

Monitoring System For Project Cost Control In Construction Industry

Pramod M^{*}, K. Phaniraj^{**}, V. Srinivasan^{***}

^{*}Post graduate student: Construction Engineering and Management, Manipal Institute of Technology, Manipal, Karnataka-567104

^{**}Associate Professor: Civil engineering department, Manipal institute of technology, Manipal, Karnataka-567104

^{***}Visiting Professor: Civil engineering department, Gopalan College of Engineering, Bangalore, Karnataka

Abstract— Effective cost monitoring and controlling has gained much attention in the construction industry due to excessive cost escalation, project delays and underperformance. The absence of a well-established effective system for monitoring and controlling project cost is the main reason for cost escalation and delays in the project. This necessitates implementation of a monitoring system in a construction project and to adopt the most effective one out of all the known systems. This study considers Earned Value analysis and Earned Schedule concept as the two monitoring systems which can be used to monitor a construction project.

Keywords—monitoring systems; Earned Value; Earned Schedule; (key words)

I. INTRODUCTION

In a project, plans are usually drawn to ensure that work is carried out to the desired quality; in the allowed time; and according to budget. However, in a construction project, divergences are bound to happen and are common. Such divergences are nevertheless expected because of the nature of construction work and the uncertainties associated with it. In the case where the differences between the plan and the actual work performance are large, control action is normally required to try to bring the actual performance on course with the desired state of the plan.

Progress on the project is required to be monitored and compared as the work proceeds in order to be able to identify and measure these differences. There are a number of systems that are traditionally used in construction to monitor and report on the progress of the work. But there is no certainty as to which of these monitoring system is the best to be implied for a construction project. The effectiveness of the monitoring system in showing deviations of project performances varies considerably from one system to another.

Monitoring systems that we consider in this study are:

- Earned value analysis.
- Earned schedule.

II. LITERATURE REVIEW

A. Earned Value Analysis

Earned Value analysis is a method of measuring performance. Earned Value is a program management technique that uses “work in progress” to indicate what will happen to work in the future (Bhosekar & Vyas, 2012). Earned Value is an enhancement over conventional accounting methods. Conventional approaches focus on planned expenditure and actual costs. Whereas Earned Value goes one step further and examines actual completion. This gives managers better understanding of probable risk areas. Hence with stronger picture, managers can create risk mitigation plans based on actual cost, schedule and actual development of the work

Earned value formula and interpretations

NAME	FORMULA	INTERPRETATION
Cost Variance (CV)	$EV - AC$	Negative is over budget Positive is under budget
Scheduled Variance (SV)	$EV - PV$	Negative is behind schedule Positive is ahead of schedule
Cost Performance Index (CPI)	EV / AC	I am [only] getting ___ paisa out of every rupee
Schedule Performance Index (SPI)	EV / PV	I am [only] progressing at ___ % of the rate originally planned

Estimate At Completion (EAC)	BAC / CPI AC + ETC / CPI AC + BAC - EV AC + (BAC - EV) / CPI	As of now how much do we expect the total project to cost
Estimate To Completion (ETC)	EAC - AC	How much more will the project cost?
Time estimate at completion (EAC)t	(BAC / SPI) / (BAC / months)	How much time will the project need?
Variance At Completion (VAC)	BAC - EAC	How much over budget will we be at the end of the project?

B. Earned Schedule Analysis

For more than 30 years earned value management has been providing valuable insight into project cost and schedule status during project execution. A study of more than 700 completed major programs over three decades has shown that earned value provides insight into the project health when as little as 15 percent of the work is complete. However, while traditional earned value management did an excellent job of estimating the final cost of the project, it failed to do the same for estimating the finish date. Lately, new work in the application of earned value management principles has created novel approaches to obtain Schedule information from the application of earned value management, and have resulted in means to predict the project completion date (Stratton, 2007).

According to Stratton (2007), the concept of Earned Schedule corrects the fundamental weakness of the classical EVM concept and proposes the schedule performance indicators which are time and not cost-based.

Earned Schedule terms and formulae

•Earned schedule: The value of ES is equal to the cumulative time to the beginning of that increments plus a fraction of it. The fractional amount is equal to the portion of EV extending into the incomplete time increment divided by the total PV planned for that same time period.

$$\text{Earned Schedule: } ES = C + I$$

Where, C = number of time increments where $EV \geq PV$

$$I = (EV - PVC) / (PVC+1 - PVC)$$

•Schedule variance: it is the time difference between the actual time elapsed or taken to complete the work and the earned schedule. In other words the schedule variance gives the real delay for a given point of time.

$$\text{Schedule variance: } SV(t) = ES - AT$$

•Schedule performance index: it gives an idea about how much work is completed with respect to the work planned in terms of time.

$$\text{Schedule performance index: } SPI(t) = ES/AT$$

•Time Estimate At Completion: as the name suggests it gives the estimated time of the project at completion

$$EAC t = AT + (PD - ES) / SPI t$$

III. RESEARCH METHODOLOGY

From the literature review it is evident that the most practiced monitoring system is the Earned Value Management (EVM) analysis. It is also known that EVM indicators related to schedule which are schedule variance and schedule performance index are flawed and misleading towards the end of the project.

