performance index value in the completion of work on the Construction of the Probolinggo - Banyuwangi Toll Road Package 3. This analysis is expected to provide a comprehensive picture of project performance and efficient use of resources, so as to support the success of project implementation optimally. The benefits of this research include as a tool for project managers to comprehensively evaluate project performance, provide important information related to variance, performance index, and cost and time estimation, thus supporting more informed decision making in resource allocation, budgeting, and scheduling.

METHOD

This research was conducted on the Probolinggo - Banyuwangi Toll Road Package 3 project, Sta. 20+200 to Sta. 45+800, along 25.6 km in Situbondo Regency, East Java. The data analysis technique uses the *earned value* method to evaluate project performance in terms of cost and time. The analysis begins by calculating the basic project indicators, namely BCWS (*Budgeted Cost of Work Scheduled*), BCWP (*Budgeted Cost of Work Performance*), and ACWP (*Actual Cost of Work Performance*). Furthermore, to assess the efficient use of resources, a performance analysis is conducted involving the *Schedule Performance Index* (SPI) and *Cost Performance Index* (CPI).

RESULTS AND DISCUSSION

Job Data

The work data here is secondary data obtained from the project where the author will conduct research. The secondary data in question is obtained from the contractor implementing the work.

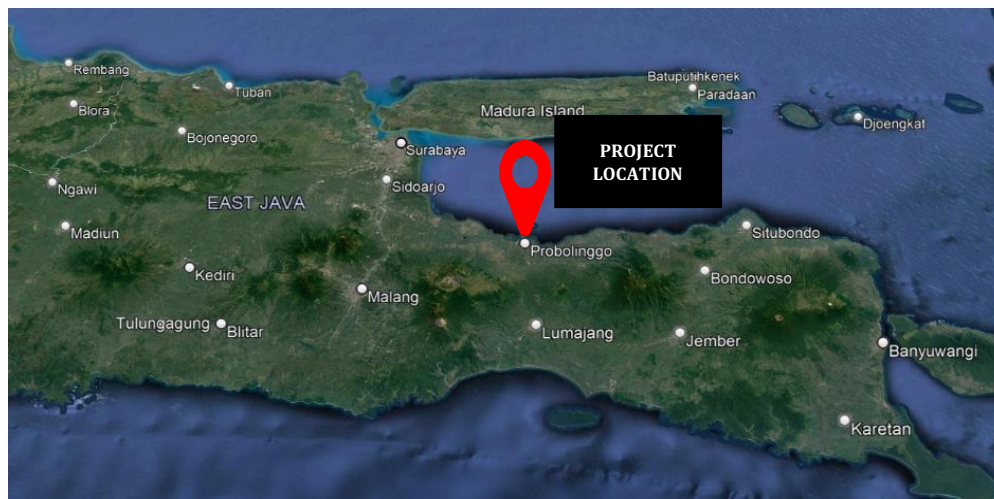
Project Overview

1. General Data

Job Name	:	Construction of Probolinggo - Banyuwangi Toll Road Package 3
Location	:	Probolinggo - Banyuwangi Toll road section, from Paiton - Besuki, Situbondo Regency, East Java Province
Project Owner	:	PT Jasa Marga Probolinggo Banyuwangi
Supervisory Consultant	:	PT. Eskapindo Matra PT Parama - Daksinapati - Krida (KSO)
Planning Consultant	:	PT Buana Archicon
Implementation Contractor	:	PT Pembangunan Perumahan (Persero) Tbk, PT Wijaya Karya (Persero) Tbk, PT Waskita Karya (Persero) Tbk (KSO).
Contract No.	:	021/KONTRQK/2023
Contract Date	:	February 21, 2023
No. SPMK	:	DU.PP.02.02.205
Date of SPMK	:	June 12, 2023
Contract Value	:	Rp. 4,425,887,630,000.00 (include Ppn 11%)
Implementation Time	:	728 calendar days
Maintenance Period	:	1,095 calendar days (3 years)
2. Road Technical Data

Toll Road Length	:	25.6 km
Toll Road Width	:	25.9 meters
Work Items	:	- 12 Bridges (Include Paiton Big Bridge 3); - 2 Overpass; - 41 Box Underpass; - 135 Box Culvert; - 2 Rest Area.

Figure 1 Research location map



Project Data

The project data obtained as research materials include:

1. Contract Budget Plan (RAB) Data

It is a recap and breakdown of the cost of each item of work in the contract that has been mutually agreed upon according to the agreement - an agreement that has been agreed upon with legal force between the owner of the work and the implementing contractor. In the contract cost budget plan there is also an analysis of unit prices, a list of wages and material prices. RAB data is used in the calculation of *Budgeted Cost Work Schedule* and *Budgeted Cost for Work Performed*. The following is a recapitulation table of the Cost Budget Plan.

