

Earned Value Analysis of an Under-Construction Bridge in Dhaka City

P. Debnath¹, M. B. Shamim², M. Hasan³

¹Department of Building Engineering & Construction Management, RUET, Bangladesh (debnathpushpita99@gmail.com)

²Department of Building Engineering & Construction Management, RUET, Bangladesh (mafruhabss@gmail.com)

³Department of Building Engineering & Construction Management, RUET, Bangladesh (mehedi@becm.ruet.ac.bd)

Abstract

Earned Value Management (EVM) is a project management tool that integrates the three basic elements: scope, cost, and schedule. It gauges project progress by comparing actual completed work to planned work and costs. EVM addresses cost and time overruns in construction projects due to mismanagement. Its results aid in tracking project alignment and identifying issues before they escalate. This study employs EVM to assess an ongoing bridge construction project's advancement. EVM's efficacy is highlighted for ensuring project success and goal attainment. Project performance is measured through key indicators like planned value (PV), actual cost (AC), and earned value (EV). The analysis reveals below-par project performance, attributed to schedule delays, material procurement setbacks, and labor shortages, with SPI and CPI values of 0.9 and 1.13 respectively. The study also acknowledges EVM implementation challenges in Bangladesh, notably the necessity for precise data and expert involvement. In summary, Earned Value Management serves as a powerful technique in project management, allowing holistic progress evaluation by considering scope, cost, and schedule. Its application to a bridge construction project underscores its utility in detecting issues and steering projects toward success while acknowledging the specific challenges of its implementation in certain contexts.

Keywords: EVM; Project Monitoring; KPIs; SPI; CPI.

1 Introduction

A project's time duration refers to the predetermined timeframe set for the contractor to complete the delivery of products or services. On the other hand, the cost encompasses all the expenses involved in providing the necessary resources to physically approach or produce the final product and achieve the desired outcome. The conventional way of monitoring project time and cost focuses on overseeing projects using basic parameters and, in this motive, there are two sources of data: the allocated budget and the actual expenses. By comparing the planned budget with the actual spending, it reveals how much was originally intended versus what was utilized up to a specific point (Zulkefli et al., 2018a). However, this traditional approach is not worth enough to predict future performance based on current performance trends. Due to these limitations, Earned Value Management (EVM) has been developed to unify project scope, cost, and time to measure project performance objectively. Earned Value Management (EVM) originated from PERT/COST and became a specialized financial analysis approach in U.S. government programs in the 1960s. It evolved into a key part of project management and cost engineering. Initially, it was implemented as Program Evaluation and Review Technique (PERT) in the U.S. Department of Defense, but contractors found it burdensome. In 1989, EVM was integrated into program management and procurement. Its use has since expanded beyond the U.S. Department of Defense to other entities such as the National Aeronautics and Space Administration (NASA), the United States Department of Energy, and various technology-related agencies (*Earned Value Management - Wikipedia*, n.d.).

In a nutshell, EVM calculates the differences either between EV and AC (for cost deviations) or EV and PV (for time deviations). If EV exceeds PV or AC, the project is on schedule or within budget. Regardless of whether the order of execution was ideal, EV increases as more tasks are finished. Because every activity contributes to the overall project cost depending on its budget (Ballesteros-Pérez & Elamrousy, 2018). However, this study aims to look into how EVM is now understood and perceived, as well as its uses, restrictions, and challenges in the Asian construction industry, particularly in Bangladesh.

2 Literature Review

M. Sharun and P. Sundara Kumar stated that EVM is one of the greatest project management techniques developed ever for assessing project performance as it helps to accelerate management control systems and to find out and control the potential risks (M. Sharun, 2018). According to Rajesh Ganpat Virle and Sumedh Y Mhaske, conducting the EVA of a project enables the project manager to feel assured about the analysis and the actions taken regarding assessing and controlling the project, increasing the likelihood of achieving success significantly (Ganpat Virle & Mhaske, 2013). Prof. B. Prakash Rao and Jacob Cherian have researched “EARNED VALUE ANALYSIS ON AN ONGOING RESIDENTIAL BUILDING PROJECT IN BANGALORE, INDIA”. This paper discusses the significance of various parameters of earned value analysis. By utilizing MSP for project planning, scheduling, and budgeting, the authors tracked project performance. Ultimately, the study predicts the potential delays in project completion and estimates the additional profit or loss that the contractor may experience compared to the original plan (Prakash Rao & Cherian, 2015). According to “A Guide to Project Management Body of Knowledge” (PMBOK), Earned value analysis is a method that evaluates the performance of a project by comparing the planned schedule baseline and cost baseline with the actual performance. It combines the scope, cost, and schedule baselines to create a performance measurement baseline (Project Management Institute & Project Management Institute, n.d.).

