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Cost and Time Performance Evaluation of a Sports Hall Construction Project Using the Earned Value Method: A Case Study at Gunung Kidul Campus, Universitas Negeri Yogyakarta

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ABSTRACT

The main objectives in managing construction work involve controlling costs, ensuring quality, and meeting project deadlines. Construction projects are regarded as successful when they deliver outputs that satisfy predefined quality standards, are finished on time, and stay within the agreed budget. The Earned Value Method (EVM) is a valuable technique in project management for assessing both cost efficiency and schedule adherence throughout the project's duration. Important indicators for this analysis include BCWP (Budgeted Cost of Work Performed), BCWS (Budgeted Cost of Work Scheduled), ACWP (Actual Cost of Work Performed), Schedule Variance (SV), Cost Variance (CV), Schedule Performance Index (SPI), Cost Performance Index (CPI), Estimated At Schedule (EAS), and Estimated Temporary Schedule (ETS). This research focuses on evaluating the performance of the Sports Hall Building construction project at Gunung Kidul Campus by applying the earned value method. The assessment emphasizes time scheduling and cost management to gauge how well the project progresses relative to its planned schedule and budget. The study's findings reveal the current condition of both cost and schedule aspects of the Sports Hall Building project at Gunungkidul Campus, Universitas Negeri Yogyakarta. The data showed a positive cost variance, indicating that the project's actual expenditures were less than originally planned.

1. Introduction

Effective project monitoring is crucial for successful delivery across all industries. Conventional methods, often limited to merely tracking actual expenditures against budgets or progress against schedules, frequently fall short of providing a truly integrated and forward-looking view of a project's health. This compartmentalized approach can obscure underlying issues, leading to reactive decision-making, unmanaged cost escalations, inevitable schedule delays, and, ultimately, project failure [1]. The fundamental complexity and dynamic nature of contemporary projects, particularly within the construction industry, necessitate a more sophisticated and thorough performance measurement system capable of synthesizing financial, temporal, and physical progress data into a coherent and actionable framework.

To overcome these limitations, Earned Value Management (EVM) has emerged as a widely recognized and highly effective methodology for project control. EVM systematically integrates project scope, schedule, and cost performance into a unified system, offering project managers a powerful suite of metrics to objectively evaluate project status, forecast future performance, and proactively identify variances requiring corrective action [2]. At its core, EVM operates by comparing three fundamental dimensions: the Planned Value (PV), representing the budgeted cost of work scheduled to be completed; the Actual Cost (AC), representing the total cost incurred for the work performed; and the Earned Value (EV), which is the budgeted cost of the work actually accomplished. This tripartite comparison provides a holistic picture of project efficiency and

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effectiveness, enabling a deeper understanding of performance compared to conventional methods alone [3].

The primary function of EVM is to offer an objective, quantitative, and integrated assessment of project performance. Unlike basic cost tracking, EVM reveals not just how much has been spent, but the actual value received for that expenditure relative to the initial plan. This integration facilitates the calculation of critical performance indicators such as the Cost Performance Index (CPI), which quantifies cost efficiency (EV/AC), and the Schedule Performance Index (SPI), which quantifies schedule efficiency (EV/PV). A CPI or SPI below one immediately flags cost overruns or schedule delays, respectively, serving as crucial early warnings. Furthermore, EVM enables more accurate forecasting by allowing the calculation of the Estimate at Completion (EAC) and Estimate to Complete (ETC), providing project managers with a clearer projection of the final project cost and duration based on current performance trends [4]. These functions collectively empower project teams to make data-driven decisions, anticipate problems before they become critical, and refine project strategies in real-time.

Numerous international studies and case reports consistently underscore the positive impact of EVM implementation on construction project outcomes and, specifically, its ability to evaluate project performance effectively. For example, research on various construction projects has shown that applying EVM principles enables the early detection of schedule delays and cost overruns, providing critical insights that facilitate timely corrective actions [5]. Studies have detailed how EVM metrics, such as CPI and SPI, deliver objective performance indicators that assist project teams not only in tracking progress but also in predicting future performance with greater accuracy, ultimately leading to enhanced profitability and project completion within planned parameters [6]. Furthermore, in the Gaza Strip revealed EVM's effectiveness in managing time and cost overruns in building projects, highlighting its practical benefits in achieving desired outcomes and facilitating post-project evaluation [7]. Similarly, infrastructure projects in Jordan have emphasized how EVM enhances decision-making processes by providing clear performance data, which is crucial for ongoing project evaluation [8]. More recently, EVM's utility in improving project performance measurement in the UAE's construction sector, underscoring its adaptability to diverse regional contexts and its role in overall evaluation [9]. Integrating EVM with BIM for enhanced project control, a synergy that directly supports detailed performance evaluation [10], investigated the application of EVM in highway construction projects, confirming its efficacy in monitoring and forecasting performance for thorough assessment [11]. These findings collectively emphasize EVM's capacity to elevate project management beyond simple tracking to truly predictive and proactive control, yielding measurable benefits in terms of efficiency and success rates in construction ventures globally, thereby ensuring projects are effectively evaluated.