Table1 Cost Budget Recapitulation

No	Work Items	Total Price (Rp)
1	Division 1 General	Rp. 52,471,960,124.00
2	Division 2 Workplace Cleaning	Rp. 9,382,488,518.80
3	Division 3 Demolition	Rp. 4,612,779,971.93
4	Division 4 Earthworks	Rp. 1,365,749,110,091.18
5	Division 5 Structure Excavation	Rp. 8,371,749,663.53
6	Division 6 Drainage	Rp. 164,529,175,140.41
7	Division 7 Subgrade	Rp. 4,371,653,837.44
8	Division 8 Aggregate Foundation Layer (Subbase)	Rp. 73,002,651,177.82
9	Division 9 Pavement	Rp. 514,220,953,422.68
10	Division 10 Concrete Structures	Rp. 1,071,272,180,971.02
11	Division 12 Miscellaneous Work	Rp. 624,779,973,922.47
12	Division 13 Traffic Light Lighting and Electrical Works	Rp. 15,443,989,189.04
13	Division 14 Toll Plaza	Rp. 5,737,821,993.00
14	Division 15 Diversion and Protection of Existing Utilities	Rp. 66,416,790,000.00
15	Division 16 Toll Facility Work and Toll Gate Work	Rp. 6,914,493,105.00
Total Contract (excluding VAT)		Rp. 3,987,277,771,128.31

Source: Processed by the author based on the weekly reports of PT PP (Persero) Tbk, PT Wika (Persero) Tbk and PT Waskita (Persero) Tbk, 2024.

2. Time Schedule Data

The data is divided into two, among others:

a. Project Plan *Time Schedule*

It is a measure of project implementation. In the *time schedule* there are job descriptions, work volumes, and weight units (%).

b. Actual Project *Time Schedule*

It is a project plan *time schedule* but contains the progress of the work that has been carried out with a description of the weight that has been carried out and that has not been carried out.

3. Weekly project report data

Is a report on the progress, achievement or weight of work achievements that have been realized in one week. Generally this report contains the RAB volume and percentage on work items, the cumulative volume that has been completed in a week and the obstacles experienced in the weekly project. This weekly report is used as work realization/earned value data. The weekly report also includes a *backup* volume containing the results of joint work between the supervisory consultant and the contractor executor. The basis for making weekly reports from daily reports, usually specific and detailed project reports made by field implementers. This report is useful to avoid disputes or differences in conditions in the field. In addition, it can be used as an important indicator to monitor activities and costs that are or will be incurred, as an evaluation for the contractor's team of a progress that has been achieved, can be used as a report to the project owner on construction progress from time to time, facilitate monitoring or monitoring of work by the contractor, and become one of the requirements in submitting a project term. The following is a weekly report recapitulation table:

Table2 Weekly Report Recapitulation

No	Sunday Period	(%) Plan Per week	(%) Cumulative Plan Per week	(%) Realization Per week	(%) Cumulative Realization Per week	Deviation
	12 Jun 2023 - 14 Jul 2024	46.03	46.03	38.24	38.24	-7.79
1	58th 15 Jul - 21 Jul	0.57	46.60	0.92	39.16	-7.44
2	59th 22 Jul - 28 Jul	0.51	47.11	1.04	40.20	-6.91
3	60th 29 Jul - 04 Aug	0.51	47.62	0.95	41.15	-6.47
4	61st 05 Aug - 11 Aug	0.35	47.97	1.06	42.21	-5.76
5	62nd 12 August - 18 August	0.35	48.32	1.28	43.49	-4.83
6	63rd 19 August - 25 August	0.35	48.67	0.74	44.23	-4.44
7	64th 26 Aug - 01 Sep	0.34	49.01	0.83	45.06	-3.95
8	65th 02 Sep - 08 Sep	0.34	49.35	0.49	45.55	-3.80
9	66th 09 Sep - 15 Sep	0.34	49.69	0.38	45.93	-3.76
10	67th 16 Sep - 22 Sep	0.35	50.04	0.74	46.67	-3.37
11	68th 23 Sep - 29 Sep	0.35	50.39	1.09	47.76	-2.63
12	69th 30 Sept - 06 Oct	0.79	51.18	0.89	48.65	-2.53
13	70th 07 Oct - 13 Oct	0.83	52.01	0.92	49.57	-2.44
14	71st Oct 14 - Oct 20	0.77	52.78	0.92	50.49	-2.29
15	72nd Oct 21 - Oct 27	0.79	53.57	1.01	51.50	-2.07
16	73rd 28 Oct - 03 Nov	1.05	54.62	1.10	52.60	-2.02
17	74th 04 Nov - 10 Nov	1.08	55.70	0.57	53.17	-2.53
18	75th 11 Nov - 17 Nov	1.09	56.79	0.59	53.76	-3.03
19	76th 18 Nov - 24 Nov	1.10	57.89	0.71	54.47	-3.42
20	77th 25 Nov - 01 Dec	1.10	58.99	0.65	55.12	-3.87