3 Research Methodology

Radhika Gupta emphasized the importance of Earned Value Management System (EVMS) and demonstrated its application by creating a project schedule to calculate the percentage of work completed within a set timeframe. (Gupta, 2014). Shyama Salikuma and Ms. Minu Anna Johny used software to collect and input data into MSP for project tracking in their research work (Salikuma et al., n.d.). Sachin Nalawade, Omkar Ghode, and Piyush Vaidya conducted their study using Primavera P6 software, where they established a project, assigned resources, developed a Work Breakdown Structure (WBS), and ultimately created a project schedule to predict project outcomes (Nalawade et al., n.d.). EunHong Kim, William G. Wells Jr., and Michael R. Duffey conducted survey-based research using the Project Management Institute (PMI) and performed case studies in six different organizations. (Kim et al., 2003).

To conduct our case study on the Earned Value Analysis of a bridge under construction, we initially collected all the required information from a renowned local government organization. Subsequently, we employed EVM techniques and formulas to examine those data and obtain the outcome manually. Drawing upon the result, we formulated conclusions and provided recommendations for future endeavors. The whole process is portrayed in the flow chart below:



Figure 1: Research Methodology using EVM.

4 Limitations of the EVM Method

Although the EVM technique is a very beneficial tool for evaluating project performance, it has some obstacles:

1. Firstly, it is true that EVM can track project progress and determine if it is on schedule, but its schedule indicators become less accurate as the project advances (Miguel et al., 2019).
2. EVM (Earned Value Method) does not account for the influence of project quality on the schedule as it lacks quality-related metrics, making it unable to provide an objective assessment of project quality (Aliverdi et al., 2013).

3. Earned Value Management (EVM) is often considered unsuitable for Agile and discovery-driven software development projects, such as research-based endeavors, due to their dynamic nature and the challenge of quantifying project plans in advance (*Earned Value Management - Wikipedia*, n.d.).

These limitations can impede the optimal management of construction projects. However, it is undeniable that EVM has significantly accelerated and streamlined project control compared to previous methods.

5 Barriers & Suggestions to EVM Implementation

Earned Value Management is considered a reliable tool for measuring the health of a project, that is, the cost and schedule performance of a project. To effectively utilize this method, an accurate and periodic gathering of information on actual expenditure and scope completion is essential for comparison with estimated baseline figures (Hazini et al., 2006). EVM's awareness and adoption are high, but effective use is limited in Asian projects, including Bangladesh. Obstacles hinder precise EVM implementation. A survey of 2500 Project Management Institute and Performance Management Association members explored barriers. Those EVM barriers are (Zulkefli et al., 2018b):

- EVM may not be compatible with the organization's needs.
- There is a lack of knowledge, expertise, and experience in using EVM
- There is a lack of computer and software infrastructure needed for EVM implementation.
- There is also a tendency to ignore the project risk analysis (Hazini et al., 2006).

The most critical and top-level concerns revolve around the "lack of knowledge, expertise, and experience in using EVM" and the "excessive burden of regulations and obligations to acquire and apply." Issues categorized as minimal or insignificant due to widespread EVM methodology use in projects (Zulkefli et al., 2018b)

Earned Value Management provides detailed project insights, empowering managers to assess and enhance project effectiveness (Earned Value Management Guide | Sprintzeal, n.d.). Project management benefits from this approach as it identifies underperformance, ensures timely actions, and incorporates factors like time value and cash flows, but these complexities are most relevant for exceptionally long projects, periods of high inflation, or specific economic conditions (Anbari, 2003). Earned Value Management's accuracy, especially in short-term averages (1-3 days), highlights project progress precisely, crucial during cost-intensive mid-stages. Inclusive monitoring requires cost and schedule forecast incorporation. Subjective factors influence estimates, aiding corrective actions.

