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APPLICATION OF EARNED VALUE ANALYSIS FOR COST MONITORING IN CONSTRUCTION PROJECTS

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ABSTRACT

In construction or any other projects periodical monitoring and identification of key indicators is necessary. These indicators represent financial and non-financial efficiency of project activities. Among these, the monitoring of financial indicators is an important function of project management. Therefore, during the construction phase, it is the prime responsibility of project managers to monitor cost and avoid any overruns to maintain the cost baseline. Cost monitoring is an ongoing process and its importance cannot be undermined during the project life cycle. It can be monitored by using traditional approach of direct reporting of actual cost against budget. However, the comparison of budget versus actual spending does not indicate the worth of the work which is completed at any given time. This approach does not portray the true cost performance of the project. Because of these limitations, this paper discusses the applications of Earned Value Analysis (EVA) for cost management of construction projects. Besides traditional approach, EVA is a three-dimensional technique that compares the budgeted value of work scheduled with the earned value of physical work completed and the actual cost of work completed. Therefore, cost management by EVA is an objective measure of actual work performed. This paper uses a case study, an example application of EVA as a cost monitoring tool. This case study reaffirms the benefits of using EVA for project cash flow analysis and forecasting.

INTRODUCTION

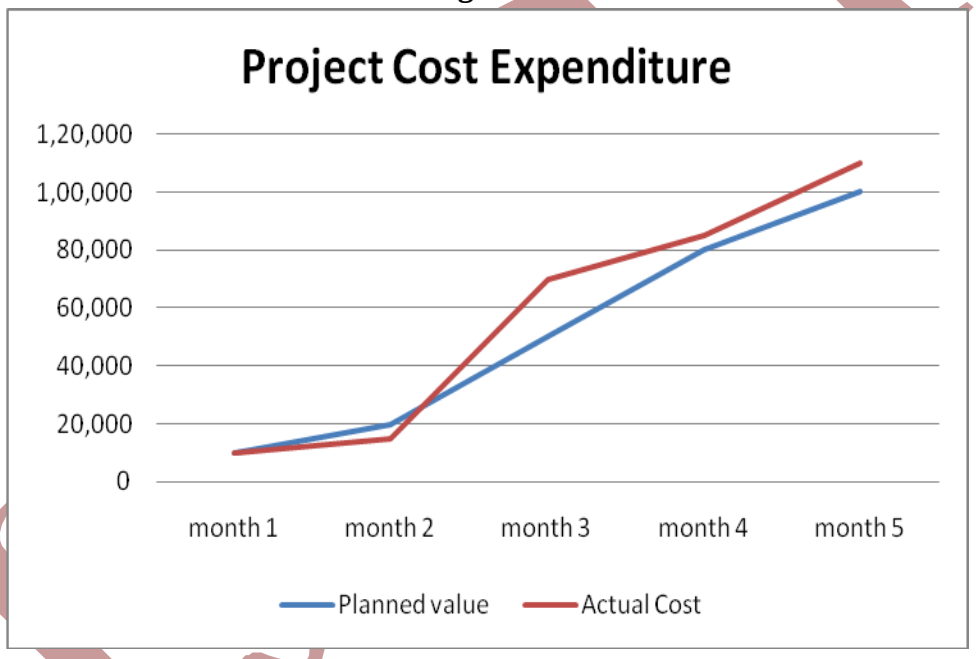
During the Initiation stage of the project, project team develops budget for the project and this budget is generally set as baseline cost for the project. Based on the duration and activity sequence the timeline program is prepared for the project. Based on budget and project program project cash flow and cost s-curves are developed. In the normal process baseline cost s-curve is compared with the actual cost curve to judge the project performance.

It has been observed that certain causes may lead to delays in construction activities. This will result in time and cost overruns in projects.

Construction projects need significant capital investment and the most of which are used up during the execution stage. All construction projects inherit a large degree of risk and may bear

the loss, if the project completion is delayed or the costs are overrun. Therefore, to secure the mutual interest of all the key stakeholders, a systematic monitoring and controlling of a project is a prerequisite. The traditional method of project cost monitoring is based on simple parameters using two data sources that is the budget (or planned) spending and the actual spending. The comparison of budget versus actual spending merely tells what was planned to be spent versus what was actually spent at any given time. Besides, it does not relate any current performance trend to forecast future performance.