This journal aims to provide a detailed examination of Earned Value Management, analyzing its core functions and elucidating its critical roles in enhancing project performance within the construction sector, with a specific focus on its contribution to evaluating construction project outcomes. It will examine the specific adaptations and practical considerations required for successful EVM implementation in construction projects, review recent advancements and successful case studies, and discuss the persistent challenges and emerging best practices associated with its deployment. By synthesizing current research and practical insights from the last decade, this paper seeks to contribute to a deeper understanding of how EVM can be strategically leveraged to improve project predictability, enhance transparency, optimize resource allocation, and ultimately foster a more efficient, resilient, and successful construction industry.

This research uses objects from the construction project of the Sports Building or Sports Arena (GOR) of Yogyakarta State University, Gunungkidul Campus, which is a forum or location designated for organizing sports events or an arena usually called a sports venue. Yogyakarta State University currently has a sports building, namely in the downtown area of the Special Region of Yogyakarta and Gunungkidul. The sports building in Gunungkidul has just been built because not long ago the Yogyakarta State University, Kulon Progo, and Gunungkidul campuses were formed. Therefore, one way to build a superior university is to complete the facilities needed to carry out various activities.

2. Methods

The fact that this project involves complex tasks that must be completed on schedule and within the specified time led to the selection of this object for research so that this work must be carried out in a timely manner in order to be able to carry out analytical calculations and be reviewed from a management perspective, with a focus on utilizing the Earned Value Concept to limit costs and implementation time.

The data collection method used in this study is to use primary and secondary data. Secondary data in the form of sources from journals and literature study literature and primary data obtained from PT. Wahyu Kusuma Jati Pratama such as RAB, Time Schedule / S Curve, Progress Report, Daily and weekly reports. The data is used to process data using the Earned Value. The object of study used in the preparation of this final project is the Sports Building (GOR) Construction Project of Yogyakarta State University, Gunungkidul Campus can be seen in Figure 1.

Figure 1. GOR UNY Gunungkidul

The concept of Earned Valued is measurement method that uses "work in progress" to indicate what will happen in future work. This method can detect if there is a deviation in cost or time [12]. The concept of earned value presents 3 dimensions, namely physical completion of the project, calculation of planned costs on the project, actual costs incurred by the project [13]. There are several types of indicators in the earned value method, namely ACWP, BCWP, and BCWS. The earned value method has a weakness, namely that this method must be equipped with the expertise of the project manager, as an important factor in decision making using information generated from its application [14]. From the various problems that occur during the project, an effort is needed to control the time and cost of project implementation using the earned value method [15].

There are indicators used in the concept of yield value, namely: Indicators used in Earned Valued are [9, 16] first, BCWS (Budgeted Cost for Work Schedule) is a planned cost budget based on a work plan that has been prepared against time. Second, BCWP is the value received from the completion of work during a certain period of time. When the ACWP figure is compared with the BCWP value, a comparison will be seen between the costs that have been incurred for work that has been carried out against the costs that should have been incurred for that purpose. Third, ACWP is the actual cost incurred for the completion of work in the relevant time period to complete the work within a certain period of time.

Productivity and Performance Index consist of:

$$\text{Time Productivity Index (SPI)} = \text{BCWP / BCWS} \quad (1)$$

$$\text{Cost Productivity Index (CPI)} = \text{BCWP/ACWP} \quad (2)$$

There are has three performance index criteria, first, performance index <1, means that expenditure is greater than the budget or the implementation time is longer than the planned schedule. Second, performance index > 1, then the performance of the project implementation is better than the planning, smaller than the budget or the schedule is faster than the plan. Third, The greater the difference between the performance index and the number 1, the greater the deviation from the basic planning or budget.

Estimated time for completion of all work:

$$\text{ETS} = \text{remaining time / SPI} \quad (3)$$

$$\text{EAS} = \text{time finish} + \text{ETS} \quad (4)$$

This study was conducted to assess the performance of project implementation in terms of time and cost based on the understanding of value and results (Earned Value), evaluate the estimated time and cost of completing the deviation or delay. The stages of this research are carried out as follows:

2.1 Literature study

The literature study used in this study is a literature study related to or in line with solving problems regarding cost and time control using the Earned Value method. This study uses several relevant references regarding the calculation aspect using the yield value method.

2.2 Data collection

This study uses secondary data sourced from PT. Wahyu Kusuma Jati Pratama in the form of RAB, Time Schedule/S Curve, Progress Report, Daily and weekly reports. After that, the data is used as material for data processing using the Earned Value method.

2.3 Data processing

If all data has been collected, data processing is carried out. The ACWP, BCWP, and BCWS indicators are determined in the first few steps in the Earned Value method. RAB, RAP, Time Schedule, project progress reports, and project expenditure reports are the main sources of secondary data used to create these indicators.

These indicators are in the form of determining ACWP, BCWP, BCWS. After that, it is analyzed to determine the values of CV, SV, CPI, SPI, ETS, EAS, EAC and ETC.