Differences in the perception and adoption of Earned Value Management (EVM) are attributed to factors such as industry characteristics and cultural influences. Asian organizations, often characterized by a conservative mindset, require engineering managers to proactively introduce and implement EVM to overcome barriers to its acceptance. Because Asians are generally less inclined to adopt a new tool or aid unless it is initiated by management (Zhan et al., 2019). At present, very few companies utilize Earned Value Management to enhance their projects. However, shortly, the cost of EVM will rise further due to the increasing demand for swift project completion (*Earned Value Management Guide / Sprintzeal*, n.d.). As a result, it is very important to raise awareness about EVM among the people and enable them to implement it successfully.

6 Case Study

To conduct our case study, we opted for an ongoing bridge construction project that was overseen by a local government organization. For our EVM analysis on this project, we required four specific pieces of information initially. They are Budget at Completion (BAC), Planned Value (PV), Earned Value (EV), and Actual Cost (AC). Budget at Completion (BAC) refers to the budget of each task set at the very early stage of the project planning phase. The planned value (PV) represents the approved budget allocated for the scheduled tasks. PV, is, also known as the Budget Cost of Work Scheduled (BCWS) (*Earned Value Management Systems (EVMS)*, n.d.). Earned value (EV) is a metric that quantifies the amount of work accomplished based on the budget allocated for that specific work. On the other hand, AC is the realized cost. It refers to the actual expenses accumulated during a given timeframe for the completion of a particular activity. (Project Management Institute & Project Management Institute, n.d.).

Next comes variance analysis. PMI's PMBOK® Guide there are two types of variances: schedule variance and cost variance. The Schedule Variance represents the difference in monetary value between completed or unfinished work in comparison to the planned schedule. The formula to calculate schedule variance is $SV = EV - PV$. If the variance is zero, it means that the project is on schedule. If a negative variance is determined, it indicates that the project is behind schedule, and if the variance is positive, it means the project is ahead of schedule. Similarly, the cost variance can be described as the disparity between the earned value and the actual costs incurred $CV = EV - AC$. When the variance equals zero, it indicates that the project is within budget. If the variance is negative, it signifies that the project is exceeding the budget, whereas a positive variance indicates that the project is under budget (*Earned Value Management Systems (EVMS)*, n.d.)

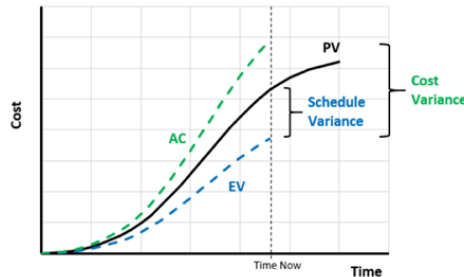


Figure 2: Earned Value Management Graph.

The earned value graph is a way of displaying earned value management metrics over time. Typically, the chart has lines that represent budget (planned project cost), actual cost, and earned value, which is a measure of how much progress has been made. Together, these data points create a chart that provides useful management information about project performance. The earned value graph you see most often is the S-curve that shows all the different data points. It gives you a visual representation of variance and the difference between planned value, actual cost, and earned value. It has three lines, often in different colors to make them easier to identify.

Likewise, other parameters, SPI, CPI, EAC, ETC, VAC, and TCPI are also important. SPI and CPI are the same as the SV and CV respectively but it is a relative measure rather than an absolute one. We calculate them using the following equations:

$$SPI = \frac{EV}{PV}$$

$$CPI = \frac{EV}{AC}$$

Other formulas are: $EAC = AC + (BAC - EV)$

$$ETC = \frac{BAC - EV}{CPI}$$

$$VAC = BAC - EAC$$

$$TCPI = \frac{BAC - EV}{BAC - AC}$$

We collected all the necessary data regarding the four inputs of our bridge construction project for Earned Value Analysis. From the data, we see:

$$BAC = 44,530,104.09 \text{ TK}$$

$$PV = 44,530,104.09 \text{ TK}$$

$$EV = 40,967,695.76 \text{ TK (92\% of BAC)}$$

$$AC = 36,082,743.34 \text{ TK (81.03\% of BAC)}$$

The construction started on 21.07.2021 and is scheduled to complete within 30.09.2021. But the construction didn't finish at that time, so the construction procedure again started on 01.10.2021 and was scheduled to complete within 20.05.2022. However, the construction got delayed again for some unexpected reason and from the 21.05.2022 date, the scheduled time got extended to 22.01.2023.



