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Controlling Project Cost and Time with the Result Value Concept Method

(Case Study: Klaten Trasan 2 Bridge Replacement Project)

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***Abstract* - Construction projects play an important role in supporting infrastructure development. However, there are often deviations between the initial plan and actual implementation, either in terms of money or time, which can result in delays and cost overruns. This study aims to examine the implementation of the Earned Value Concept Method in controlling costs and time on the Trasan II Bridge Replacement Project in Klaten Regency. The study results prove that until week 15, the project has exceeded the plan target with a realization of 81.38%, higher than the plan of 35.21%. The SPI of 2.207813348 indicates a time performance that is ahead of schedule, but the CPI of 0.995142328 indicates the costs incurred exceeded the plan budget. The projected remaining cost (ETC) is Rp701,350,409.24, and the remaining completion time (ETS) is estimated at 4,759 weeks. In addition, analysis using the Precedence Diagram Method (PDM) identified a critical path involving seven activities with a total duration of 21 days. Rescheduling was carried out to optimize project implementation. This study provides recommendations to improve project management efficiency through periodic performance evaluation and integrated control using the Earned Value Concept Method.**

Keywords: Control, Earned Value Concept, Optimum.

I. INTRODUCTION

Planning and controlling costs and time are important elements in overall construction project management. Project deliverables are usually evaluated based on quality, budget, and schedule. However, in practice, there are often changes in the form of delays, accelerations, or cost differences that can lead to profits or losses. Construction projects have unique or non-recurring characteristics.[3] Regular monitoring needs to be done of the expenditure of funds and the use of time in completing the work. In its implementation, construction management is inseparable from cost and time management. [Significant deviations in both cost and time aspects can indicate suboptimal project management. Performance indicators in terms of cost and time provide an opportunity to take preventive steps so that project implementation remains in accordance with the plan. [Therefore, a management function is needed starting from planning, implementation, to control. If a project is completed on schedule, within budget, and of high quality, then the project can be considered successful. [2]

A method that has proven effective in project control is the Earned Value Concept, which allows quantitative measurement of project performance by comparing planned work with completed work and costs incurred. These projections can provide useful information to both project managers and owners, allowing them sufficient time to devise strategies to address potential problems in the future [6].

The replacement of Trasan 2 Bridge in Klaten Regency is one of the infrastructure projects that requires the implementation of strict controls, given its scale and complexity. The project involved various resources, including materials, labor, and equipment, with a contract of IDR 4,141,410,000 and a target completion date of 180 calendar days. During its implementation, the project underwent changes that affected the original plan, including additional work volume and schedule changes. This triggered the need for a project evaluation using the Earned Value Concept method to monitor progress and identify potential deviations.

Precedence Diagram Method (PDM) is one of the network methods that fall under the activity on node (AON) category. In the following method, each activity is depicted on a rectangular node shape, while arrows are used to show the links between activities. The earliest completion time for each activity is usually recorded in the top corner of the node, which is used in the forward calculation process to determine the duration and sequence of project execution. [8]

A number of related studies that have been carried out include Widya Kartika (2023) with the title "Cost and Time Control on the Implementation of the Borobudur Tourism Area Concourse Project with the Earned Value Concept Method." This study concluded that the Actual Cost (ACWP) score graph is located below the Planned Value (BCWS) and

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Earned Value (BCWP) graphs, which means that the overall project implementation cost is lower than the score on the contract. [5]

Another study from Muh Nur Sahid, et al (2023), in his research entitled "Controlling of Time and Cost Implementation by Using Earned Value Analysis (Case Study: Shrimp Cultivation Development Project with Area-Based in Kebumen Regency)," found that the project ran faster than planned without over budgeting. The project can be completed 2 weeks earlier than planned without additional labor. [9]

This research aims to evaluate the application of the Earned Value Concept method in analyzing project implementation performance. In addition, this research also uses the Precedence Diagram Method (PDM) for rescheduling, as well as optimizing the duration of project completion time.

II. RESEARCH METHODS

The research location is in Dusun II Trasan Kecematan Juwiring precisely in Klaten Regency, and the research implementation time took place during the period June 2024. This research uses a case study approach with the application of the Earned Value Concept method to analyze cost and time control on the Trasan 2 Bridge Replacement Project in Klaten Regency.