And by the introduction of Earned Schedule concept and the studies undergone, it is definitely one of the better practice to monitor a project. Hence in this project we will be considering Earned Value Analysis and Earned Schedule Analysis for research purpose.

A. Research process

- Data collection from schedule and monthly reports
- Using Primavera to find out Earned Value terms.
- Using spreadsheet to find out Earned schedule terms.
- Compare the results of Earned Value and Earned Schedule analysis
- Do the above process for an ongoing project and completed project.

B. Research data

The required data for the study is of a residential apartment situated in Bangalore. The apartment has four blocks which has similar plan and each block consists of 13 floors. One set of data is from Block 1 which has already been completed with total project duration of 19 months and the next set of data is from block 4 which is in progress at present.

C. Research Method

The data collected is fed into primavera, through scheduling and progress tracking the Planned Value, Earned Value and Actual Cost for each month are obtained. The illustration of this can be found in the annexure.

Earned Value and Earned Schedule analysis is carried out in the spreadsheet from results obtained from Primavera and results are tabulated and compared. The same method is done for the second set of data.

IV. DATA ANALYSIS AND RESULTS

A. Ongoing project

Budget At Completion = INR 9,45,95,950.00

Planned Project Duration = 27 months

month	cumulative planned value	cumulative earned value	cumulative act cost
may	0.00	0.00	
june	79,650.00	73,650.00	73,65
july	24,25,238.27	22,50,325.68	22,50,32
august	48,68,500.00	50,55,650.00	50,56,42
september	70,67,123.56	69,96,750.29	70,39,40
october	97,07,300.00	97,11,350.00	97,67,27
november	131,88,597.08	126,90,422.22	127,85,84
december	166,36,283.33	147,55,813.63	148,70,15
january	199,65,820.61	193,34,064.91	194,71,32
february	223,04,147.62	216,28,211.44	217,73,39
march	265,06,117.66	250,77,052.94	252,37,67
april	292,15,518.96	284,13,190.93	286,17,45
may	334,67,054.42	324,56,275.00	327,18,60

Table 1: CV, PV and AC values in INR

month	SCHEDULE VARIANCE(SV)	SCHEDULE PERFORMANCE INDEX(SPI)	ESTIMATE AT COMPLETION (EACt)
may	0.00	0	27.2182251
june	-6000.00	0.924670433	29.19959267
july	-174912.59	0.927878183	28.04569617
august	187150.00	1.038440998	26.32777789
september	-70373.27	0.990042162	27.21779596
october	4050.00	1.000417212	26.991719
november	-498174.86	0.96222685	27.65968514
december	-1880469.70	0.886965757	29.2815764
january	-631755.70	0.96835814	27.65593939
february	-675936.18	0.969694597	27.89598265
march	-1429064.72	0.946085476	27.95058249
april	-802328.03	0.972537608	27.74696708
may	-1010779.42	0.969797778	27.54573743

Table 2: EV parameters

month	SCHEDULE VARIANCE[SV(t)]	SCHEDULE PERFORMANCE INDEX [SPI(t)]	ESTIMATE AT COMPLETION (EACt)
may	0	0	27
june	-0.075329567	0.924670433	29.19959267
july	-0.074570884	0.962714558	28.04569617
august	0.076598425	1.025532808	26.32777789
september	-0.032007876	0.991998031	27.21779596
october	0.001533988	1.000306798	26.991719
november	-0.143100358	0.97614994	27.65968514
december	-0.545429475	0.922081504	29.2815764
january	-0.189742792	0.976282151	27.65593939
february	-0.289068286	0.967881302	27.89598265
march	-0.340093981	0.965990602	27.95058249
april	-0.296127425	0.973079325	27.74696708
may	-0.237744558	0.980187953	27.54573743