Figure 1



When you will look at the above chart it shows the cost performance was below till month 2 but then got better in month 3. However there is always possibility that there are extra money spent to achieve same or even less progress. So this way of analysis may be giving wrong indications about the project progress.

Therefore this paper aims to highlight the importance of Earned Value Analysis as an effective tool that relates time and cost for monitoring project cash flows.

PROJECT COST MONITORING

Most of the project budget is consumed during the construction process. Therefore, it is the prime responsibility of the project manager to control the costs associated with the work packages. A project cost can be usually classified into direct, indirect and overhead costs. During the budgeting process, all these costs are sum up to develop a cost baseline. A cost baseline is defined as a cumulative time-phased budget that will be used to measure and monitor the current

and future project cost performance. It is graphically represented in the form of S-curve and it is an important cost monitoring tool. It allows the user to see the project cash flows over the period of time and make it possible to forecast the trends of future spending. Neale and Neale (1989) expressed that S-curve is an important tool for managing the cash flows in construction projects. It defines the amount of construction spending according to the budget allocation.

S-curve is a convenient tool for cost management. It can produce different cost scenarios that will make possible for the manager to envisage the cost trends. Fig. 2 shows an example of typical S-curve that is based on accumulative values of cost estimates.

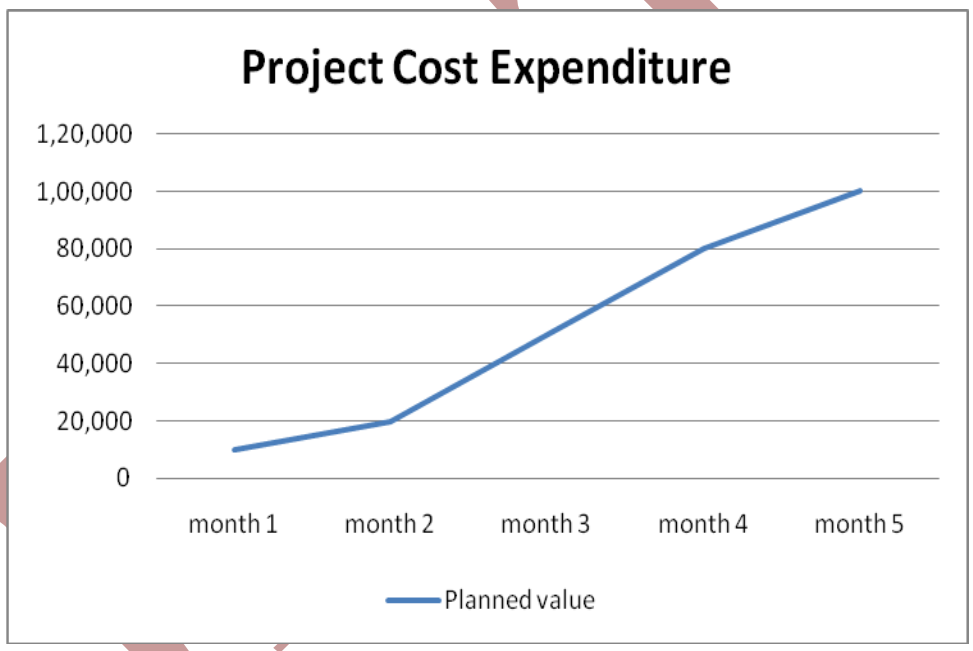
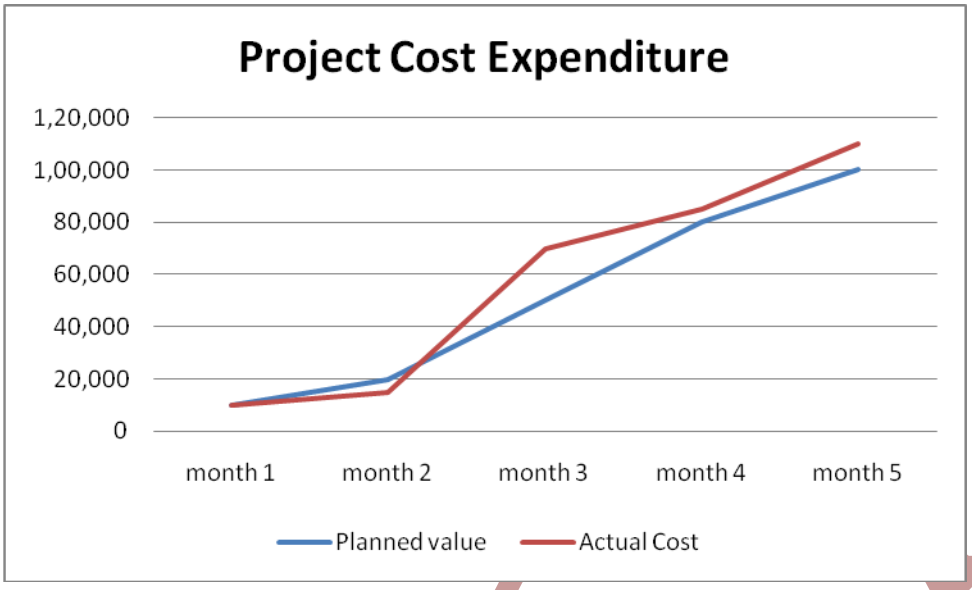


