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Cost Management Analysis of Project Delays Using The Earned Value Method for The Mbambang River Gabion Construction Project Malang Regency

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Abstract

River protection infrastructure requires effective cost and schedule control because construction delays can increase expenditures and reduce project performance. This study aimed to evaluate the cost and schedule performance of the Mbambang River gabion construction project in Malang Regency using the Earned Value Method (EVM). A quantitative applied research design was employed using primary data obtained from field observations, project implementation records, and construction documentation, along with secondary data consisting of project schedules, budgets, progress reports, and the work breakdown structure. Project performance was assessed using the Budgeted Cost for Work Scheduled (BCWS), Budgeted Cost for Work Performed (BCWP), Actual Cost for Work Performed (ACWP), Cost Variance (CV), Schedule Variance (SV), Cost Performance Index (CPI), and Schedule Performance Index (SPI). The results showed that gabion installation experienced significant schedule delays and cost inefficiency, with an SPI of 0.40, CPI of 0.90, SV of −Rp1,391,064,088, and CV of −Rp103,333,416. Nonwoven geotextile installation performed closer to the planned schedule but remained cost-inefficient, recording an SPI of 0.95, CPI of 0.91, SV of −Rp1,966,686, and CV of −Rp4,110,373. These findings demonstrated that both activities experienced schedule and cost deviations, although the magnitude of the deviations differed. The study concluded that EVM provides an effective early-warning framework for identifying project performance deviations and supporting timely corrective decisions in river infrastructure construction.

INTRODUCTION

River infrastructure development plays an essential role in mitigating flood hazards and maintaining riverbank stability. One of the most common river protection structures is gabion work, which functions to prevent riverbank erosion, scouring, and slope failure caused by river flow (Abas & Sherley, 2022). The successful implementation

of gabion construction is determined not only by the quality of the completed structure but also by effective management of project costs (Assaf & Al-Hejji, 2006), schedules, and available resources throughout the construction process (Kerzner, 2017). Therefore, project control is an important aspect of ensuring that construction activities are completed according to the planned objectives (Anfaal Al Ghifari & Djuanda, 2023).

Project delays remain one of the most common challenges encountered in construction projects. Delays may result from various factors, including adverse weather conditions, limited resources, material procurement issues, site constraints, and low work productivity (Doloi, 2009). These conditions not only extend project completion time but also increase construction costs due to additional labor requirements, equipment operation, and project overhead expenses (Fadila et al., 2024). Consequently, ineffective delay management may reduce project performance and significantly affect the efficiency of project implementation (Sa'adah et al., 2021).

To evaluate project performance in terms of cost and schedule, the Earned Value Method (EVM) has been widely adopted as an integrated project control technique. This method combines cost performance (Fleming & Koppelman, 2000), schedule performance, and work progress into a single evaluation framework, allowing project managers to assess actual project conditions against the original project plan (Oktatiyana et al., 2024). Through the analysis of Budgeted Cost for Work Scheduled (BCWS), Budgeted Cost for Work Performed (BCWP), and Actual Cost for Work Performed (ACWP), EVM can identify cost and schedule deviations while simultaneously estimating the projected cost and completion time of a project if the current performance trend continues (Darma Dirawan et al., n.d.) (Kim et al., 2003).

The application of EVM is particularly relevant to river engineering projects, including gabion construction, where project performance is strongly influenced by field conditions such as river flow, weather variability, and material availability (Love et al., 2008). These factors frequently affect construction productivity and may lead to discrepancies between planned and actual project progress. Consequently, periodic project performance evaluations are necessary to identify potential delays and cost overruns at an early stage, enabling appropriate corrective actions before significant (Alaghbari et al., 2007) project deviations occur (Alfriani et al., 2025).

The gabion construction project on the Mbambang River, Malang Regency, represents a river protection project that requires effective monitoring of both project costs and schedules. Delays during project execution may significantly influence the overall project budget and completion time (Adrianti et al., 2024). Therefore, an analytical approach capable of comprehensively evaluating project performance is required. The Earned Value Method provides an effective framework for assessing project performance by integrating cost and schedule information into measurable performance indicators (Massie et al., n.d.).

