

Environmental Sustainability of Project Schedule Management by Earned Value Analysis

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Abstract. The innovative aspect of this study is the explicit incorporation of environmental sustainability metrics into conventional Earned Value Analysis (EVA) to facilitate schedule-driven decision-making in construction projects. The proposed approach differs from traditional EVA by connecting Schedule Performance Index (SPI) trends with environmental impact indicators. This helps project teams find out what is causing delays early on, use fewer resources, and cut down on environmental losses. The study further illustrates this integration through actual Indian construction case studies, demonstrating how EVA-based monitoring facilitated proactive responses to Cyclone Tauktae, timely insurance claims, and the planning of sustainable recovery actions—an aspect previously unexamined in EVA-centric research. Keywords: EVA, civil conflict, project management, project control.

1 Introduction

Modern project management increasingly requires incorporation of environmental sustainability in conjunction with cost and schedule management. Earned Value Analysis gives a structured way to include sustainability issues in schedule management so that projects can be done in an environmentally friendly way. In the fast-changing world of construction, it is still important for businesses to finish projects on time, within budget, and according to the plan. It's always hard to build things because there are a lot of tasks that need to be done on time and in the right order. It is especially hard to keep track of project deadlines because delays can lead to big financial losses, contract disputes, and damage to reputation [1]. The Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT) are two well-known ways to organise project tasks and figure out which ones are the most important. But these methods don't always give a complete picture of cost and schedule performance, which can make it hard to make decisions when schedules change [2].

Earned Value Management (EVM) is a well-known project management tool that combines scope, time, and cost to give a full picture of how a project is going [3-4]. Earned Value Analysis (EVA) is a key part of EVM. It shows how well a project is going in terms of money, which lets project managers find and fix problems early on. The Schedule Performance Index (SPI) and Schedule Variance (SV) are two important EVA metrics that help project teams figure out how well their schedules are working compared to their budgets and plans [5].

Even though EVA is becoming more common in the construction industry, projects still go over schedule. This means that there are still issues with how it is used and understood. EVA is a powerful tool, but it only works well, combines cost and schedule data [6-8]. Misapplication or misunderstanding of these metrics can undermine their potential, leading to ineffective project control [9].

While effective schedule control continues to be a significant challenge in construction project management, there is a necessity to systematically assess tools that facilitate prompt decision-making." In this context, the goal of this study is to see how well Earned Value Analysis (EVA) works for schedule management in the construction industry. The study evaluates EVA's predictive accuracy regarding schedule deviations, identifies factors affecting its performance, and analyses its limitations across projects of diverse scales and complexities. The study will also suggest the best ways to include EVA into the larger project management framework to make schedule control better. This analysis will focus primarily on medium-scale construction projects and consider best practices for EVA's practical application, recognizing potential limitations such as labour productivity fluctuations and baseline scheduling updates due to non-standard work conditions during the Covid-19 era. The research acknowledges that findings may be specific to certain project types and scales, potentially impacting their general applicability.

2 Methodology

This study analyses a medium-scale construction project in India using a mixed-methods approach to address schedule disruptions caused by COVID-19, a cyclone, and heavy monsoon rainfall. The project, involving RCC retaining wall construction at Jaigarh Port, was selected due to the availability of reliable primary data from planning and monitoring records

2.1 Selection of a Construction Project for Case Study

This research is focused on an empirical analysis of a medium-scale construction project in India. A mixed-methods approach, incorporating both quantitative and qualitative analyses, was employed to address the various complexities faced during project execution. These challenges included interruptions from the COVID-19 pandemic, a cyclone, and heavy monsoon rains. The project's location and natural features had a big impact on these problems. Choosing a case study project that was affected by COVID-19 and a cyclone gives us a strong real-world setting to thoroughly test how well Earned Value Analysis (EVA) works for managing schedules when things are uncertain. The various factors which affected the construction schedule included of absolutely measurable, partially measurable and non-measurable causes such as loss of productivity due to Covid-19 pandemic, devastation caused by Cyclone "Tauktae", excessively heavy & prolonged rainfall during monsoon season in the Konkan region of Maharashtra, delayed payments by the client, delayed supply of Free Issued Materials & deliverables by the client, loss of productivity due to equipment breakdown, loss of productivity due to non-availability of clear work-front at construction site etc.