2.4 Cost and time

The initial step taken is to first determine the values or indicators of ACWP, BCWP, and BCWS to make it easier to manage data and see the progress of costs and time on the research objects being carried out.

To make it easier to understand the stages of this research, it can be seen in the flowchart shown in Figure 2.

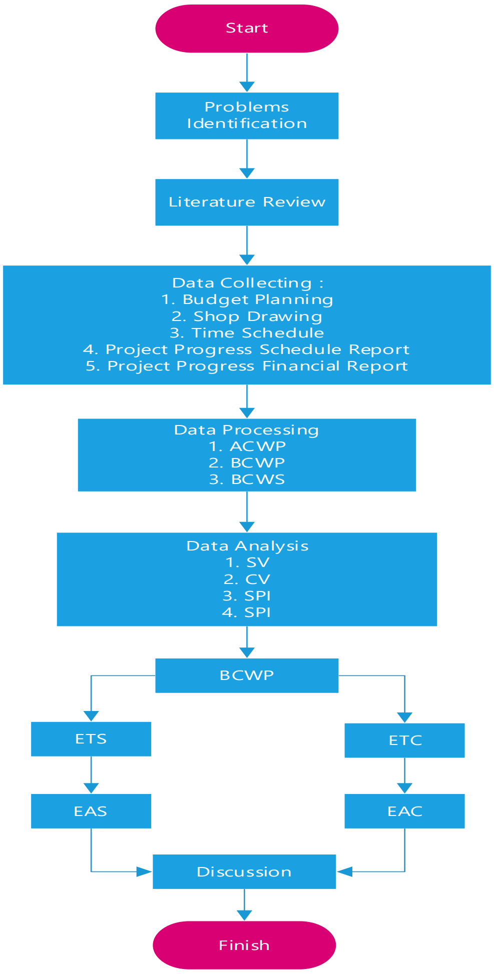

Figure 2. Flowchart

3. Result and Discussion

3.1 Result

The first thing to do in this study is to examine the data obtained from the project, then process the data and then analyze it to determine the efficiency of the work using the Earned Value method. The data can be used to find out the cause if a problem occurs and then analyze it to find alternative solutions to the problem. This aims to monitor so that the steps taken lead to the goals that have been set.

If all data has been collected, data processing is carried out. The ACWP, BCWP, and BCWS indicators are determined in the first few steps in the Earned Value method. RAB, RAP, Time Schedule, project progress reports, and project expenditure reports are the main sources of secondary data used to create these indicators. The indicators are as follows:

Calculation of ACWP (Actual Cost of Work Performed)

The processing of ACWP data is calculated to serve as a guideline to ensure that costs do not exceed the budget with the intention of completing work with the quality and standards set. Actual Cost of Work Performed is the amount of actual costs of work that has been carried out. Data calculating of ACWP can be seen in Table 1.

Table 1. Calculation of ACWP

Week	ACWP (Rp)	Cumulative ACWP (Rp)
1	25,978,706	25,978,706
2	158,063,863	184,042,569
3	526,498,175	710,540,745
4	1,004,110,728	1,714,651,474
5	925,627,993	2,640,279,467
6	829,810,073	3,470,090,061
7	817,787,073	4,287,877,135
8	911,081,616	5,198,958,751
9	1,001,144,542	6,200,103,293
10	1,075,983,321	7,276,086,614
11	1,075,983,321	8,352,069,936
12	1,065,026,048	9,417,095,985
13	1,065,026,048	10,482,122,034
14	707,500,530	11,189,622,565
15	782,705,898	11,972,328,463
16	721,222,133	12,693,550,597
17	759,028,854	13,452,579,451
18	608,418,463	14,060,997,915
19	344,065,320	10,405,063,236
20	299,456,806	14,704,520,043
21	207,872,526	14,912,392,569
22	8,548,929	14,920,941,498

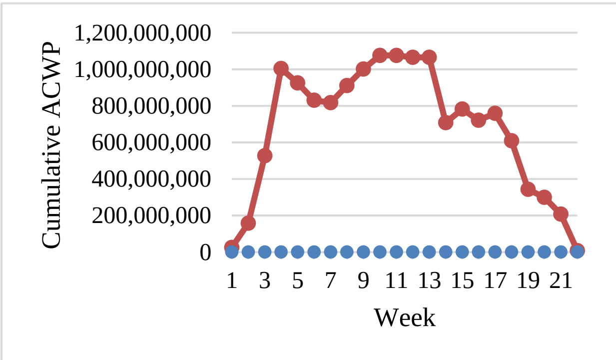

Figure 3. Graphic ACWP

The weekly ACWP can be plotted on Figure 3, where the x-axis shows time and the y-axis shows costs.

The actual costs incurred in the field for completed work are depicted in the ACWP chart. On the reporting date, these costs are derived from the project's financial accounting data. The chart above shows that the cost expenditure from week 1 to week 22 tends to decrease.