Based on the aforementioned background, this study aimed to analyze the impact of project delays on construction cost management using the Earned Value Method (EVM) in the Mbambang River gabion construction project, Malang Regency (Institute,

2021). (Vanhoucke, 2011) The analysis was conducted by evaluating project performance indicators related to cost and schedule to determine the extent of project deviations and estimate the projected cost and completion time (Mar'aini, 2022). The findings of this study are expected to provide useful information for contractors, project owners, and construction managers in improving project cost and schedule control, particularly in river engineering projects (Zachry et al., 2025).

METHOD

This study employed a quantitative approach with an applied research design to evaluate cost management performance affected by construction delays in the Mbambang River gabion construction project, Malang Regency. The analysis focused on assessing the impact of delays on project cost and schedule performance using the Earned Value Method (EVM) as an integrated project control technique.

The study used data obtained from the Mbambang River gabion construction project. Primary data consisted of project progress observations, actual work implementation records, and supporting field documentation collected during project execution. Secondary data included the project schedule, work breakdown structure (WBS), contract value, progress reports, project budget documents, and other technical documents provided by the contractor. Relevant literature on construction project management and earned value analysis was also reviewed to support the analysis.

Data collection was conducted through literature review and field observation. Field observations were performed to verify project implementation, monitor actual work progress, and identify factors contributing to project delays. The collected data were verified to ensure consistency between planned and actual project conditions before being analyzed.

Data analysis was performed using the Earned Value Method (EVM) by calculating the Budgeted Cost for Work Scheduled (BCWS), Budgeted Cost for Work Performed (BCWP), and Actual Cost for Work Performed (ACWP). These indicators were used to evaluate project performance based on cost and schedule deviations. Schedule Variance (SV) and Cost Variance (CV) were calculated to identify deviations from the project plan, while Schedule Performance Index (SPI) and Cost Performance Index (CPI) were used to assess project efficiency.

Forecasting analysis was conducted using Estimate at Completion (EAC) and Estimate to Complete (ETC) parameters to predict the projected total project cost and the additional cost required to complete the remaining work based on current performance conditions. The forecasting results provided an overview of the potential financial impact if existing project conditions continued until completion.

The analysis results were interpreted to evaluate cost management performance during the implementation of the Mbambang River gabion construction project. The discussion focused on the relationship between project delays and cost performance, as well as the effectiveness of the Earned Value Method in supporting project monitoring and decision-making. The findings were used as the basis for developing

recommendations to improve project cost control and minimize the impact of delays in future river engineering projects.

RESULTS AND DISCUSSION

Project Profile

The retaining wall construction project using gabion structures along the Mbambang River in Malang Regency was implemented as an emergency disaster mitigation project aimed at preventing river overflow during the rainy season (Anbari, 2003). This measure was undertaken to minimize riverbank erosion, which could otherwise lead to landslides if left unaddressed. The detailed information regarding the gabion construction project along the Mbambang River in Malang Regency is presented as follows.

Table 1. Project Profile of the Gabion Construction Works on the Mbambang River, Malang Regency

Item	Description
Project Package	Gabion Construction Works on the Mbambang River
Project Location	Sitiarjo Village, Sumbermanjing Wetan District, Malang Regency, Indonesia
Project Type	Self-Managed Project (Swakelola)
Funding Source	DIPA of the Brantas Water Resources Operation Unit (Satker OP SDA Brantas)
Project Start Date	February 16, 2026
Project Completion Date	July 4, 2026
Type of Work	Gabion Retaining Wall Construction
Retaining Wall Length	225 m
Retaining Wall Top Width	2 m
Retaining Wall Height	5.50 m

Source: Project Data

Work Quantities

The Bill of Quantities (BoQ) for the gabion construction project on the Mbambang River, Malang Regency, consists of preparation works, dewatering works, earthworks, structural works, masonry works, and piling works. The work quantities are presented in Table 2.