Figure 2

In these customary approaches, usually separate and direct monitoring is used for time and cost analysis. Kenley (2003) described the direct monitoring techniques for time and cost management in construction projects. In direct monitoring, there is split up between the time and cost performance indicators. Both of them are measured and reported in isolation with each other by comparing their planned and actual values at stipulated time frames. The direct monitoring does not point out anything about what has actually been produced for the amount of money spent nor whether it is being produced at the rate, or according to the schedule, originally planned. In other words, it does not relate the time versus cost performance of the project. An effective project performance control cannot be achieved only by monitoring the actual physical progress with the planned progress and actual spending with the budgeted values. This approach may be deceptive as it does not take into consideration the worth of the work which is completed during a particular period.

Figure 3



The cost performance graph as shown in Fig. 3 suggests the actual cost against budget. It does not point out any information that how much has been produced against the spent money. This aspect may limit the scope of traditional cost monitoring as it does not address the complete depiction of project current and as well as future progress trends in a true manner.

EARNED VALUE ANALYSIS

Earned Value Analysis (EVA) is a project control technique which integrates cost, schedule and technical performance. It proves the earn value of a completed work and compares it with actual cost and planned cost to determine the project performance and forecast its future trends. EVA is also described as an integrated, indirect or remote monitoring technique for the complex interaction of time and cost parameters to provide the performance measurement of a whole project. It is an effective and useful project tool that helps the client and as well as contractor to assess the project performance. As discuss in the previous section, the traditional approach of project performance measurement usually separates the time and cost parameters during the progress reporting. Nevertheless, EVA integrates time and cost functions and allows the project manager to see a clear insight of project performance with an open eye. The concept of Earned Value was evolved in 1967 by US Department of Defense and subsequently developed a 35 criterion-based approach which is the then called Cost/Schedule Control Systems Criteria (C/SCSC). Initially, it was considered that C/SCSC is a financial control tool which confined its use in project and program management. However, in 1989, Undersecretary of US Department for Acquisition adopted this criterion for program management and procurement. In 1996, it was revised by the US industry and renamed it as Earned Value Analysis (EVA). Since then, it has been used as a widely accepted tool by many US government agencies like United States.