Both primary and secondary data were used in this research. Primary data was obtained directly from the executing contractor, CV Technisi in the form of weekly reports, weekly financial reports, realized and planned S-curves, Cost Budget Plans, and project contract documents. Meanwhile, secondary data includes additional information such as AHSP (Analysis of Unit Price of Work) of Bina Marga.

Formulating the problem and objectives was the first step in conducting the research. Data was then collected through a literature review. Then, the Earned Value Concept approach was used to analyze the data obtained. In the following step, three main elements were used: the planned cost to complete the activity at a certain time in the project schedule (BCWS), the planned budget for the work completed up to a certain point in the project (BCWP), and the actual cost for the work completed up to a certain point in the project (ACWP) From these data, CV, SV, CPI, and SPI were performed.

The final stage of this research involves rescheduling using the Precedence Diagram Method to identify critical trajectories and measure project performance in completing critical activities that have a direct impact on project completion time. The results of this method are expected to convey more in-depth information regarding project performance from the aspects of cost and time, as well as provide suggestions regarding corrective steps that need to be taken. The last stage is drawing conclusions and providing suggestions

III. RESULTS AND DISCUSSIONS

3.1 “S” Curve Analysis

Based on the S-Curve and the project performance report up to week 15, as shown in Figure 1, it is known that implementation is progressing ahead of schedule. The weekly progress of the works showed realizations that exceeded the plan and had the potential to increase cost overruns when the project was completed. In the week 15 weekly report, the cumulative progress realization reached 81.38%, far exceeding the plan cumulative of only 35.21%.

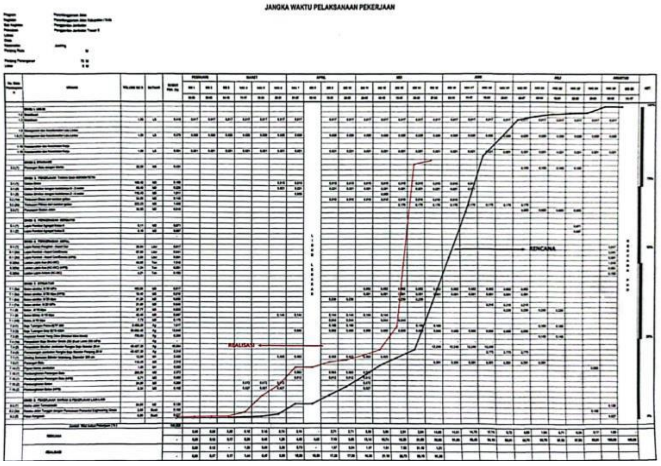

Figure 1: Curve

(Source: CV Technisi)

3.2 Analyze the Result Value Concept

The weight of work, plans, and execution of tasks are some of the things included in the weekly report. [1] In the following study, the value concept method is used on 3 indicators, namely Actual Cost of Work Perfomed from the financial records of the project, Budgeted Cost of Work Performed from the planning of funds to be spent, and Budgeted Cost of Work Scheduled from the time schedule.

a) Budgeted Cost of Work Scheduled

This indicator, which is calculated by multiplying the weekly design weight for the week by the total project budgetset, is used to analyze project performance during week 15. This calculation provides an overview of the planned cost allocation compared to the actual progress up to a certain time. The BCWS calculation can be done in the following way:

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BCWS Week 15 = % Plan Weight x Total Budget
= 15 x Rp. 3,731,000,273
= Rp. 559,650,040.95

b) Budgeted Cost of Work Performed

Performance analysis using this indicator for week 15 can be done by calculating the weight of weekly work realization in that week, then multiplying it by the total project budget that has been determined. This indicator helps measure the extent to which the allocated costs are in accordance with the work successfully completed up to a certain period. BCWP calculation can be done in the following way:

BCWP Week 15 = % Weighted Realization x Total Budget
= 51.46 x Rp. 3,731,000,273
= Rp. 1,919,972,740.49