Source: Processed by the author based on the weekly reports of PT PP (Persero) Tbk, PT Wika (Persero) Tbk and PT Waskita (Persero) Tbk, 2024.

Calculation of BCWS, BCWP and ACWP

The use of *Earned Value Method* in this project produces *Planned Value (PV)* or *Budgeted Cost Work Schedule (BCWS)*, *Earned Value (EV)* or *Budgeted Cost Work Performed (BCWP)*, *Actual Cost (AC)* or *Actual Cost of Work Performed (ACWP)*, then the value is compared continuously in each phase of the project until completion. Cost and value utilization information obtained quickly throughout the *project life cycle* is very helpful for a fast and integrated project control and supervision system. The method used in controlling costs and time in the field is to use a *time schedule*. This method is often used in construction projects and the percentage of the project plan and the percentage of realization are depicted in an S-curve. Based on the S-curve of project planning and realization, the percentage of work taken from week 58 to week 77, because the project is still running. The actual physical percentage (realization) of the project tends to be smaller or late than the percentage of the plan. *Earned value* analysis was conducted in week 77.

Calculation of Planned Value (PV) or Budgeted Cost Work Schedule (BCWS)

Budgeted Cost Work Schedule (BCWS) is a cost budget allocated based on a work plan that has been prepared against time. In this project, the total contract value including ppn is Rp. 4,425,887,630,000.00. To calculate PV or BCWS, it is obtained from data on the percentage of work completion plans multiplied by the Budget Plan Cost (RAB) using the following formula:

$$PV \text{ or } BCWS = (\% \text{ plan}) \times (RAB)$$

The calculation of PV or BCWS at week 58 is :

PV or BCWS = (0.57%) x (IDR 3,987,277,771,128.31)

PV or BCWS = IDR 22,727,483,295.43

For the next week's calculation, it can be done in the same way as the calculation above, seen in table 3 below:

Table3 Planned Value or Budgeted Cost Work Schedule

No	Sunday Period	(%) Plan Per week	(%) Cumulative Plan Per week	PV or BCWS (Weekly)	PV or BCWS (Cumulative)
a	b	c	d	e=cx WED	f= d x RAB
		46.03	46.03	Rp 1,835,343,958,050.36	Rp. 1,835,343,958,050.36
1	58th	0.57	46.60	Rp 22,727,483,295.43	Rp. 1,858,071,441,345.79
2	59th	0.51	47.11	Rp 20,335,116,632.75	Rp 1,878,406,557,978.55
3	60th	0.51	47.62	Rp 20,335,116,632.75	Rp. 1,898,741,674,611.30
4	61st	0.35	47.97	Rp 13,955,472,198.95	Rp. 1,912,697,146,810.25
5	62nd	0.35	48.32	Rp 13,955,472,198.95	Rp 1,926,652,619,009.20
6	63rd	0.35	48.67	Rp 13,955,472,198.95	Rp 1,940,608,091,208.15
7	64th	0.34	49.01	Rp 13,556,744,421.84	Rp. 1,954,164,835,629.99
8	65th	0.34	49.35	Rp 13,556,744,421.84	Rp. 1,967,721,580,051.82
9	66th	0.34	49.69	Rp 13,556,744,421.84	Rp. 1,981,278,324,473.66
10	67th	0.35	50.04	Rp 13,955,472,198.95	Rp. 1,995,233,796,672.61
11	68th	0.35	50.39	Rp 13,955,472,198.95	Rp. 2,009,189,268,871.56
12	69th	0.79	51.18	Rp 31,499,494,391.91	Rp 2,040,688,763,263.47
13	70th	0.83	52.01	Rp 33,094,405,500.37	Rp 2,073,783,168,763.83
14	71st	0.77	52.78	Rp 30,702,038,837.69	Rp 2,104,485,207,601.52
15	72nd	0.79	53.57	Rp 31,499,494,391.91	Rp. 2,135,984,701,993.44
16	73rd	1.05	54.62	Rp 41,866,416,596.85	Rp. 2,177,851,118,590.28
17	74th	1.08	55.70	Rp 43,062,599,928.19	Rp 2,220,913,718,518.47
18	75th	1.09	56.79	Rp 43,461,327,705.30	Rp 2,264,375,046,223.77
19	76th	1.10	57.89	Rp 43,860,055,482.41	Rp 2,308,235,101,706.18
20	77th	1.10	58.99	Rp 43,860,055,482.41	Rp. 2,352,095,157,188.59