Table 3: ES parameters

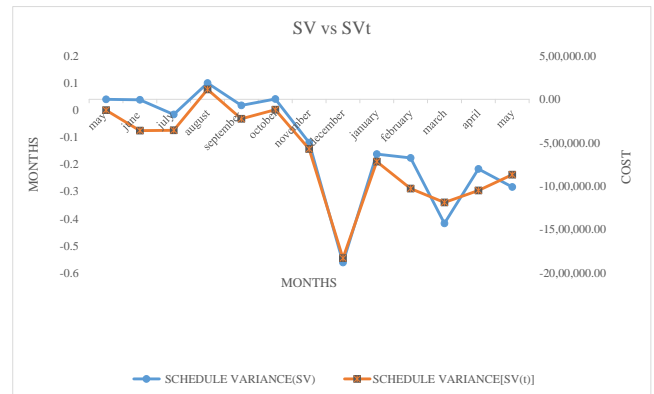


Figure 1: SV vs SVt

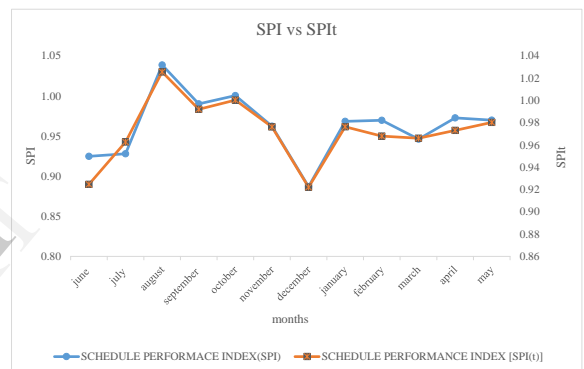


Figure 2: SPI vs SPIt

B. Completed project

Budget At Completion = INR 8,35,75,650

Project duration = 20 months

month	cumulative planned value	cumulative earned value	cumulative actual cost
october	1022871.44	936278.09	940023.2
november	2856985.74	2720058.98	2738484.5
december	5572885.76	5380615.44	5429082.47
january	9346928.65	9092712.65	9177675.09
february	13650042.97	13326315.61	13444966.12
march	19258200.16	18771926.22	18927072.14
april	25677600.16	25168628.61	25360131.23
may	32097000.16	31514929.85	31738051.71
june	38269500.16	37651532.44	37893946.63
july	44688900.16	44056335.76	44305887.65
august	51355200.16	50790958.47	51049055.86
september	57280800.16	56908767.34	57180854.93
october	63718541.30	63414691.77	63712953.61
november	69247337.72	68703173.98	69025671.24
december	73894348.42	73467909.27	73814641.95
january	77915643.97	77457207.62	77829325.05
february	80635776.51	80171750.29	80563484.48
march	82659651.04	82360301.79	82769119.09
april	83575649.99	83575649.99	83995380

Table 4: PV, EV and AC

month	SCHEDULE VARIANCE(SV)	SCHEDULE PERFORMANCE INDEX(SPI)	ESTIMATE AT COMPLETION (EAct)
october	-86593.35	0.91534288	19.07599995
november	-136926.76	0.952072998	19.12870489
december	-192270.32	0.965498966	19.17114651
january	-254216	0.972802189	19.17753628
february	-323727.36	0.976283785	19.16916601
march	-486273.94	0.974749772	19.1570309
april	-508971.55	0.980178383	19.14456687
may	-582070.31	0.981865274	19.13451768
june	-617967.72	0.983852213	19.12232888
july	-632564.4	0.985845156	19.10762325
august	-564241.69	0.989012959	19.09654967
september	-372032.82	0.993505104	19.09084126
october	-303849.53	0.99523138	19.08936375
november	-544163.74	0.992141738	19.08918726
december	-426439.15	0.994229069	19.08967073
january	-458436.35	0.994116248	19.09127919
february	-464026.22	0.994245405	19.09283756
march	-299349.25	0.996378532	19.09431156
april	0	1	19.09542098

Table 5: EV parameters

month	SCHEDULE VARIANCE[SV(t)]	SCHEDULE PERFORMANCE INDEX [SPI(t)]	ESTIMATE AT COMPLETION (EAct)
october	-0.08465712	0.91534288	20.75724891
november	-0.07465522	0.962672239	19.73672786
december	-0.070794329	0.97640189	19.45920034
january	-0.067359065	0.983160234	19.32543582
february	-0.075230946	0.984953811	19.29024467
march	-0.086708329	0.985548612	19.27860257
april	-0.079286468	0.988673362	19.21767161
may	-0.090673631	0.988665796	19.21781868
june	-0.100116277	0.988875969	19.21373417
july	-0.09853949	0.990146051	19.1890883
august	-0.084640909	0.992305372	19.1473316
september	-0.062783991	0.994768001	19.09993082
october	-0.047198159	0.996369372	19.06923328
november	-0.098423544	0.992969747	19.13452052
december	-0.091766337	0.993882244	19.11695285
january	-0.114002153	0.992874865	19.13634906
february	-0.170589563	0.98996532	19.19259152
march	-0.147908996	0.991782834	19.15741971
april	0	1	19