Department of Energy, NASA and US Defense Acquisition Department etc. Besides United Sates, EVA has also attracted many other governments and public departments including industrial sectors like engineering, construction, oil and gas, infrastructure, information technology etc. In the construction industry, EVA is being used as a time and cost control tool. It has an ability to bring together planning and management functions. During the last decade, many developed countries have imposed EVA technique in their public and private funded construction projects and achieved remarkable improvements in their practices. South Korean Congress in July 2000 passed a bill named „The Effective Plan of the Public Construction Industry Bill" which mandated the construction firms to adopt Earned Value Management System (EVMS) in their project having worth more than USD 50 million.
EVA is a three-dimensional approach and is based on following data sources:

Planned Value (PV): describes portion of the project budget planned to be spent at any givenpoint in time.
Earned Value (EV): is a description of work progress at a given point in time and reflects theamount of work that has actually been accomplished at any particular time frame.
Actual Costs (AC): is the amount of spending that is utilized for the completion of the workpackage activity.

EVA takes these three data sources and is able to compare the budgeted value of work scheduled (PV) with the Earned Value (EV) of physical work completed and the Actual Value (AV) of work completed. So, performance data achieved by using EVA is an objective measure of actual work performed. Fig. 4 shows a graphical example of EVA approach.

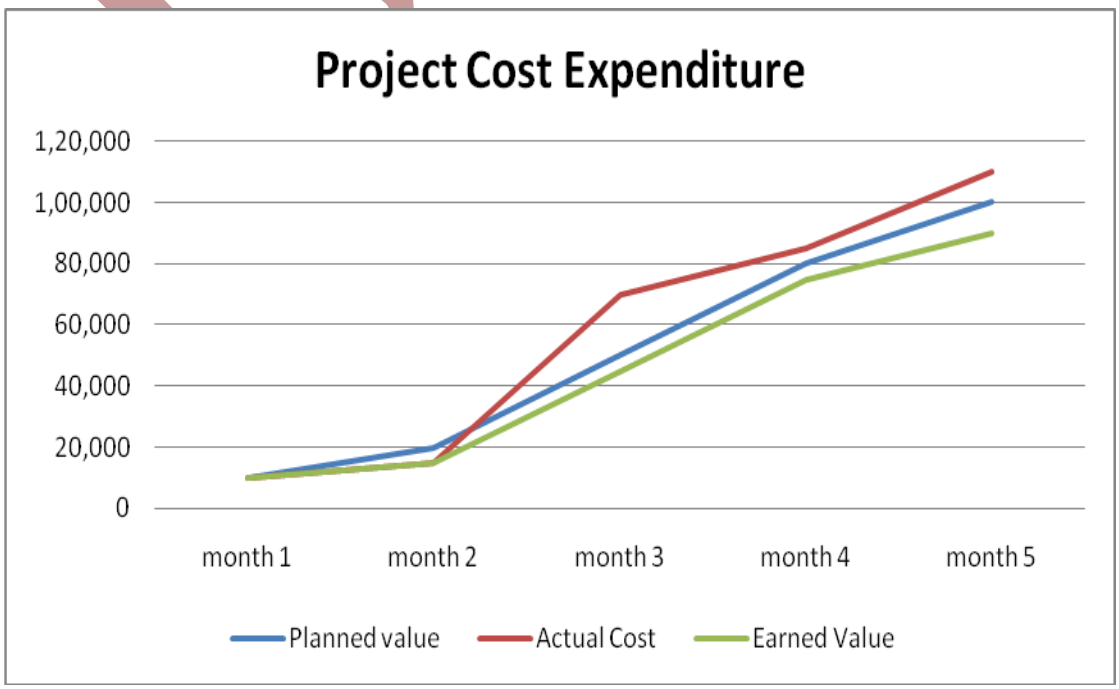


Figure 4

After the terms PV, EV and AC are defined; the assessment of current and future cost performance can be done which will provide important information on the project progress.

Project cost analysis and forecasting is an important concern of management and it needs for the cost wise evaluation of project performance. PMI PMBOK® provides a list of Earned Value cost performance variance and indicators. Some of the key parameters are discussed below;

Cost Variance (CV): It is the difference between the worth of the work that has been carried out and to the amount of money that was spent to do it.
Mathematically it is represented as;

$$CV = EV - AC$$

A positive value of CV shows the project is spending less than the planned budget whereas the negative value shows that actual cost is exceeded than the budgeted amount. Whenever the later condition happens, it signals an unfavorable scenario to the management and needs necessary corrective measures to control the negative variance with in the approved limits.