Source: Processed by the author based on the weekly reports of PT PP (Persero) Tbk, PT Wika (Persero) Tbk and PT Waskita (Persero) Tbk, 2024.

Earned Value (EV) or Budgeted Cost Work Performed (BCWP) Calculation

Budget Cost for Work Performed is the value received from the completion of work during a certain period of time, this indicator is usually used to measure work that has been completed. In this project *Earned Value* (EV) or *Budget Cost for Work Performed* (BCWP) is the budgeted cost for work that has been completed, obtained by multiplying the percentage of work realization completed by the Budget Plan Cost (RAB) using formula 2.2 as follows:

$$EV \text{ or } BCWP = (\% \text{ realization weight}) \times (RAB)$$

The calculation of EV or BCWP in week 58 is :

PV or BCWP = (0.92%) x (IDR 3,987,277,771,128.31)

PV or BCWP = IDR 36,682,955,494.38

For the next week's calculation, it can be done in the same way as the calculation above, seen in table 4.4 below:

Table4 Earned Value or Budgeted Cost Work Performed

No	Sunday Period	(%) Realization Per week	(%) Cumulative Realization Per Week	EV or BCWP (Weekly)	EV or BCWP (Cumulative)
a	b	c	d	e=cx WED	f= d x RAB
		38.24	38.24	Rp. 1,524,735,019,679.47	Rp. 1,524,735,019,679.47
1	58th	0.92	39.16	Rp. 36,682,955,494.38	Rp. 1,561,417,975,173.85
2	59th	1.04	40.20	Rp. 41,467,688,819.73	Rp. 1,602,885,663,993.58
3	60th	0.95	41.15	Rp. 37,879,138,825.72	Rp. 1,640,764,802,819.30
4	61st	1.06	42.21	Rp. 42,265,144,373.96	Rp. 1,683,029,947,193.26
5	62nd	1.28	43.49	Rp. 51,037,155,470.44	Rp. 1,734,067,102,663.70
6	63rd	0.74	44.23	Rp. 29,505,855,506.35	Rp. 1,763,572,958,170.05
7	64th	0.83	45.06	Rp. 33,094,405,500.37	Rp. 1,796,667,363,670.42
8	65th	0.49	45.55	Rp. 19,537,661,078.53	Rp. 1,816,205,024,748.95
9	66th	0.38	45.93	Rp. 15,151,655,530.29	Rp. 1,831,356,680,279.23
10	67th	0.74	46.67	Rp. 29,505,855,506.35	Rp. 1,860,862,535,785.58
11	68th	1.09	47.76	Rp. 43,461,327,705.30	Rp. 1,904,323,863,490.88
	12th 69th	0.89	48.65	Rp. 35,486,772,163.04	Rp. 1,939,810,635,653.92
13	70th	0.92	49.57	Rp. 36,682,955,494.38	Rp. 1,976,493,591,148.30
14	71st	0.92	50.49	Rp. 36,682,955,494.38	Rp. 2,013,176,546,642.68
15	72nd	1.01	51.50	Rp. 40,271,505,488.40	Rp. 2,053,448,052,131.08
16	73rd	1.10	52.60	Rp. 43,860,055,482.41	IDR 2,097,308,107,613.49
17	74th	0.57	53.17	Rp. 22,727,483,295.43	Rp. 2,120,035,590,908.92
18	75th	0.59	53.76	Rp. 23,524,938,849.66	IDR 2,143,560,529,758.58
19	76th	0.71	54.47	Rp. 28,309,672,175.01	Rp. 2,171,870,201,933.59
20	77th	0.65	55.12	Rp. 25,917,305,512.33	Rp. 2,197,787,507,445.93

Source: Processed by the author based on the weekly reports of PT PP (Persero) Tbk, PT Wika (Persero) Tbk and PT Waskita (Persero) Tbk, 2024.