This work had an original scope of constructing 380 RMT of Buttress type RCC Retaining wall including pile foundations on both the parallel sides of a Cover-shed facility designed for the storage of coal stack at Jaigarh Port, Ratnagiri, Maharashtra. The above case has been chosen for studying the various aspects of controlling construction schedules by using Earned value analysis (EVA) mainly due to the author viz. Yatish Priyadarshi being directly involved in planning and monitoring of the selected project during its entire life cycle [20-24]. Most of the historical data utilized for studying the schedule performance are primary in nature. The results and observations derived from the empirical study are expected to be highly reliable as most of the data are collected from primary sources such as Daily/Weekly/Monthly Progress reports (DPR/WPR/MPR), Monthly Cost Statement, Approved Baseline Schedule and Approved Budget Plan and BOQ & other contractual data.

2.2 Data Collection

Collection of prerequisite data as required to perform EVA on the selected project, begins with fetching the baseline programme accepted by the client in the Kick-off meeting. The approved baseline programme encompassing the original scope & agreed schedule of the project. Further, according to the baseline programme, a baseline time schedule was created by using Primavera P6 software to perform a comparative analysis. This was a schedule based on the critical path method (CPM), and no costs or resources were added to it to make it easier to update the status. The following steps were followed for creating the CPM based baseline schedule:

- Creating the new project under relevant EPS
- Creating the WBS under newly created project
- Creating all the activities with names and estimated time duration as per the productivity consideration of agreed baseline programmes.
- Creating the customized calendar and assigning to the various activities.
- Making sure all the activities have Task dependent activity type with duration type as Fixed duration and units. This is to avoid complications during status update.
- Maintaining the correct relationships between predecessors and successors as per logical considerations.
- Running the schedule with a data date same as the project start date.

- Applying the required sorting/grouping option with desired views/layouts for table as well as Gantt chart.
- Printing and saving the report for future record.

The next input data as required for EVM analysis is the actual progress report at regular intervals. This is to make sure that actual performance based EVM metrics such BCWP can be calculated on the required data date, which is the end of each month in this case study. Hence, the Monthly Progress Reports (MPR), which are based on the regular reporting of actual work performed in the project, are referred to derive respective BCWP with status date as the end of the month. Further, the actual monthly progress was tabulated against the planned monthly progress for each of the activities.

The steps followed for updating the schedule manually in the Primavera P6 are as follows:

- Maintaining the copy of the original schedule as the project baseline.
- Assigning the maintained project baseline to the current schedule to be updated.
- Making sure that % complete type is “physical” for all the activities in our case study.
- Going to the status tab in the details window for each activity and checking for “started” if the activity has already started on or before the data date. Putting the actual date of start and updating the Physical % completion till the data date. If the activity has completed on or before the data date, “finished” to be checked.
- It will look at how accurate EVA is at predicting schedule changes, find out what affects its performance, and look at the limits of EVA across projects of different sizes and levels of difficulty.
- Saving, printing and reporting of the updated schedule for both the data dates.

The third & last stage of data collection for the case study is fetching of the monthly cost statement towards all the expenditures and accrued cost against the actual work performed in the project. The accounting department usually finalises and keeps track of the real cost. The contracting company's ERP system (SAP) had a module that could show the actual cost report for this project. All the monthly cost report applicable for the project was exported which, in turn, gave the value of ACWP (Actual cost of work performed) for all the months falling in the project life cycle.

2.3 Data Analysis by Earned Value Method (EVA)

The planned revenue for each month is calculated by multiplying the monthly planned quantity of each activity by the respective unit rate specified in the BOQ of the agreed contract document.

1. The earned revenue for each month is calculated by multiplying the actual performed quantity of each activity by the respective unit rate specified in the BOQ of the agreed contract document.
2. Planned Value (PV) or BCWS (Budgeted cost of work scheduled) is calculated by discounting the planned revenue by 10% profit margin which was considered in the original budget estimate prepared by the contracting firm. When figuring out Planned Value (PV/BCWS) and Earned Value (EV/BCWP), the 10% profit margin was always taken off of all project activities.