Calculation of BCWS (Budgeted Cost of Work Schedule)

The BCWS value is the total amount of work scheduled and related to the allocation of implementation time. The weight of the weekly work plan multiplied by the project budget produces the weekly BCWS as shown in Table 2.

Table 2. Calculation of BCWS

Week	BAC (RP)	BCWS (%)	BCWS (Rp)
1	16,562,245,000.00	0.17	28,155,816.5
2		1.06	175,559,797
3		3.53	584,647,248.5
4		6.73	1,114,639,088.5
5		6.20	1,026,859,190
6		5.56	920.860.822
7		5.48	907.611.026
8		6.11	1,011,953,169.5
9		6.71	1,111,326,639.5
10		7.21	1,194,137,864.5
11		7.21	1,194,137,864.5
12		7.14	1,182,544,293
13		7.14	1,182,544,293
14		4.74	785,050,413
15		5.25	869,517,862.5
16		4.83	799,956,433.5
17		5.09	843,018,270.5
18		4.08	675,739,596
19		2.31	382,587,859.5
20		2.01	332,901,124.5
21		1.39	230,215,205.5
22		0.06	9,937,347

The S curve on the plan is the data needed for the analysis. The weekly BCWS can be plotted on Figure 4, where the x-axis shows time and the y-axis shows costs. The graph below shows that the implementation costs tend to decrease. In the 1st to 4th week, there was a very steep increase in the graph, this happened because of the addition of overtime hours of workers to pursue the targets hat had been set in the work plan. This increase in work can be seen as an increase in weekly work weight. Then from the 10th to the 13th week the graph looks sloping with a stable value.

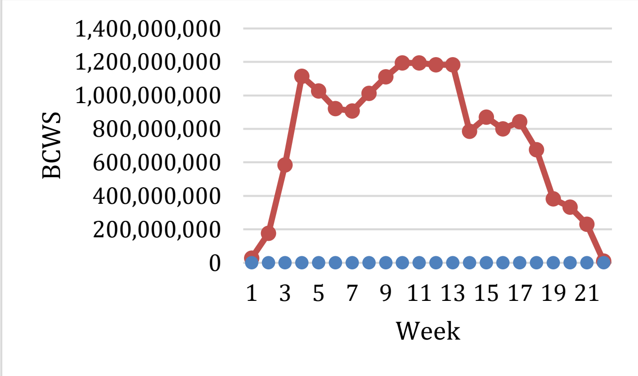

Figure 4. Graphic BCWS

Calculation of BCWP (Budgeted Cost of Work Performance)

The cost incurred to complete work within a certain period of time is called BCWP, and is determined by adding up all the work that has been completed. Weekly BCWP is calculated by multiplying the weekly progress weight of work completed by the total budget of the project. The data is taken from the weekly work report can be seen in Table 3.

Table 3. Calculation of BCWP

Week	BAC	BCWP (%)	BCWP (Rp)
1	16,562,245,000.00	1.56	5,837,102,200
2		4.63	76,683,194,350
3		4.32	71,548,898,400
4		4.40	72,873,878,000
5		5.45	90,264,235,250
6		4.76	78,836,286,200
7		4.20	69,561,429,000
8		6.76	111,960,776,200
9		8.97	148,563,337,650
10		6.22	103,017,163,900
11		9.18	152,041,409,100
12		3.00	49,686,735,000
13		5.92	98,048,490,400
14		4.30	71,217,653,500
15		3.76	62,274,041,200
16		1.97	32,627,622,650
17		4.36	72,211,388,200
18		3.38	55,980,388,100
19		4.20	69,561,429,000
20		4.51	74,695,724,950
21		2.25	37,265,051,250
22		0.92	15,237,265,400

The BCWP for each week can be plotted on a weekly chart and can be created with the x-axis showing time and the y-axis showing costs in Figure 5.

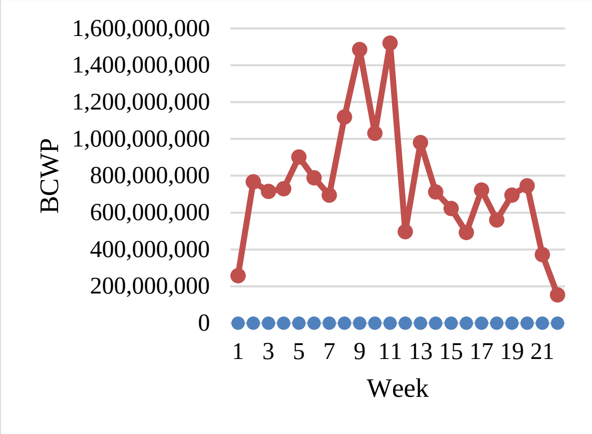

Figure 5. Graphic BCWP

The actual weight of work completed in relation to planned expenditure is shown in the BCWP graph above. In week 5 there is a decline as shown in the attached graph, and this continues until week 7 with an average decline of 12% due to the presence of cavities in some pedestal columns, then there is a steep increase from week 7 to week 9 with an average increase of 31%. After analysis, the three indicators will show the achievement of schedule and budget. The three indicators can be depicted as a graph with a vertical axis of cost and a horizontal axis of time.