Cost Performance Index (CPI): It indicates the efficiency of resource use and measures the worth of the work that is achieved by spending every single unit dollar. Mathematically it is expressed as;

$$CPI = EV \div AC$$

A ratio less than 1.0 is an unfavorable and suggests the value of the work that has been accomplished is less than the amount of money spent. Similarly, conversely is the case for CPI ratio greater than 1.0.

Cost Estimate at Completion (EACc): It is a forecasting indicator and calculates the finishing cost of the project by assuming the current cost performance efficiency. It is calculated as;

$$EACc = BAC \div CPI$$

Estimate to Complete (ETC): It indicates the estimated remaining worth of the project work. It is calculated as;

$$ETC = (BAC - EV) \div CPI$$

CASE STUDY

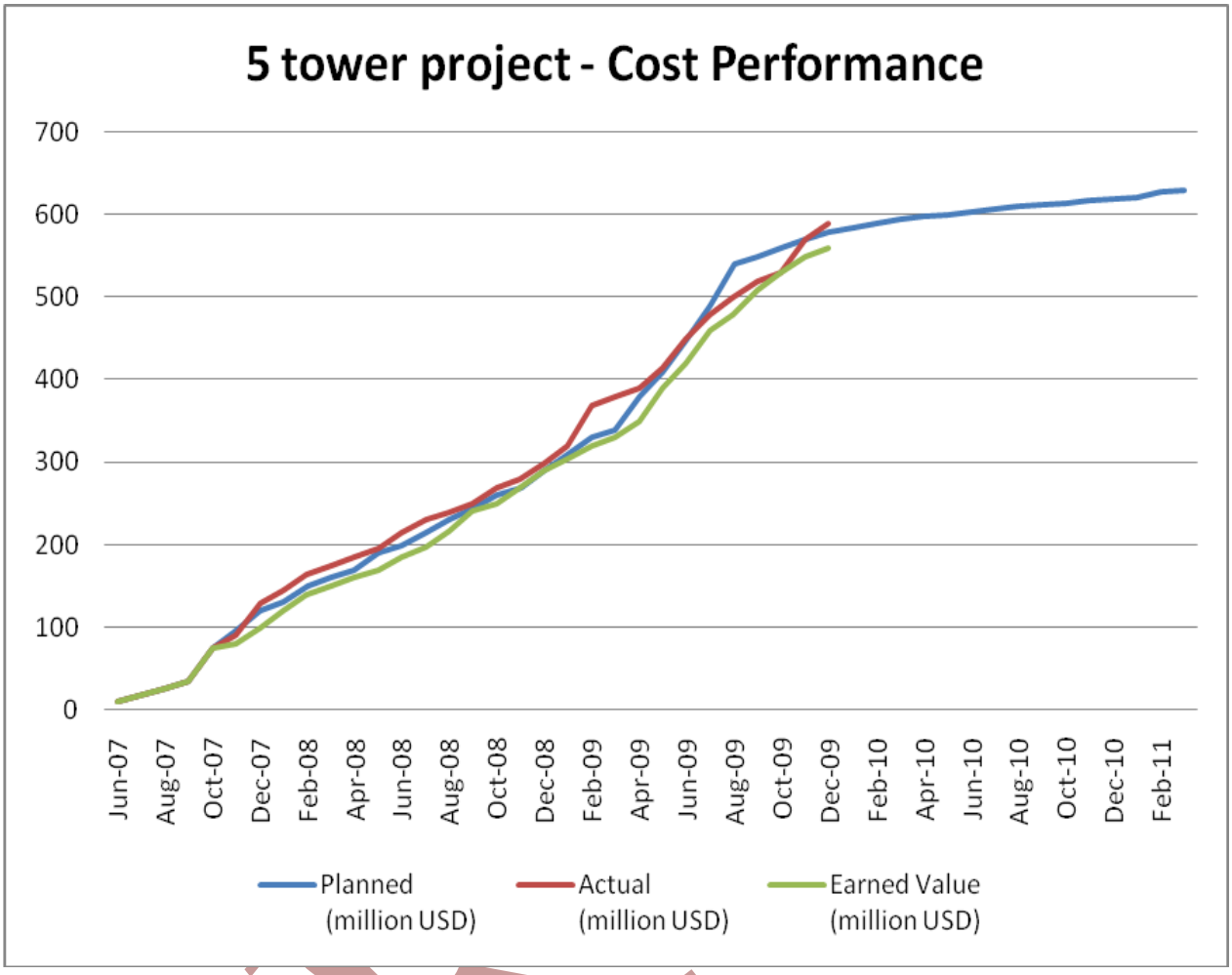
This case study illustrates the applications of EVA in real situation and demonstrates that how this approach can be useful in cost monitoring of construction projects and helps the project organization to monitor their performance in an objective manner rather than the traditional approach. It is applied on building projects in Abu Dhabi, UAE. This is a private funded project of total cumulative budget USD 630 million that was awarded in May 2007. The scope of work includes construction of five 15 story towers with 5 levels of basement for them. The planned completion timeline for this project is March 2011. Table 1 depicts PV, AC and EV which are calculated on monthly basis. In the case study the project is still running and data has been updated up to Dec-09. Trend analysis of the EV data has been performed up to the reporting period and same has been displayed to demonstrate application Earned Value Management System.