Figure 3: Ongoing Work of the Project.

The followings are the reasons for the bridge construction project's delay:

- The occurrence of unexpected events such as storms, floods, earthquakes, and bad weather.
- Global Pandemic caused by COVID-19.
- Improper implementation techniques.

Now, here is the EVM analysis of the project:

Determining Schedule Status:

$$SV = EV - PV = - 3,562,408.33 \text{ TK}$$

$$SPI = \frac{EV}{PV} = 0.9$$

We know that when SV is negative, it indicates that the task is falling behind schedule; similarly, when SPI is below 1, it signifies that the task is behind schedule. Here, SV is negative and SPI is less than 1. So, the project is behind schedule. It means the construction project needs extra time for completion.

Determining Cost Status:

$$CV = EV - AC = 4,884,952.42 \text{ TK}$$

$$CPI = \frac{EV}{AC} = 1.13$$

It is known that if the CV is positive, the task is under budget. Also, for CPI, if the CPI is greater than 1, the task is under budget. So, from both CV and CPI, we see that the cost is under budget. It means we don't need extra financial help to complete the project.

Project Forecasting:

$$ETC = \frac{BAC - EV}{CPI} = 3,152,573.74 \text{ TK}$$

$$EAC = AC + (BAC - EV) = 39,645,151.67 \text{ TK}$$

$$VAC = BAC - EAC = 4,884,952.42 \text{ TK}$$

$$TCPI = \frac{BAC - EV}{BAC - AC} = 0.42$$

As we know, if TCPI is less than 1, it means the project has more funds and less work. And if the TCPI is greater than 1, the project has less funding and more work. Here, the TCPI value of 0.42 shows that this road construction project has more funds and less work. So, finally, we can leave a comment on our analysis that the chosen project is Behind Schedule, Under Budget, but has adequate funds to complete the work.

7 Conclusion

This research examined the existing stage of development, obstacles encountered, and factors contributing to the effectiveness of EVM implementation. The study also contains a case study of the analysis of an under-construction bridge. When SV is negative, it means the project is behind schedule. The study gives the values for SV = - 3,562,408.33. Similarly, when CV is positive, it designates the project to be under budget, and from the case study, CV was found to be 4,884,952.42. Again, the forecasting index TCPI came to 0.42, which is greater than 1 indicating that the project has sufficient funds. So, the schedule status determination, the cost status determination, and project forecasting give us the same feedback, which is the project is behind schedule, under budget and the fund is enough for project completion but they need extra time to complete the project. Efficient project monitoring

is crucial for construction companies and contractors to meet targets and prevent deviations. Earned Value Management (EVM) integration of cost and time offers benefits by prioritizing project focus and enhancing overall management. Managing a project involves multiple aspects like cost, schedule, quality, and scope, requiring consideration of their interrelationships. This text focuses on integrating cost, schedule, quality, and scope within EVM for improved project management. Despite the current limited level of maturity in EVM, the ongoing endeavor is promising. The enthusiasm of top management is undoubtedly crucial. To promote the adoption of EVM, organizations need to establish an earned value management system (EVMS) that encompasses the necessary processes, tools, and templates associated with this approach. However, future studies should aim to incorporate additional factors into this system, expanding its scope and enhancing its methodology. Simplifying EVM calculations, utilizing graphical tools, developing and ameliorating soft aids, and introducing risk analysis may accelerate the course of understanding and successful implementation of EVM. In this way, the theory and practice of project-earned value management can be further developed and enriched.