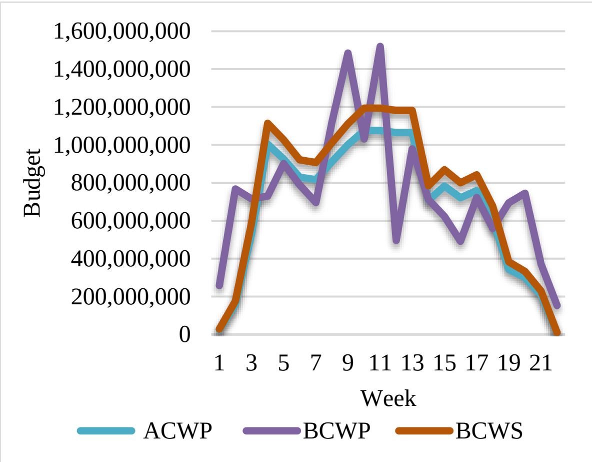

Figure 6. Earn Value Graph

Based on Figure 6 illustrates the dynamics of project implementation. The increase in BCWP in weeks 7 to 9 indicates an acceleration effort through overtime to meet the target. Technical constraints at the grounding location in week 10 caused a decrease in productivity and resulted in delays. Recovery efforts were carried out in week 11, but the impact of the delay was still visible in the following weeks. The significant decrease in BCWP at the end of the period indicates that most of the work has been completed, although there was a deviation from the initial schedule due to the constraints encountered." In the 4th week to the 7th week, ACWP is below BCWS which shows that the actual costs incurred are smaller than planned. The comparison between BCWS and BCWP is that BCWS is below BCWP which means that the work is faster than the planned schedule. So, on the project journey based on the graph above, the project had experienced losses but in the last few weeks showed significant progress, so that the project until the 22nd week showed the project journey according to plan.

The Graph 6 shows that the project experienced interesting dynamics. In the early phase, there was cost efficiency, but the work progress was also faster than expected. This indicates good cost management and effective planning. However, it should be noted that too much cost efficiency can potentially sacrifice the quality or quantity of work. Overall, the project was successfully completed on time in week 22, indicating the success of the project team in managing risks and achieving goals.

3.1.1 Variance Analysis

Cost Variance

The value of the decrease between the actual BCWP value of the project and the intended ACWP value is also known as the cost variance (CV) value.

The reduction of the difference between anticipated costs and actual costs of field activities can also be used to characterize cost variance. If the cost of the work is smaller than the anticipated cost, it is said to be more efficient, conversely if the cost of the work is greater than the planned cost, it is said to be more wasteful.

From Table 4. it is obtained for the total minus of the weeks stated as negative with a total amount of Rp. 1,635,448,910.18 and for the total positive of the weeks, namely with a total amount of Rp. 3,276,745,786.43. So, it can be concluded that if the total positive minus the total negative, the result is 1,641,296,876.25 which means this project is profitable.

Time Variance

The difference between the project's actual BCWP value and the planned BCWS value is known as the schedule variance value or SV.

Schedule variance can also be interpreted as the difference between the planned work schedule and the actual schedule. In data processing, the value of this schedule variance indicates the condition of the project each week. If the schedule variance number is positive, it means that the work is running faster than expected, and if it is negative, it means that the work is running slower than expected.

Based on Table 5, it is explained that in weeks 1 to 3 and weeks 8 to 9, weeks 11, weeks 19 to 22, it produces a positive CV and positive SV, which indicates that the expenditure projection is lower than that specified and the implementation of the schedule is completed faster than specified. In weeks 4 to 7 and weeks 10, weeks 12 to 13, weeks 15 to 18, it produces a negative CV and negative SV, this means that the work is behind schedule with a cost that is greater than the planned budget, this occurs due to the replacement of the GOR door material so it must be recalculated Partly to be adjusted. In Week 14 resulted in positive CV and negative SV, meaning the work was completed faster at a cost that exceeded budget.

3.1.2 Productivity Index Analysis

Cost Productivity Index (CPI)

Actual BCWP and projected ACWP are compared using the cost productivity index (CPI). The indicator value used to assess whether or not the cost productivity index of a job is in accordance with the projected budget is called the cost productivity index (CPI). Compared to the project budget plan, cost performance is more efficient if the CPI value is more than 1 (one), but a CPI value of less than 1 (one) means that cost performance is more wasteful can be seen in Table 6.