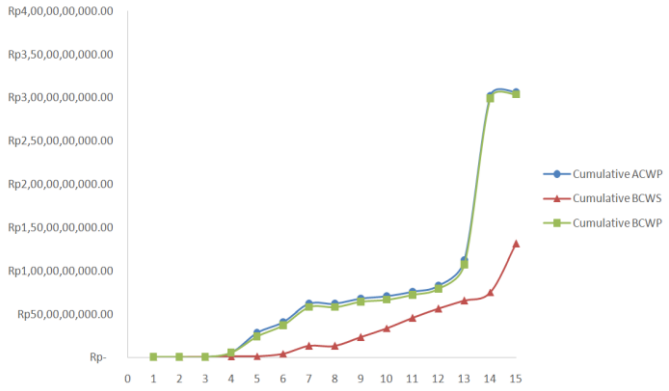
c) Actual Cost of Work Performed

Assessment of project performance using the Actual Cost of Work Performed indicator up to week 15 is carried out based on the project's actual weekly financial report. Direct or indirect costs, as well as taxes are summed up to determine ACWP. Total indirect costs divided by the number of weeks available will result in indirect costs."[10] This indicator is obtained by summarizing weekly expenditure data recorded during the study period, as reported by CV Technisi as the project implementer. This analysis provides a detailed overview of the actual cost management used at each stage of the work.

Table 1: ACWP Calculation

Week To	Spending	Cumulative Expenses
1	Rp 2,159,483.00	Rp 2,159,483.00
2	Rp 4,318,966.00	Rp 6,478,449.00
3	Rp...	Rp 6,478,449.00
4	Rp 47,409,706.00	Rp 53,888,155.00
5	Rp 230,039,614.00	Rp 283,927,769.00
6	Rp 124,948,399.00	Rp 408,876,168.00
7	Rp 210,690,558.00	Rp 619,566,726.00
8	Rp...	Rp 619,566,726.00
9	Rp 61,738,634.00	Rp 681,305,360.00
10	Rp 23,513,667.00	Rp 704,819,027.00
11	Rp 54,382,984.00	Rp 759,202,011.00
12	Rp 66,544,222.00	Rp 825,746,233.00
13	Rp 299,725,960.00	Rp 1,125,472,193.00
14	Rp 1,893,973,158.00	Rp 3,019,445,351.00
15	Rp 44,452,856.00	Rp 3,063,898,207.00

Based on the calculation of BCWS, BCWP, and ACWP, it can be seen the performance value of each job depicted in the following graph:



Graph 1: Comparison of Performance Value per week

Judging from the graph above the three variables (BCWS, BCWP and ACWP), the weekly actual cost ACWP is above the BCWS and BCWP lines, which means that the project is overrun and not in accordance with planning. The three variables above can be used to determine the status of the project whether there is a delay or faster..

1) Cost Parameter Analysis

Evaluation of cost performance during project implementation can be done through Cost Variance and Cost Performance Index analysis. These two indicators are used to measure the extent to which actual expenditure is in accordance with the planned budget as well as the efficiency of using costs at each stage of the work.

a) Cost Variance (CV)

This indicator provides an overview of the difference between planned costs and actual costs that have been incurred. The calculation steps for Cost Variance (CV) can be explained in:

CV week 15 = BCWP week 15 - ACWP week 15
= Rp3,036,029,280.36 - Rp3,063,898,207.
= -Rp 27,868,926.64

The negative CV result means that the actual costs that have been used are greater than the planned budget for carrying out work each week.

b) Cost Performance Index (CPI)

This indicator is used to evaluate cost efficiency in project implementation, with the value indicating the level of conformity between the planned budget and the actual costs used. The CPI calculation is carried out in steps:

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CPI week 15 = BCWP week 15 / ACWP week 15
=Rp 3,036,029,280.36 / Rp 3,063,898,207.00
= 0,9909

The CPI result for week 15 is below 1 (<1), meaning that in that week the actual cost exceeded the designed cost.

2) Time Parameter Analysis

The length of project implementation work time can be evaluated through Schedule Variance and Schedule Performance Index analysis. These two indicators provide important information regarding the comparison between the planned schedule and the actual progress, as well as the time efficiency in completing the work in a certain period.

a) Schedule Variance (SV)

This indicator helps identify whether the work progress is running according to the planned schedule or not. The steps for calculating the Schedule Variance (SV) are:

SV Week 15 = BCWP week 15 - BCWS week 15
=Rp3,036,029,280.36 – Rp 1,313,426,454.32
=Rp 1,722,602,826.04

From the calculations that have been carried out, the work planned for 15 weeks shows a positive value, which means that the project is completed faster than the specified schedule.

b) Schedule Performance Index (SPI)

This indicator helps identify whether implementation is ahead of schedule or delayed according to plan. The Schedule Performance Index (SPI) is calculated using the following formula:

SPI Week 15 = BCWP week 15 / BCWS week 15
=Rp3,036,029,280.36 / Rp. 3,036,029,280.36
= 2.3115 (> 1 Poyek on time)

From the calculations that have been carried out in this project, SPI values greater than 1 in the first 15 weeks indicate acceleration in project performance, which means that this project is being completed faster than the predetermined schedule.