Calculation of Actual Cost (AC) or Actual Cost of Work Performed (ACWP)

Actual Cost for Work Performed is a representation of the overall expenditure incurred to complete the work within a certain period. In this project *Actual Cost (AC)* or *Actual Cost of Work Performed (ACWP)* is the actual cost incurred to achieve the percentage of work realization completed. *Actual Cost* consists of direct costs and indirect costs. Direct costs consist of labor and material costs, while indirect costs consist of office *overhead* and field *overhead*. In this study, both direct costs and indirect costs use the author's assumptions because the job owner is not willing to provide financial data. Direct and indirect costs are broken down so that they are close to the percentage of work that has been completed and is being done. The contract is assumed to be the sum of construction costs and project profits. The average project profit is 10%, so the construction cost is obtained:

$$\begin{aligned} \text{RAB} &= \text{Construction Cost} + (10\% \times \text{RAB}) \\ \text{Construction Cost} &= \text{RAB} - (10\% \times \text{RAB}) \end{aligned}$$

Construction Cost = Rp 3,987,277,771,128.31 - (10% x Rp 3,987,277,771,128.31) Construction Cost = Rp 3,588,549,994,015.48

Construction costs are the sum of direct costs and indirect costs. Direct costs on the project are assumed to be 85% of the construction cost, while indirect costs are 15% of the construction cost.

Construction Cost = Direct Cost + Indirect Cost

Construction Cost = (85% x Construction Cost) + (15% x Construction Cost)

Direct Cost = 85% x Construction Cost

Direct Cost = 85% x Rp 3,588,549,994,015.48

Direct Cost = IDR 3,050,267,494,913.16

Indirect Cost = 15% x Construction Cost

Indirect Cost = 15% x IDR 3,588,549,994,015.48

Indirect Cost = IDR 538,282,499,102.32

Indirect cost per week = IDR 538,282,499,102.32 : 104

Indirect cost per week = IDR 5,175,793,260.60

The following is the ACWP formula for week 58 according to the author's assumptions:

ACWP = (% realized progress x direct cost)+weekly indirect cost

ACWP = (0.92% x Rp 3,050,267,494,913.16) + Rp 5,175,793,260.60

ACWP = IDR 33,238,254,213.80

For the calculation of *Schedule Variance* from week 58 to week 77 can be seen in table 5 below:

Table5 Value of Actual Cost or Actual Cost of Work Performed

No	Sunday Period	(96) Realization Per week	Direct Costs (Weekly)	Indirect Costs (Weekly)	AC or ACWP (Weekly)	AC or ACWP (Cumulative)
a	b	c	d	e	f	g=g+f
		38.24	Rp. 1,166,422,290,05479	Rp. 295,020,215,854.16	Rp. 1,461,442,505,908.95	Rp. 1,461,442,505,908.95
1	58th	0.92	Rp. 28,062,460,953.20	Rp. 5,175,793,260.60	Rp. 33,238,254,213.80	Rp. 1,494,680,760,122.75
2	59th	1.04	Rp. 31,722,781,947.10	Rp. 5,175,793,260.60	Rp. 36,898,575,207.70	Rp. 1,531,579,335,330.45
3	60th	0.95	Rp. 28,977,541,20168	Rp. 5,175,793,260.60	Rp. 34,153,334,46227...	Rp1,565,732,669,792.72
4	61st	1.06	Rp. 32,332,835,446.08	Rp.5,175,793,260.60.	Rp. 37,508,628,706.68.	Rp...1,603,241,29,8,49,9,40...
5	62nd	1.28	Rp. 39,043,423,934.89	Rp.5,175,793,260.60.	Rp. 44,219,217,195.49	Rp.1,647,460,515,694.89...
6	63rd	0.74	Rp. 22,571,979,46236	Rp. 5,175,793,260.60.	Rp. 27,747,772,722.96)	Rp.1,675,208,288,417.84...
7	64th	0.83	Rp. 25,317,220,207.78	Rp. 5,175,793,260.60	Rp. 30,493,013,46838	Rp. 1,705,701,301,886.22
8	65th	0.49	Rp. 14,946,310,725.07	Rp. 5,175,793,260.60	Rp. 20,122,103,985.67	Rp. 1,725,823,405,871.90
9	66th	0.38	Rp. 11,591,016,480.67	Rp. 5,175,793,260.60	Rp. 16,766,809,74127	Rp. 1,742,590,215,613.16
10	67th	0.74	Rp. 22,571,979,46236	Rp. 5,175,793,260.60	Rp. 27,747,772,72296	Rp. 1,770,337,988,336.12
11	68th	1.09	Rp. 33,247,915,69455	Rp. 5,175,793,260.60	Rp. 38,423,708,955.15	Rp. 1,808,761,697,291.27
12	69th	0.89	Rp. 27,147,380,70473	Rp. 5,175,793,260.60	Rp. 32,323,173,96533	Rp. 1,841,084,871,256.60
13	70th	0.92	Rp. 28,062,460,953.20.	Rp.5,175,793,260.60.	Rp. 33,238,254,213.80	Rp. 1,874,323,125,470.40...
14	71st	0.92	Rp. 28,062,460,953.20.	Rp. 5,175,793,260.60.	Rp. 33,238,254,213.80	Rp.1,907,561,879,684.28...
15	72nd	1.01	Rp. 30,807,701,698.62	Rp. 5,175,793,260.60	Rp. 35,983,494,959.22	Rp. 1,943,544,874,643.42
16	73rd	1.10	Rp. 33,552,942,44404	Rp. 5,175,793,260.60	Rp. 38,728,735,704.64	Rp. 1,982,273,610,348.07
17	74th	0.57	Rp. 17,386,524,72101	Rp. 5,175,793,260.60	Rp. 22,562,317,98160	Rp. 2,004,835,928,329.67
18	75th	0.59	Rp. 17,996,578,219.99	Rp. 5,175,793,260.60	Rp. 23,172,371,480.59	Rp. 2,028,008,299,810.26...
19	76th	0.71	Rp. 21,656,899,213.88	Rp. 5,175,793,260.60	Rp. 26,832,692,47448	Rp. 2,054,840,992,284.74
20	77th	0.65	Rp. 19,826,738,71694	Rp. 5,175,793,260.60	Rp. 25,002,531,977.53	Rp. 2,079,843,524,262.28