Table 1

Months	Planned (million USD)	Actual (million USD)	Earned Value (million USD)
Jun-07	10	10	10
Aug-07	25	25	25
Sep-07	35	35	35
Oct-07	75	75	75
Nov-07	95	90	80
Dec-07	120	130	100
Jan-08	130	145	120
Feb-08	150	165	140
Mar-08	160	175	150
Apr-08	170	185	160
May-08	190	196	170
Jun-08	200	215	185
Jul-08	215	230	198
Aug-08	230	240	216
Sep-08	245	250	241
Oct-08	260	270	250
Nov-08	270	280	270
Dec-08	290	300	290

Jan-09	310	320	305
Feb-09	330	370	320
Mar-09	340	380	330
Apr-09	380	390	350
May-09	410	415	390
Jun-09	450	450	420
Jul-09	490	480	460
Aug-09	540	500	480
Sep-09	550	520	510
Months	**Planned (million USD)**	**Actual (million USD)**	**Earned Value (million USD)**
Oct-09	560	530	530
Nov-09	570	570	550
Dec-09	580	590	560
Jan-10	585		
Feb-10	590		
Mar-10	595		
Apr-10	598		
May-10	600		
Jun-10	603		
Jul-10	607		
Aug-10	610		
Sep-10	612		
Oct-10	615		
Nov-10	617		
Dec-10	620		
Jan-11	622		
Feb-11	628		
Mar-11	630		

Figure 5



The data shows that during the first four month planned value (PV), earned value (EV) and actual costs (AC) are same, which means project is running exactly as planned. But for the rest of reporting period EV has remained lower than the PV suggesting the project running late and the same time AC is more than EV and PV which indicates cost overrun.

A. Cost Analysis

The success of a construction project depends on the ability of a project team to control the causes of cost overruns which threatens its completion within the approved budgets. This aim can be achieved by a periodical EV Cost Analysis.

Table 2 shows the variance and performance index relating to cost for this project.