Table 2. Bill of Quantities

No	Work Description	Unit	Quantity
I	***PREPARATION WORKS***		
1.1	Surveying / Setting Out (Bouwplank)	m	255,00
1.2	Site Clearing	m2	510,00
II	**EARTHWORKS**		
2.1	Common Excavation (Depth >1 m to 2 m)	m3	540,00
2.2	Earth Fill	m3	127,50
III	**GABION WORKS**		
3.1	Gabion Installation	m3	2292,00
3.2	Non-Woven Geotextile Installation	m2	969,00
IV	**PILING WORKS**		
4.1	Supply and Installation (Driving) of 20 × 20 cm Concrete Piles	m	918,00

Source: Project Data

Workforce and Equipment

Based on field observations, the number of workers assigned to each activity was identified, along with the construction method employed, whether manual or mechanized using heavy equipment. The workforce allocation and equipment utilized during project implementation are presented in Table 3.

Table 3. Workforce and Equipment Allocation

No	Work Description	Number of Workers	Construction Method	Equipment
I	**PREPARATION WORKS**			
1.1	Surveying / Setting Out (Bouwplank)	3	Manual	-
1.2	Site Clearing	4	Manual	-
II	**EARTHWORKS**			
2.1	Common Excavation (Depth >1 m to 2 m)	2	Mechanized	1 PC 200 Excavator
2.2	Earth Fill	2	Mechanized	1 PC 200 Excavator
III	**GABION WORKS**			
3.1	Gabion Installation	5	Manual	-
3.2	Non-Woven Geotextile Installation	2	Manual	-
IV	**PILING WORKS**			
4.1	Supply and Installation (Driving) of 20 × 20 cm Concrete Piles	2	Mechanized	1 PC 200 Excavator

Source: Project Data

Work Coefficients

Based on field observations, the number of workers assigned to each activity and the construction method, whether manual or mechanized using heavy equipment, were identified. In addition, the work coefficients were determined based on the Indonesian Standard Analysis of Unit Prices AHSP (Analisis Harga Satuan Pekerjaan) The work coefficient indices for each activity are presented in Table 4.

Table 4. Work Coefficient Indices Based on AHSP

No	Work Description	Coefficient Index
I	**PREPARATION WORKS**	
1.1	Surveying / Setting Out (Bouwplank)	0,018
1.2	Site Clearing	0,100
II	**EARTHWORKS**	
2.1	Common Excavation (Depth >1 m to 2 m)	0,008
2.2	Earth Fill	0,006
III	**GABION WORKS**	
3.1	Gabion Installation	0,936
3.2	Non-Woven Geotextile Installation	0,016
IV	**PILING WORKS**	
4.1	Supply and Installation (Driving) of 20 × 20 cm Concrete Piles	0,400

Source: AHSP

Project Cost Estimate

The Project Cost Estimate (Rencana Anggaran Biaya—RAB) is a planning document that details all costs required to execute a construction project. For the gabion construction works on the Mbambang River in Malang Regency, the RAB includes the costs of preparation works, earthworks, gabion works, and piling works. The detailed project cost estimate is presented in Table 5.

Table 5. Project Cost Estimate (RAB)

No	Work Description	Unit	Qty	Unit Price	Total Cost
I	**PREPARATION WORKS**				
1.1	Surveying / Setting Out (Bouwplank)	m	255,00	Rp. 20.665,88	Rp 5.269.800
1.2	Site Clearing	m2	510,00	Rp. 13.300,00	Rp 6.783.000
II	**EARTHWORKS**				
2.1	Common Excavation (Depth >1 m to 2 m)	m3	540,00	Rp. 23.856,07	Rp 12.882.279
2.2	Earth Fill	m3	127,50	Rp. 177.741,06	Rp 22.661.986
III	**GABION WORKS**				
3.1	Gabion Installation	m3	2292,00	Rp. 1.327.464,90	Rp 3.042.549.551
3.2	Non-Woven Geotextile Installation	m2	969,00	Rp. 77.124,93	Rp 74.734.055
IV	**PILING WORKS**				
4.1	Supply and Installation (Driving) of 20 × 20 cm Concrete Piles	m	918,00	Rp. 84.888,86	Rp 77.927.973
	TOTAL (INCLUDING 11% VAT)				Rp 3.262.111.544
	ROUNDED TOTAL				Rp 3.262.111.000

Source: Project Data

Earned Value Indicator Analysis

The Earned Value Method (EVM) was applied to evaluate the project performance in terms of schedule and cost. The analysis was conducted by calculating the Budgeted Cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP), and Actual Cost of Work Performed (ACWP) for the gabion works.