Source: Author's Report, 2024.

From the three basic indicators that have been calculated, namely *Budgeted Cost Work Schedule*, *Budgeted Cost Work Performed* and *Actual Cost of Work Performed*, it can provide an overview of the cumulative cost and time achievements in each week, as contained in table 6 below:

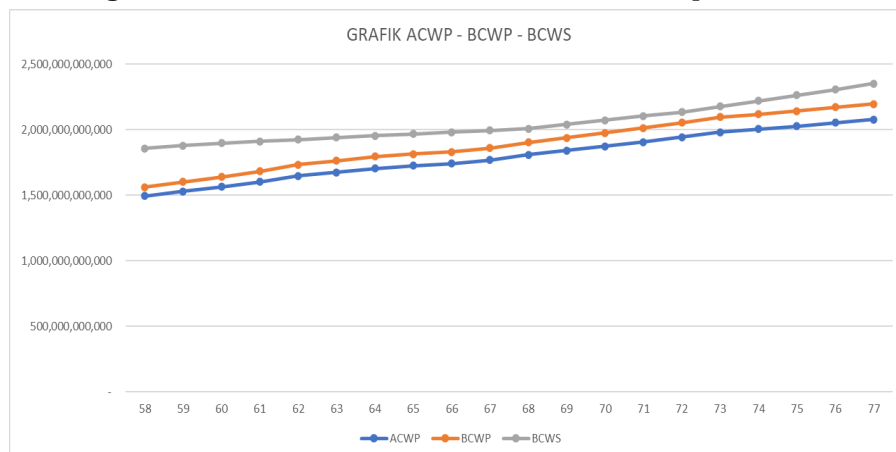
Table 6 Recapitulation of BCWS, BCWP and ACWP Calculations Cumulative