3) Estimated Project Completion Cost / Estimated At Completion (EAC)

The purpose of EAC allocation is to determine the overall budget required to complete a project. After that, further analysis is done to calculate the additional costs that are still needed, known as the Estimated Time to Completion (ETC). This process helps in providing a more accurate picture of the projected costs that need to be incurred until the project is completed.

ETC = (Total Cost - BCWP) / CPI

EAC = ETC + ACWP

ETC = (Total Cost - BCWP) / CPI
= (Rp 3,731,109,310 - Rp 3,036,029,280.36) / 0.9909
= Rp 701,350,409.24

EAC = ETC + ACWP
= Rp 701,350,409.24 + Rp 3,063,898,207.00
= Rp 3,771,686,592.06

The value of the estimated cost to complete the Trasan II bridge project is IDR 3,771,686,592.06, an increase of IDR 40,686,319.06 which was originally IDR 3,731,000,273.00.

4) Estimated Project Completion Time / Estimated All Schedule (EAS)

The estimated amount of time required to complete the project as a whole is known as EAS. The following calculation is often referred to as the Estimated Temporary Schedule (ETS), which gives an idea of the duration required until the project is completed.

ETS = Remaining Time / SPI
= 11 weeks / 2.3115
= 4,759
= 5 weeks (rounded)

EAS = ETS + Time spent
= 5 weeks + 15 weeks
= 20 weeks

The result of the calculation of the Estimated All Schedule is 20 weeks there is a change in the project completion time which was previously 30 weeks due to the realization of the project experiencing acceleration.

5) Reschedule

Reschedule serves to efficiently distribute the available time in the execution of each job, so as to ensure the project is completed with the expected results. This process helps in adjusting time and resources so that project goals can be achieved according to plan. Based on the analysis of the concept of the value of the results on the variable Schedule Variance (SV) week 15 obtained Rp 1,722,602,826.04 is positive, this indicates that there is timeliness in implementation. The 15th week Cost Variance (CV) value of -Rp27,868,926.64 obtained a negative value which indicates a cost overrun, namely actual costs greater than plan costs.

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Week 15 Cos Performance Index (CPI) value of 0.9909 (<1) and Week 15 Scehedule Performance Index (SPI) of 2.3115 (>1) which indicates week 15 Although the project was completed earlier than expected, the costs incurred were greater than anticipated.

Based on the above conclusions, the Trasan II Bridge replacement project is in fairly good condition, to complete the remaining work, rescheduling will be carried out using the Precedence Diagram Method (PDM) work network. The estimated time needed to complete the project, which is about five weeks, starting from week 15 to 20, is obtained by calculating the Temporary Schedule Estimate. This time frame is the basis for rescheduling with the PDM technique. Work that still had more than 0.005% progress was included in the rescheduled work, while work with less than 0.005% remaining progress was considered completed at the time of the study.

3.3 Network Diagram Creation

Work Logic Relationship. The next step is carried out using Microsoft Project 2019 software. Below are the results of inputting rescheduling in the Microsoft Project 2019 application. In Figure 4 Rescheduling Using Microsoft Project as follows:

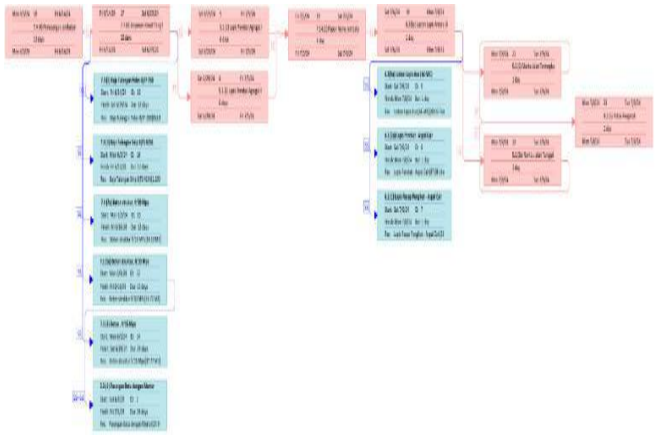

Figure 1: Network Diagram in Microsoft Project

In a network diagram, the critical trajectory includes several tasks or activities shown with red boxes. Additional focus is required for the jobs that are on these critical trajectories, as any delays in these jobs can have a significant impact on the overall project completion duration. If one of the jobs in this trajectory is delayed, it will affect other jobs and potentially cause a delay in the overall project completion. Critical trajectories in PDM have similar characteristics to Activity on Arrow (AOA).