Table 5. SV Calculation Analysis

Week	BCWP	BCWS	SV
1	257,758,218	28,155,816	229,602,40
2	767,461,308	175,559,797	591,901,51
3	715,604,919	584,647,248	130,957,67
4	729,103,149	1,114,639,08	-385,535,93
5	902,707,955	1,026,859,19	-124,151,23
6	789,157,849	920,860,822	-131,702,97
7	695,465,229	907,611,026	-212,145,79
8	1,119,442,13	1,011,953,16	107,488,97
9	1,484,888,07	1,111,326,63	373,561,43
10	1,030,834,12	1,194,137,86	-163,303,73
11	1,519,966,91	1,194,137,864	325,829,046
12	496,387,044	1,182,544,293	-686,157,24
13	979,656,791	1,182,544,293	-202,887,50
14	712,044,037	785,050,413	-73,006,376
15	622,376,042	869,517,862	-247,141,82
16	491,766,178	799,956,433	-308,190,25
17	722,859,183	843,018,270	-120,159,08
18	559,621,696	675,739,596	-116,117,90
19	694,951,800	382,587,859	312,363,941
20	745,816,110	332,901,124	412,914,986
21	372,269,580	230,215,205	142,054,375
22	152,737,023	9,937,347	142,799,676

Table 4. CV Calculation Analysis

Week	BCWP	ACWP	CV
1	257,758,218	25,978,706	231,779,512
2	767,461,308	158,063,863	609,397,445
3	715,604,919	526,498,175	189,106,744
4	729,103,149	1,004,110,728	-275,007,579
5	902,707,955	925,627,993	-22,920,038
6	789,157,849	829,810,594	-40,652,745
7	695,465,229	817,787,073	-122,321,844
8	1,119,442,139	911,081,616	208,360,523
9	1,484,888,075	1,001,144,542	483,743,533
10	1,030,834,128	1,075,983,321	-45,149,193
11	1,519,966,910	1,075,983,321	443,983,589
12	496,387,044	1,065,026,048	-568,639,004
13	979,656,791	1,065,023,048	-85,366,257
14	712,044,037	707,500,530	4,543,507
15	622,376,042	782,705,898	-160,329,856
16	491,766,178	721,222,133	-229,455,955
17	722,859,183	759,028,854	-36,169,671
18	559,621,696	608,418,463	-48,796,767
19	694,951,800	344,065,320	350,886,480
20	745,816,110	299,456,806	446,359,304
21	372,269,580	207,872,526	164,397,054
22	152,737,023	8,548,929	144,188,094

Table 6. CPI Calculation Analysis

Week	BCWP	ACWP	CPI
1	257,758,218	25,978,706	9.92
2	767,461,308	158,063,863	4.86
3	715,604,919	526,498,175	1.36
4	729,103,149	1,004,110,728	0.73
5	902,707,955	925,627,993	0.98
6	789,157,849	829,810,594	0.95
7	695,465,229	817,787,073	0.85
8	1,119,442,139	911,081,616	1.23
9	1,484,888,075	1,001,144,542	1.48
10	1,030,834,128	1,075,983,321	0.96
11	1,519,966,910	1,075,983,321	1.41
12	496,387,044	1,065,026,048	0.47
13	979,656,791	1,065,023,048	0.92
14	712,044,037	707,500,530	1.01
15	622,376,042	782,705,898	0.80
16	491,766,178	721,222,133	0.68
17	722,859,183	759,028,854	0.95
18	559,621,696	608,418,463	0.92
19	694,951,800	344,065,320	2.02
20	745,816,110	299,456,806	2.49
21	372,269,580	207,872,526	1.79
22	152,737,023	8,548,929	17.87

Time Productivity Index (SPI)

The actual BCWP and planned BCWS are compared to determine the time productivity index (SPI) value. The indicator value used to assess whether or not the schedule productivity index is achieved on a task according to the scheduled schedule is called the time productivity index or SPI. If the SPI value is more than one, it means that the work is completed earlier, while if it is less than one, it means that the work schedule is running behind schedule.

Based on Table 5 and Table 6, it is explained that in weeks 1 to 3 and weeks 8 to 9, week 11, and week 19 to week 22, the CPI and SPI values are greater than 1, meaning that the work is ahead of schedule with a cost lower than budgeted. In weeks 4 to 7, week 10, week 12 to 13, and week 15 to 18, the CPI and SPI values are less than 1, meaning that there is a delay with cost overruns. In week 14 the SPI value is greater than 1 and the CPI value is less than 1, which means the work is ahead of schedule with a cost greater than the planned budget as shown in Table 7.

3.1.3 Estimated cost and time to complete the project

Estimated cost for remaining work Estimate to Completion (ETC)

ETC can be defined as an estimate of the amount of time remaining to complete work that has not been completed. The job performance index (CPI) and the remaining scheduled time are compared to determine the equivalent time (ETC).

The projection of the remaining difference in work costs each week must be displayed in the calculation results of the ETC value on the work costs. The efficient ETC value must be at a positive number where the work has been completed in accordance with the remaining work budget set. If not, the work realized is considered ineffective. From the results of the ETC analysis above, it is depicted in weeks 1 to 22 that the ETC value tends to decrease until the reporting of week 22 is at Rp. 918,465,791.56 can be seen in Table 8.