No	Sunday Period	PV or BCWS (Cumulative)	EV or BCWP (Cumulative)	AC or ACWP (Cumulative)
a	b	d	e	f
1	58th	Rp1,858,071,441,345.79	Rp1,561,417,975,173.85	Rp1,494,680,760,122.75
2	59th	Rp1,878,406,557,978.55	Rp. 1,602,885,663,993.58	Rp1,531,579,335,330.45
3	60th	Rp1,898,741,674,611.30	Rp. 1,640,764,802,819.30	Rp1,565,732,669,792.72
4	61st	Rp. 1,912,697,146,810.25	Rp. 1,683,029,947,193.26	Rp1,603,241,298,499.40
5th	62nd	Rp1,926,652,619,009.20	Rp1,734,067,102,663.70	Rp1,647,460,515,694.89
6	63rd	Rp. 1,940,608,091,208.15	Rp. 1,763,572,958,170.05	Rp1,675,208,288,417.84
7	64th	Rp1,954,164,835,629.99	Rp. 1,796,667,363,670.42	Rp1,705,701,301,886.22
8th	65th	Rp1,967,721,580,051.82	Rp. 1,816,205,024,748.95	Rp1,725,823,405,871.90
9	66th	Rp1,981,278,324,473.66	Rp. 1,831,356,680,279.23	Rp1,742,590,215,613.16
10	67th	Rp1,995,233,796,672.61	Rp. 1,860,862,535,785.58	Rp1,770,337,988,336.12
11	68th	Rp2,009,189,268,871.56	Rp. 1,904,323,863,490.88	Rp1,808,761,697,291.27
12	69th	Rp2,040,688,763,263.47	Rp. 1,939,810,635,653.92	Rp1,841,084,871,256.60
13	70th	Rp2,073,783,168,763.83	Rp. 1,976,493,591,148.30	Rp1,874,323,125,470.40
14	71st	Rp2,104,485,207,601.52	Rp2,013,176,546,642.68	Rp1,907,561,379,684.20
15	72nd	Rp2,135,984,701,993.44	Rp2,053,448,052,131.08	Rp1,943,544,874,643.42
16	73rd	Rp2,177,851,118,590.28	Rp2,097,308,107,613.49	Rp1,982,273,610,348.07
17	74th	Rp2,220,913,718,518.47	Rp2,120,035,590,908.92	Rp2,004,835,928,329.67
18	75th	Rp2,264,375,046,223.77	Rp2,143,560,529,758.58	Rp2,028,008,299,810.26
19	76th	Rp2,308,235,101,706.18	Rp. 2,171,870,201,933.59	Rp2,054,840,992,284.74
20	77th	Rp2,352,095,157,188.59	Rp2,197,787,507,445.93	Rp2,079,843,524,262.28

Source: Author's Report, 2024.

From the table above, it is then poured in the form of a graph so that it is known where the BCWS, BCWP and cumulative ACWP positions are according to the graph 4. 2 below:

Figure 2 Cumulative BCWS, BCWP and ACWP Recapitulation Chart



Source: Processed by Researcher, 2024.

Performance Index Calculation

The performance index consists of two things, namely the *Schedule Performance Index* which focuses on the time aspect and the *Cost Performance Index* which focuses on the cost aspect, the following is the calculation for the performance index on the Probolinggo - Banyuwangi Package 3 Toll Road Development project.

Schedule Performance Index (SPI) calculation

Schedule Performance Index is a comparison between *Budget Cost for Work Performed* (BCWP) and *Budgeted Cost Work Schedule* (BCWS). Job owners who want to know the use of resources can be guided by the *Schedule Performance Index* because it is a productivity index or performance index. *The Schedule Performance Index* calculation uses the formula below with an example of a cumulative calculation in week 77 as follows:

$$SPI = \frac{BCWP}{BCWS}$$

$$SPI = \frac{Rp\ 2.197.787.507.445,93}{Rp\ 2.352.095.157.188,59}$$

$$SPI = 0.93$$

For SPI values < 1, this means that the cumulative work up to week 77 is delayed from the planned schedule. For the calculation of *Schedule Performance Index* from week 58 to week 77 can be seen in table 9 below:

Table 7 Recapitulation of *Schedule Performance Index* Value

No	Sunday Period	EV or BCWP (Weekly)	PV or BCWS (Weekly)	<i>Schedule Performance Index</i>	Information
a	b	c	d	e = c : d	f
1	58th	Rp. 36,682,955,494.38	Rp. 22,727,483,295.43	1.61	Faster
2	59th	Rp. 41,467,688,819.73	Rp. 20,335,116,632.75	2.04	Faster
3	60th	Rp. 37,879,138,825.72	Rp. 20,335,116,632.75	1.86	Faster
4	61st	Rp. 42,265,144,373.96	Rp. 13,955,472,198.95	3.03	Faster
5	62nd	Rp. 51,037,155,470.44	Rp. 13,955,472,198.95	3.66	Faster
6	63rd	Rp. 29,505,855,506.35	Rp. 13,955,472,198.95	2.11	Faster
7	64th	Rp. 33,094,405,500.37	Rp. 13,556,744,421.84	2.44	Faster
8	65th	Rp. 19,537,661,078.53	Rp. 13,556,744,421.84	1.44	Faster
9	66th	Rp. 15,151,655,530.29	Rp. 13,556,744,421.84	1.12	Faster
10	67th	Rp. 29,505,855,506.35	Rp. 13,955,472,198.95	2.11	Faster
11	68th	Rp. 43,461,327,705.30	Rp. 13,955,472,198.95	3.11	Faster
12	69th	Rp. 35,486,772,163.04	Rp. 31,499,494,391.91	1.13	Faster
13	70th	Rp. 36,682,955,494.38	Rp. 33,094,405,500.37	1.11	Faster
14	71st	Rp. 36,682,955,494.38	Rp. 30,702,038,837.69	1.19	Faster
15	72nd	Rp. 40,271,505,488.40	Rp. 31,499,494,391.91	1.28	Faster
16	73rd	Rp. 43,860,055,482.41	Rp. 41,866,416,596.85	1.05	Faster
17	74th	Rp. 22,727,483,295.43	Rp. 43,062,599,928.19	0.53	Late
18	75th	Rp. 23,524,938,849.66	Rp. 43,461,327,705.30	0.54	Late
19	76th	Rp. 28,309,672,175.01	Rp. 43,860,055,482.41	0.65	Late
20	77th	Rp. 25,917,305,512.33	Rp. 43,860,055,482.41	0.59	Late