References

- Aliverdi, R., Moslemi Naeni, L., & Salehipour, A. (2013). Monitoring project duration and cost in a construction project by applying statistical quality control charts. *International Journal of Project Management*, 31(3), 411–423. <https://doi.org/10.1016/j.ijproman.2012.08.005>
- Anbari, F. T. (2003). 12 • *Project Management Journal*.
- Ballesteros-Pérez, P., & Elamrousy, K. M. (2018). On the limitations of the earned value management technique to anticipate project delays. *Proceedings of International Structural Engineering and Construction*, 5(1). <https://doi.org/10.14455/ISEC.res.2018.43>
- Earned value management* - Wikipedia. (n.d.). Retrieved June 4, 2023, from https://en.wikipedia.org/wiki/Earned_value_management
- Earned Value Management Guide* | Sprintzeal. (n.d.). Retrieved June 7, 2023, from https://www.sprintzeal.com/blog/earned-value-management#purpose_of_earn_value_management_evm
- Earned value management systems (EVMS)*. (n.d.). Retrieved June 7, 2023, from <https://www.pmi.org/learning/library/earned-value-management-systems-analysis-8026>
- Ganpat Virle, R., & Mhaske, S. Y. (2013). MONITORING OF CONSTRUCTION PROJECTS USING EVM AND ESM TOOLS. In *Rajesh Ganpat Virle and Sumedh Y Mhaske* (Vol. 2, Issue 4). www.ijscer.com
- Gupta, R. (2014). Earned Value Management System. *International Journal of Emerging Engineering Research and Technology*, 2(4), 160–165. www.ijeert.org
- Hazini, K., Hazini, K., Sharif, B., & Mortaheb, M. M. (2006). *Barriers Facing Proper Implementation of Earned Value Management (EVM) Projects Profitability Improvement View project Resource Management in Multi-Projects and Programs View project Barriers Facing Proper Implementation of EVM*. <https://www.researchgate.net/publication/282016078>
- Kim, E. H., Wells, W. G., & Duffey, M. R. (2003). A model for effective implementation of Earned Value Management methodology. *International Journal of Project Management*, 21(5), 375–382. [https://doi.org/10.1016/S0263-7863\(02\)00049-2](https://doi.org/10.1016/S0263-7863(02)00049-2)
- M. Sharun, P. S. K. (2018). Study and Analysis on Earned Value Management System in Construction Industry. *International Journal of Civil Engineering and Technology*, 9(3), 332–338. <http://iaeme.com/Home/issue/IJCIET?Volume=9&Issue=3http://iaeme.com>
- Miguel, A., Madria, W., & Polancos, R. (2019). Project Management Model: Integrating Earned Schedule, Quality, and Risk in Earned Value Management. *2019 IEEE 6th International Conference on Industrial Engineering and Applications, ICIEA 2019*, 622–628. <https://doi.org/10.1109/IEA.2019.8714979>
- Nalawade, S., Ghode, O., & Vaidya, P. (n.d.). *Earn value analysis of construction project using primavera p6*. <http://cikitusi.com/>
- Prakash Rao, B., & Cherian, J. (2015). EARNED VALUE ANALYSIS ON AN ONGOING RESIDENTIAL BUILDING PROJECT IN BANGALORE, INDIA. *International Research Journal of Engineering and Technology*. www.irjet.net
- Project Management Institute, & Project Management Institute. (n.d.). *A guide to the project management body of knowledge (PMBOK guide)*.
- Salikuma, S., Minu, M., & Johny, A. (n.d.). *Application of Earned Value Analysis in Analysing Project Performance*. www.ijert.org
- Zhan, Z., Wang, C., Yap, J. B. H., Samsudin, S., & Abdul-Rahman, H. (2019). Earned value analysis, implementation barriers, and maturity level in oil & gas production. *South African Journal of Industrial Engineering*, 30(4), 44–59. <https://doi.org/10.7166/30-4-2030>
- Zulkefli, N. S., Waris*, M., Firdaus, K., Khan, A., & Adeleke, A. Q. (2018a). *Exploring The Perception Of Earned Value Analysis For The Malaysian Construction Industry*. 337–346. <https://doi.org/10.15405/epsbs.2018.07.02.36>
- Zulkefli, N. S., Waris*, M., Firdaus, K., Khan, A., & Adeleke, A. Q. (2018b). *Exploring The Perception Of Earned Value Analysis For The Malaysian Construction Industry*. 337–346. <https://doi.org/10.15405/epsbs.2018.07.02.36>