Costs required to complete the project (EAC)

Estimate at Complete (EAC) is the calculation of project costs by adding the reporting ACWP and the amount of time required to complete the unfinished tasks (ETC). The EAC value of the remaining work costs in the analysis findings above illustrates the variation in the overall costs required to complete the project. If the EAC value is smaller than the budgeted amount, the EAC value is more efficient. The results of the EAC and ETS analysis in the final calculation above conclude that the value of Rp. 927,014,721.32 is a value that shows the total cost required to complete the remaining work. So, the Yogyakarta State University Sports Hall Construction Project, Gunungkidul Campus, makes a profit in Table 9.

Table 7. SPI Calculation Analysis

Week	BCWP	BCWS	SPI
1	257,758,218	28,155,816	9.15
2	767,461,308	175,559,797	4.37
3	715,604,919	584,647,248	1.22
4	729,103,149	1,114,639,088	0.65
5	902,707,955	1,026,859,190	0.88
6	789,157,849	920,860,822	0.86
7	695,465,229	907,611,026	0.77
8	1,119,442,139	1,011,953,169	1.11
9	1,484,888,075	1,111,326,639	1.34
10	1,030,834,128	1,194,137,864	0.86
11	1,519,966,910	1,194,137,864	1.27
12	496,387,044	1,182,544,293	0.42
13	979,656,791	1,182,544,293	0.83
14	712,044,037	785,050,413	0.91
15	622,376,042	869,517,862	0.72
16	491,766,178	799,956,433	0.61
17	722,859,183	843,018,270	0.86
18	559,621,696	675,739,596	0.83
19	694,951,800	382,587,859	1.82
20	745,816,110	332,901,124	2.24
21	372,269,580	230,215,205	1.62
22	152,737,023	9,937,347	15.37

Table 8. ETC Calculation Analysis

Week	BAC	BCWP	CPI	ETC
1	16,562,245,000	257,758,218	9.92	1,643,282,111
2		767,461,308	4.86	3,253,042,856
3		715,604,919	1.36	11,658,985,092
4		729,103,149	0.73	21,805,183,001
5		902,707,955	0.98	16,057,137,600
6		789,157,849	0.95	16,585,623,313
7		695,465,229	0.85	18,657,507,012
8		1,119,442,139	1.23	12,568,451,103
9		1,484,888,075	1.48	10,165,489,135
10		1,030,834,128	0.96	16,211,666,451
11		1,519,966,910	1.41	10,648,416,244
12		496,387,044	0.47	34,470,192,994
13		979,656,791	0.92	16,940,438,470
14		712,044,037	1.01	15,749,061,855
15		622,376,042	0.80	20,046,127,429
16		491,766,178	0.68	23,568,894,188
17		722,859,183	0.95	16,631,940,421
18		559,621,696	0.92	17,397,987,862
19		694,951,800	2.02	7,855,775,483
20		745,816,110	2.49	6,350,543,001
21		372,269,580	1.79	9,040,360,178
22		152,737,023	17.87	918,465,712

Table 9. EAC Calculation Analysis

Week	ACWP	ETC	EAC
1	25,978,706	1,643,282,111	1,669,260,817
2	158,063,863	3,253,042,856	3,411,106,719
3	526,498,175	11,658,985,092	12,185,483,267
4	1,004,110,728	21,805,183,001	22,809,293,729
5	925,627,993	16,057,137,600	16,982,765,593
6	829,810,594	16,585,623,313	17,415,433,907
7	817,787,073	18,657,507,012	19,475,294,085
8	911,081,616	12,568,451,103	13,479,532,719
9	1,001,144,542	10,165,489,135	11,166,633,677
10	1,075,983,321	16,211,666,451	17,287,649,772
11	1,075,983,321	10,648,416,244	11,724,399,565
12	1,065,026,048	34,470,192,994	35,535,219,042
13	1,065,023,048	16,940,438,470	18,005,461,518
14	707,500,530	15,749,061,855	16,456,562,385
15	782,705,898	20,046,127,429	20,828,833,327
16	721,222,133	23,568,894,188	24,290,116,321
17	759,028,854	16,631,940,421	17,390,969,275
18	608,418,463	17,397,987,862	18,006,406,325
19	344,065,320	7,855,775,483	8,199,840,803
20	299,456,806	6,350,543,001	6,649,999,807
21	207,872,526	9,040,360,178	9,248,232,704
22	8,548,929	918,465,712	927,014,641

Table 10. ETS Calculation Analysis

Week	SPI	ETS
1	9.15	2.29
2	4.37	4.58
3	1.22	15.52
4	0.65	27.52
5	0.88	19.35
6	0.86	18.67
7	0.77	19.58
8	1.11	12.66
9	1.34	9.73
10	0.86	13.90
11	1.27	8.64
12	0.42	23.82
13	0.83	10.86
14	0.91	8.82
15	0.72	9.78
16	0.61	9.76
17	0.86	5.83
18	0.83	4.83
19	1.82	1.65
20	2.24	0.89
21	1.62	0.62
22	15.37	0.00

Estimated schedule for remaining work Estimate to Schedule (ETS)

Estimate to Schedule is an estimate of the amount of time required to complete the remaining work. The work performance index (SPI) and the remaining planned time can be compared to obtain the ETS value. ETS is an indicator that provides information in the form of an estimate of the remaining work time from the reporting time. ETS can be interpreted as if performance is considered as reported.