Similarly, the Earned Value (EV) or BCWP (Budgeted cost of work performed) is calculated by discounting the earned revenue by profit margin (10% - as considered in the original budget estimate of the contractor).

- Actual cost (AC) or ACWP (Actual cost of work performed) is made readily available by the account department or ERP system (SAP) with required authorization.
- After tabulating the BCWS, BCWP and ACWP for each month, the cumulative values of these metrics are tabulated for each month end.
- Schedule Variance (SV) is calculated by deducting BCWS from BCWP.
- Schedule Performance Index (SPI) is calculated by dividing BCWP by BCWS.
- SPI% is calculated by multiplying SPI value with 100.

3 Results and Discussions

The summary of comparison between planned values (BCWS) and Earned Values (BCWP) for monthly standalone values as well as the cumulative values on the data date of each month are illustrated in figures.

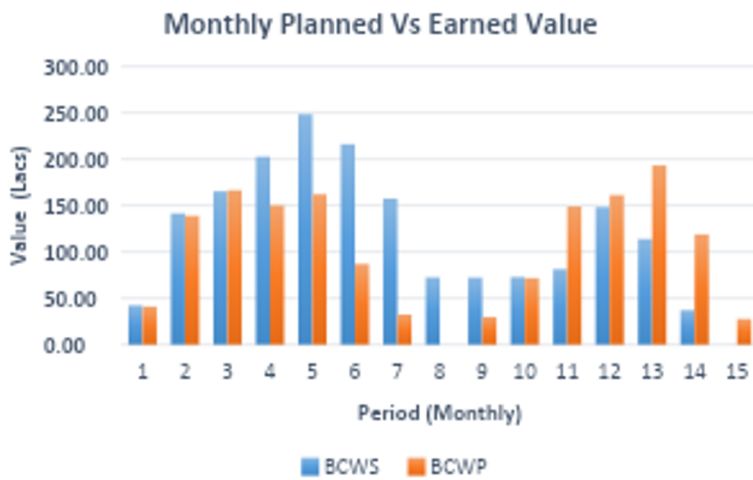


Fig. 1. BCWS Vs BCWP (Standalone values).

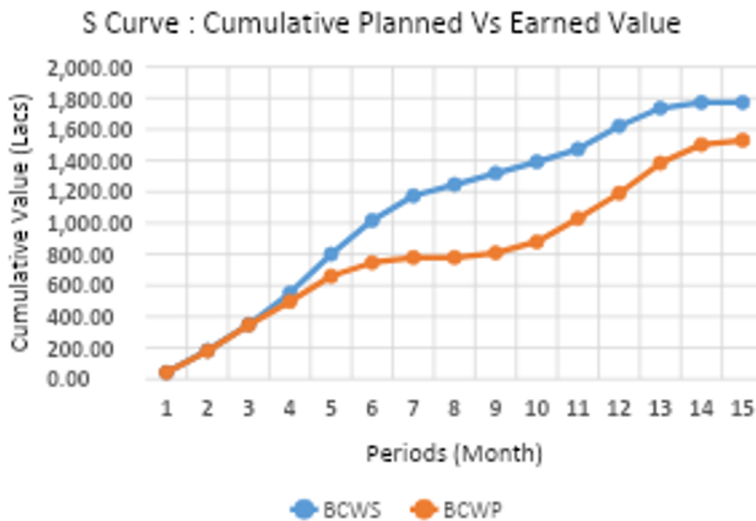


Fig. 2. BCWS Vs BCWP (Cumulative values).

During the continuous monitoring of the project, the following observations were made in view of the above results of EVA and accordingly the control measures were taken as follows:

- A noticeable gap in the progress started showing up during the month of May-21 as compared to the planned schedule.
 - The significant drop in the actual progress starting from the month of May-21 was due to the aftereffects of devastation caused by Tauktae Cyclone which had hit the project on 15th May-21.
 - For the two months i.e., June-21 & July-21 there was no progress made due to the collapse of the existing coal stack caused by the cyclone. The coal stack which was lying in the vicinity of the planned work-front for piling works, completely obstructed the site area resulting in complete standstill of all the resources and loss of productivity thereby.