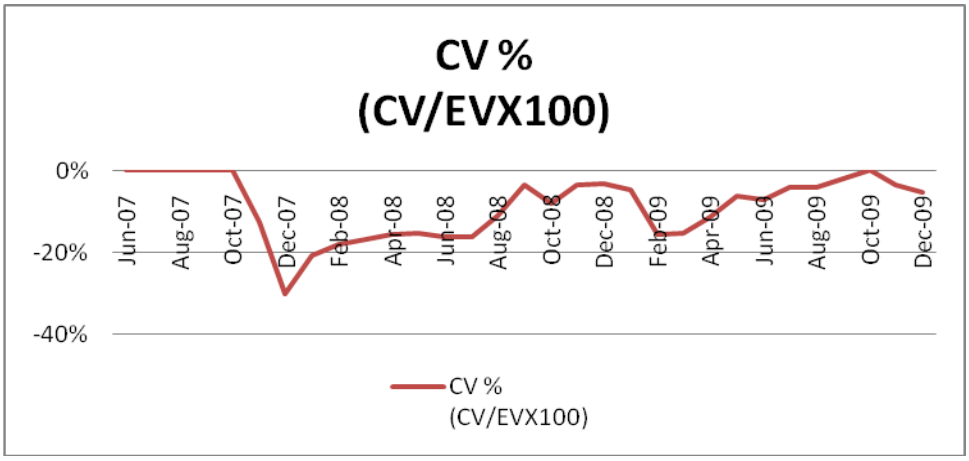
Months	Planned (million USD)	Actual (million USD)	EarnedValue (million USD)	CV (EV-AC)	CV % (CV/ EVX100)	CPI (EV/AC)
Jun-07	10	10	10	0.00	0%	1
Aug-07	25	25	25	0.00	0%	1
Sep-07	35	35	35	0.00	0%	1
Oct-07	75	75	75	0.00	0%	1
Nov-07	95	90	80	(10.00)	-13%	0.89
Dec-07	120	130	100	(30.00)	-30%	0.77
Jan-08	130	145	120	(25.00)	-21%	0.83
Feb-08	150	165	140	(25.00)	-18%	0.85
Mar-08	160	175	150	(25.00)	-17%	0.86
Apr-08	170	185	160	(25.00)	-16%	0.86
May-08	190	196	170	(26.00)	-15%	0.87
Jun-08	200	215	185	(30.00)	-16%	0.86
Jul-08	215	230	198	(32.00)	-16%	0.86
Aug-08	230	240	216	(24.00)	-11%	0.90
Sep-08	245	250	241	(9.00)	-4%	0.96
Oct-08	260	270	250	(20.00)	-8%	0.93
Nov-08	270	280	270	(10.00)	-4%	0.96
Dec-08	290	300	290	(10.00)	-3%	0.97
Jan-09	310	320	305	(15.00)	-5%	0.95
Feb-09	330	370	320	(50.00)	-16%	0.86
Mar-09	340	380	330	(50.00)	-15%	0.87
Apr-09	380	390	350	(40.00)	-11%	0.90
May-09	410	415	390	(25.00)	-6%	0.94
Jun-09	450	450	420	(30.00)	-7%	0.93
Jul-09	490	480	460	(20.00)	-4%	0.96
Aug-09	540	500	480	(20.00)	-4%	0.96
Sep-09	550	520	510	(10.00)	-2%	0.98

Months	Planned (million USD)	Actual (million USD)	Earned Value (million USD)	CV (EV-AC)	CV % (CV/EVX100)	CPI (EV/AC)
Oct-09	560	530	530	0.00	0%	1.00
Nov-09	570	570	550	(20.00)	-4%	0.96
Dec-09	580	590	560	(30.00)	-5%	0.95
Jan-10	585					
Feb-10	590					
Mar-10	595					
Apr-10	598					
May-10	600					
Jun-10	603					
Jul-10	607					
Aug-10	610					
Sep-10	612					
Oct-10	615					
Nov-10	617					
Dec-10	620					
Jan-11	622					
Feb-11	628					
Mar-11	630					

The findings of the Table 2 can be summarized as follows;