The following is the critical path and critical time in the work network for the period of week 15 to week 20:

Critical Trajectory

= 1. D18 - D17 - B5 - F19 - C10 - E21 - E23

= 2. D19 - D17 - B5 - F19 - C10 - E22 - E23

= 3. D18 - D17 - B4 - F19 - C10 - E21 - E23

= 4. D19 - D17 - B4 - F19 - C10 - E22 - E23

Critical Time

= 1. 0 + 12 + 6 + 1 + 1 + 1 + 0 = 21 Days

= 2. 0 + 12 + 6 + 1 + 1 + 1 + 0 = 21 Days

= 3. 0 + 12 + 6 + 1 + 1 + 1 + 0 = 21 Days

= 4. 0 + 12 + 6 + 1 + 1 + 1 + 0 = 21 Days

Table 2: Critical Trajectory

No.	Description	Duration (Days)	Logic Relationships
D18	Installation of 25 M Long Standard Steel Truss Bridge	12	SF
D17	Welded Wire Mesh	12	D18
B5	Class B Aggregate Foundation Layer	6	D17
B4	Class A Aggregate Foundation Layer	6	D17
F19	Bridge Nameplate	1	4B, 5B
C10	Intermediate Layer Laston (AC-BC)	1	F19
E21	Thermoplastic Road Markings	1	C10
E22	Single Road Sign with Engineering Grade Reflecting Surface	1	C10
E23	Guiding Stake	1	E21 FF, E22 FF

After the critical trajectories and critical times are obtained, one of the trajectories is selected as a reference for rescheduling. In this case, critical trajectory number 1 is chosen as the reference.

D18 - D17 - B5 - F19 - C10 - E21 - E23

After obtaining the work network using PDM and identifying the critical line of the project, the next step is to create an 'S' Curve using project tracker software by connecting the duration and logic of the updated work. Here is Figure After obtaining the work network using PDM and identifying the critical line of the project, the next step is to

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create an 'S' Curve using project tracker software by connecting the duration and logic of the updated work. Here is Figure 2 “S Curve”.

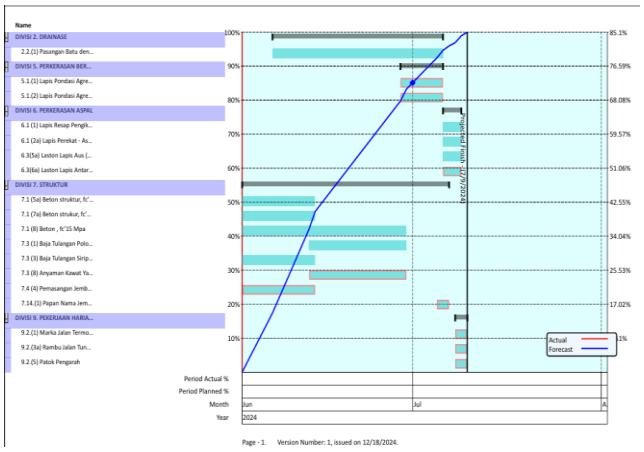

Figure 2: S-curve

IV. CONCLUSION

Overall, the project implementation performance in week 15 has exceeded the plan progress limit, with a realization percentage of 81.38% of the plan percentage of 35.21%. The advanced analysis process using the result value method shows that the Schedule Performance Index (SPI) obtained a value of 2.207813348. This indicates that the project's time performance is surplus, meaning that the project implementation is running faster than anticipated. Meanwhile, the CPI was recorded at 0.995142328, which indicates that the project cost performance was higher, so that the costs incurred exceeded the overall planned budget.

The calculation of the remaining cost required to complete the project using the earned value concept method results in an Estimated Temporary Cost value of Rp 701,350,409.24. On the other hand, the estimated time still needed to complete the project is about 4,759 weeks.

The results of project control using the Precedence Diagram Method (PDM) resulted in a critical path composed of 7 critical activities, namely D18 - D17 - B5 - F19 - C10 - E21 - E23 with a critical time of 21 days.

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