Table 6: ES parameters

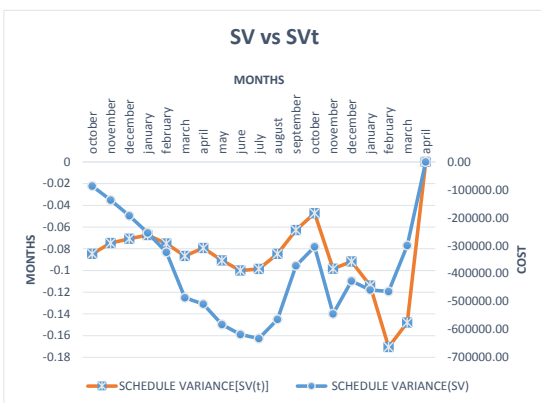


Figure 3: SV vs SVt

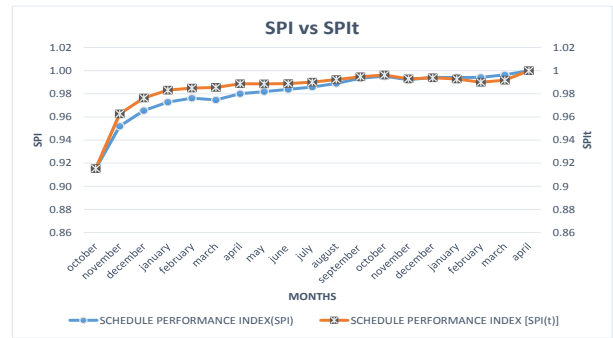


Figure 4: SPI vs SPIt

C. Results

From the results obtained from the ongoing project, the Earned value analysis suggests that the EV at the end of 12 months is INR 3,24,56,275 for a PV of INR 3,34,67,054.42 which has an AC of INR 3,27,18,600 which implies that the project is behind schedule by INR 10.11 lakhs (SV). It is sometimes confusing to say that a project is behind schedule in terms of money. And hence we have used Earned Schedule analysis to find the actual delay of the project. According to ES analysis the ES value at the end of 12 months is 11.7623 months. Which means we have accomplished only 11.7623 months of work in 12 months. It also suggests we are behind schedule by 0.2377 months (SVt). Further when we compare the schedule variances and the schedule indices of EV and ES analysis (figure 12 & figure 13) it was observed that the parameters from EV analysis follow the same trend as of the ES analysis till January, from January till May the EV parameters deviate a bit.

From the results obtained from the completed project, the Earned value analysis suggests that the EV at the end of 12 months is INR 8,35,75,649.99 for a PV of INR 8,35,75,649.99 which has an AC of INR 8,39,95,380.00 which implies that the project has been completed as the EV and PV value are the same. But the CV of the project is INR 4.2 lakhs. Further when the EV parameters SV and SPI were compare to the ES parameters SVt and SPIt, it was observed that the EV parameters follow similar trend with ES parameters throughout the project duration. But the EAct values derived from EV analysis says the project would complete in 19.1 months where as we already know that the project has been completed in 19 months

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions:

This study has helped us to find out the behaviour of Earned Value Analysis and the Earned Schedule Analysis parameters on two projects, one being completed and one in progress.

From the ongoing project it was seen that the EVA schedule parameters were flawed towards the later stages and deviated from the actuals and the ES parameters gave us appropriate data regarding the actual delay of the project.

From the completed project it was observed that both the EVA and ES parameters seemed to follow same trend, however the EACt value derived from EVA seem to be inaccurate. And once again the ES parameters gave us the actuals of the project without any problem.

Hence here are the conclusions of this study,

- Earned Value Analysis is a great monitoring system for project cost control when the required information are cost oriented.
- Earned Value Analysis parameters seem to deviate from actuals in later stages of the project.
- Earned Schedule Analysis gives us more accurate results in terms of time.

B. Recommendations:

When we want to establish a monitoring system which could help us control cost, we need to consider a system which could give us accurate results both in terms of cost and time. Since Earned Schedule Analysis uses the EVM data to find the Schedule Variances in terms of time, we still need to use the Earned Value analysis to acquire the cost details. Hence we need to use both the systems for effective monitoring of the project.

Further studies may be conducted on other projects such as early finish projects and late finish projects to see if the system is capable of finding accurate results. It would be beneficial if the Earned Schedule concept is integrated into the Earned Value Analysis so that the results acquired from the system is accurate both in terms of cost and time.

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