The result of the calculation of the ETS value on the cost of work must state the estimated variation value of the remaining work costs each week. The work achieved must be in accordance with the planned remaining work budget so that the ETC value is effective if it is at that value. Otherwise, the work completed is considered ineffective. The results of the ETS analysis above from week 1 to week 22 state that the ETS value tends to decrease until the end of the reporting week 22 is at 0.00 week can be seen in Table 10.

Time required to complete the project (EAS)

Estimate at Schedule (EAS) is an estimate of the amount of time required to complete the project calculated by adding the time required to complete the remaining tasks to the actual time (EAS). The calculation of the EAS value analysis of the remaining cost of work shows that there is a variation in the amount of time needed to complete the project. If the EAS value is less than the total specified time, it will be created faster than the work schedule. The EAS analysis calculation above shows a significant value, namely at the 4th week interval or 31.52 weeks in the project completion schedule. The project estimate will be completed 9.52 weeks later than expected because the 22nd week period is valued at 22.00 weeks as shown in Table 11.

Table 11. EAS Calculation Analysis

Week	ETS	EAS	Week	ETS	EAS
1	2.29	3	12	23.82	26
2	4.58	7	13	10.86	24
3	15.52	19	14	8.82	23
4	27.52	32	15	9.78	25
5	19.35	24	16	9.76	26
6	18.67	25	17	5.83	23
7	19.58	27	18	4.83	23
8	12.66	21	19	1.65	21
9	9.73	19	20	0.89	21
10	13.90	24	21	0.62	22
11	8.64	20	22	0.00	22

3.2 Discussion

The results of the analysis of data processing for the Yogyakarta State University Sports Hall Construction Project, Gunungkidul Branch using the concept of the Earned Value Method can be concluded as follows:

Regarding costs, this figure shows a positive number, indicating that project expenditures are smaller than planned, as indicated by the actual expenditure incurred of Rp. 14,920,941,498.86 which is smaller than the budget for completed work (BCWP) of Rp. 16,562,245,000.00. So, this project makes a profit of Rp. 1,641,303,501.14. This result is in line with reported in [17] research results that analysis revealed a cost gap of −3.24% compared to the original estimated cost. This discrepancy was attributed to a conservative project measurement baseline that did not align with the actual execution, indicating a need for better planning and measurement practices.

According to [18], the project had a negative Schedule Variance (SV) of -494,000,000, indicating it was behind schedule, with a Schedule Performance Index (SPI) of 0.78. However, it had a favorable Cost Variance (CV) of 167,000,000, suggesting it was under budget. The project was estimated to take 12 months to complete instead of the planned 9 months

Regarding the implementation time of the results of this study using the Earned Value method, there was a delay because the highest value on the EAS showed 31.52 weeks which exceeded the planned time of 22 weeks. So, the project was delayed by 9.52 weeks or rounded up to 67 days. Meanwhile, what happened in the field was that the project implementation time was on time due to overtime work and additional workers so that the project implementation time did not exceed the planned time.

This condition is similar to the findings in [19] that the results show the project was 57 weeks late from the planned
146 weeks. This means that delays in the completion of the project will occur. The results of the delay also occurred in [20] Time Estimate (TE), in week 15 shows the number 32.33 ≈ 33 calendar days, so it takes 210 calendar days to complete the project from week 15 plus the remaining time of 159 days, or total implementation time from week 1 to completion for 210 + 33 = 243 (Two hundred and forty-three) calendar days or 33 days later than the contract time of 210 calendar days. That understanding and managing the Budgeted Cost for Work Schedule (BCWS) and Actual Cost for Work Performed (ACWP) are essential for maintaining financial control over the project. Variances between planned and actual costs can provide insights into project performance and areas needing attention [19].

EVM provides valuable data for decision-making, its success heavily relies on the expertise of the project manager. The project manager plays a crucial role in interpreting EVM data and making timely corrective actions based on the information provided [17]. The EVM is highlighted as a global standard for project performance measurement, effectively integrating scope, cost, and schedule measures. This integration provides a comprehensive view of the project's current status, which is crucial for effective management [21].

As reported in [22], the proposed modeling method enhances the predictive power of Planned Value (PV) before project execution. The results indicate an average improvement in forecasting accuracy of 23.66% for Earned Value (EV) and 17.39% for Actual Cost (AC) when compared to traditional methods.

4. Conclusion

The study concluded that EVM is vital for the comprehensive management of construction projects, emphasizing the importance of cost, time, and scope control. The findings suggest that implementing EVM can lead to better project outcomes by enabling stakeholders to monitor costs and progress effectively, thus facilitating timely corrective actions. The initial organization of the project was undermined by the inexperience and lack of knowledge in project management tools. This deficiency prevented the project team from optimizing resources effectively or making timely adjustments to management strategies

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