To keep costs and schedules on track, the contractor filed the insurance claim to lessen the damage caused by the cyclone. As the ability of conventional EVA method as a time forecasting tool has not been proven significantly yet, could not rely on its predictive feature to forecast the Estimated Completion Date of the project. The client, on the other hand, agreed to the EOT by cutting the project's scope by about 14%. The contractor agreed to the EOT after analysing Cost to Benefits ratio after the client assured of reimbursement of the insurance claim.

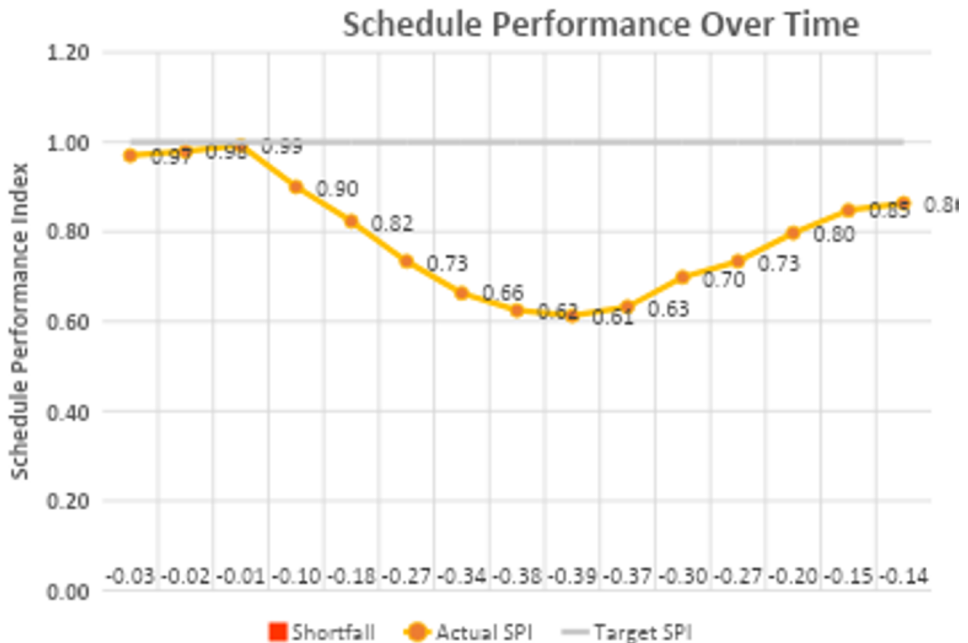


Fig.3. Schedule performance of the project.

Although the revised scope of the project got fully completed by the end of February-2022, the above chart is still showing a schedule variance (SV) of (-) 242.27 lacs, which does not add up to the reality. This is due to the comparison being done with the planned values of the original baseline schedule rather than an updated baseline as per the revised agreement

with client. The project controller did not have a system in place to conduct EVA based on the revised baseline as per the revised scope and completion date. This was due to Covid-19 related restrictions imposed on the construction site. Due to the limitations of the conventional EVA to perform as forecasting tool in the last third phase of the delayed project, the Earned Schedule (ES) method was applied to forecast the estimated completion date of the project and thereby controlling the schedule by addressing the various issues and challenges affecting productivity of the scheduled works.

4 Conclusion

The case study demonstrates that Earned Value Analysis (EVA) is effective for overseeing construction project schedules, even amid unforeseen circumstances such as COVID-19 and the Tauktae Cyclone. Metrics like SPI and SV helped find delays, but traditional EVA wasn't very good at predicting when the project would be done in later stages. The Earned Schedule (ES) method made it easier to predict how long things would take, and the study shows that it is important to update the project baseline after changes to the scope or schedule in order to get an accurate picture of how well the project is going. The Critical Path Method (CPM) and Earned Value Analysis, to make schedule forecasting and control better. This is especially true for projects that are affected by changes in scope or outside factors, which helps with environmentally friendly project schedule management.

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