Source: Author's Report, 2024.

Calculation of *Cost Performance Index* (CPI)

Cost Performance Index is a comparison between *Budget Cost for Work Performed* (BCWP) and *Actual Cost of Work Performed* (ACWP). Job owners who want to know how much cost efficiency has been spent can be guided by the *Cost Performance Index*. The *Cost Performance Index* calculation uses the formula below with an example of a cumulative calculation in week 77 as follows:

$$CPI = \frac{BCWP}{ACWP}$$

$$CPI = \frac{Rp. 2.197.787.507.445,93}{Rp. 2.079.843.524.262,28}$$

$$CPI = 1.06$$

For a CPI value > 1, this means that the actual costs that have been incurred are less than the budget so that it is considered that the project is experiencing a cumulative dependence up to week 77. For the calculation of the *Cost Performance Index* from week 58 to week 77 can be seen in table 10 below:

Table 8 Recapitulation of *Cost Performance Index* Value

No	Sunday Period	EV or BCWP (Weekly)	AC or ACWP (Weekly)	Cost Performance Index	Information
a	b	c	d	e = c : d	f
1	58th	Rp. 36,682,955,494.38	Rp. 33,238,254,213.80	1.10	Profit
2	59th	Rp. 41,467,688,819.73	Rp. 36,898,575,207.70	1.12	Profit
3	60th	Rp. 37,879,138,825.72	Rp. 34,153,334,462.27	1.11	Profit
4	61st	Rp. 42,265,144,373.96	Rp. 37,508,628,706.68	1.13	Profit
5	62nd	Rp. 51,037,155,470.44	Rp. 44,219,217,195.49	1.15	Profit
6	63rd	Rp. 29,505,855,506.35	Rp. 27,747,772,722.96	1.06	Profit
7	64th	Rp. 33,094,405,500.37	Rp. 30,493,013,468.38	1.09	Profit
8	65th	Rp. 19,537,661,078.53	Rp. 20,122,103,985.67	0.97	Make a loss
9	66th	Rp. 15,151,655,530.29	Rp. 16,766,809,741.27	0.90	Make a loss
10	67th	Rp. 29,505,855,506.35	Rp. 27,747,772,722.96	1.06	Profit
11	68th	Rp. 43,461,327,705.30	Rp. 38,423,708,955.15	1.13	Profit
12	69th	Rp. 35,486,772,163.04	Rp. 32,323,173,965.33	1.10	Profit
13	70th	Rp. 36,682,955,494.38	Rp. 33,238,254,213.80	1.10	Profit
14	71st	Rp. 36,682,955,494.38	Rp. 33,238,254,213.80	1.10	Profit
15	72nd	Rp. 40,271,505,488.40	Rp. 35,983,494,959.22	1.12	Profit
16	73rd	Rp. 43,860,055,482.41	Rp. 38,728,735,704.64	1.13	Profit
17	74th	Rp. 22,727,483,295.43	Rp. 22,562,317,981.60	1.01	Profit
18	75th	Rp. 23,524,938,849.66	Rp. 23,172,371,480.59	1.02	Profit
19	76th	Rp. 28,309,672,175.01	Rp. 26,832,692,474.48	1.06	Profit
20	77th	Rp. 25,917,305,512.33	Rp. 25,002,531,977.53	1.04	Profit

Source: Author's Report, 2024.

CONCLUSION

Based on the analysis that has been done, it is concluded that the performance index value on the Probolinggo - Banyuwangi Toll Road Construction Package 3 in the form of *Schedule Performance Index* (SPI) obtained a value of 0.93, which means that the cumulative work up to week 77 is delayed from the planned schedule. For the *Cost Performance Index* (CPI), a value of 1.06 is obtained, which means that the actual costs incurred to achieve progress in week 77 are less than the budgeted costs.

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