The calculations for the gabion installation are as follows:

a. BCWS (Gabion Installation)

$$BCWS = 1755{,}57 \times Rp.\,1.327.465 = Rp.\,2.330.458.783$$

b. BCWP (Gabion Installation)

$$BCWP = 707{,}66 \times Rp.\,1.327.465 = Rp.\,939.394.694$$

c. ACWP (Gabion Installation)

$$ACWP = 707{,}66 \times Rp.\,1.460.211 = Rp.\,1.042.728.111$$

Table 6. Summary of Earned Value Indicators

No	Work Description	BCWS	BCWP	ACWP
III	**Gabion Works**			
3.1	Gabion Installation	Rp2.330.458.783	Rp939.394.694	Rp1.042.728.111
3.2	Non-Woven Geotextile Installation	Rp39.333.713	Rp37.367.028	Rp41.477.401

Source: Processed by the Authors

Earned Value Variance Analysis

Project performance was further assessed by calculating the Cost Variance (CV) and Schedule Variance (SV).

For the gabion installation:

a. Cost Variance

$$CV = Rp\ 939.394.694\ -\ Rp1.042.728.111 = Rp\ -\ Rp103.333.416$$

b. Schedule Variance

$$SV = Rp\ 939.394.694\ -\ Rp\ 2.330.458.783 =\ Rp - 1.391.064.088$$

Table 7. Summary of Earned Value Variances

No	Work Description	CV	SV
III	**Gabion Works**		
3.1	Gabion Installation	-Rp103.333.416	-Rp1.391.064.088
3.2	Non-Woven Geotextile Installation	-Rp4.110.373	-Rp1.966.686

Source: Processed by the Authors

Earned Value Performance Indices

The project performance was also evaluated using the Schedule Performance Index (SPI) and the Cost Performance Index (CPI).

For the gabion installation:

a. Schedule Performance Index

$$SPI = \frac{Rp\ 939.394.694}{Rp\ 2.330.458.783} = 0{,}40$$

b. Cost Performance Index

$$CPI = \frac{Rp\ 939.394.694}{Rp\ 1.042.728.111} = 0{,}90$$

Table 8. Summary of Earned Value Performance Indices

No	Work Description	SPI	CPI
III	**Gabion Works**		
3.1	Gabion Installation	0,40	0,90
3.2	Non-Woven Geotextile Installation	0,95	0,91

Source: Processed by the Authors

CONCLUSION

The Earned Value Method demonstrated that the Mbambang River gabion construction project experienced both schedule delays and cost inefficiencies. Gabion installation recorded an SPI of 0.40 and a CPI of 0.90, with an SV of −Rp1,391,064,088 and a CV of −Rp103,333,416, indicating substantial schedule delays and costs exceeding the value of completed work. Nonwoven geotextile installation performed closer to the planned schedule, with an SPI of 0.95, but remained cost-inefficient, as reflected by a CPI of 0.91, an SV of −Rp1,966,686, and a CV of −Rp4,110,373. These findings confirmed that integrating schedule and cost indicators through EVM provided early evidence of project deviations and supported more timely managerial decision-making.

Future research should evaluate all project activities throughout the entire construction period and incorporate Estimate at Completion (EAC), Estimate to Complete (ETC), and completion-time forecasting to assess the final consequences of existing performance trends. Further studies should also investigate the specific causes of schedule and cost deviations, such as weather conditions, labor productivity, material availability, equipment performance, and site constraints, and compare EVM results across multiple river infrastructure projects. Combining EVM with risk analysis, the Critical Path Method (CPM), or schedule-crashing analysis may provide more comprehensive and actionable strategies for controlling delays and cost overruns.

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