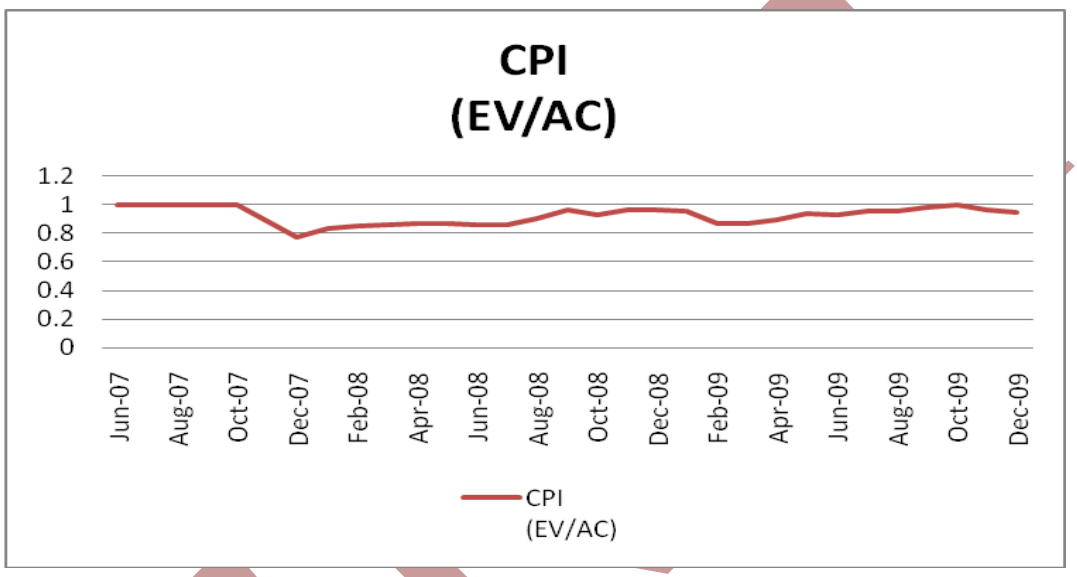
i) This project has a CV = 0 at for first four months and for the month Oct-09 and negative value of CV for rest of the periods since value of EV is less than AC during those periods. Therefore, the project progress is not favorable cost-wise.

Figure 6



ii) Fig. 6 depicts a trend of CV% for the entire reporting period. It suggests that project reached to about 30% cost overrun during Dec-07 but later on recovered and current cost overrun is 5.32% (As of Dec-09).

Figure 7

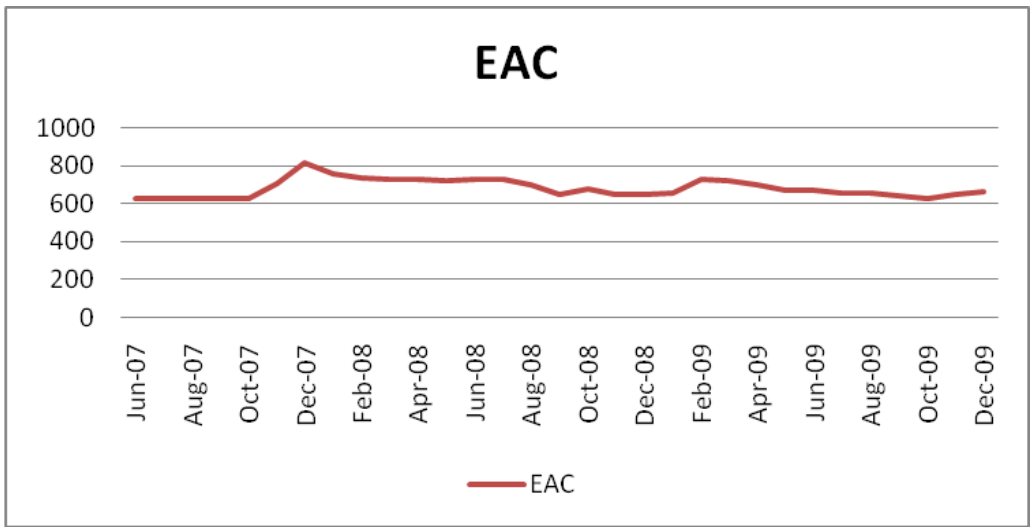


iii) Fig. 7 shows a graph of CPI. As the values are lesser than 1.00 which shows that value of the work that has been carried out is less than the amount of money spent. So, the efficiency of using project resources is not favorable.

B. Cost Forecasting

To forecast the future performance trends, cost forecasting is made by alculating the following performance measures;

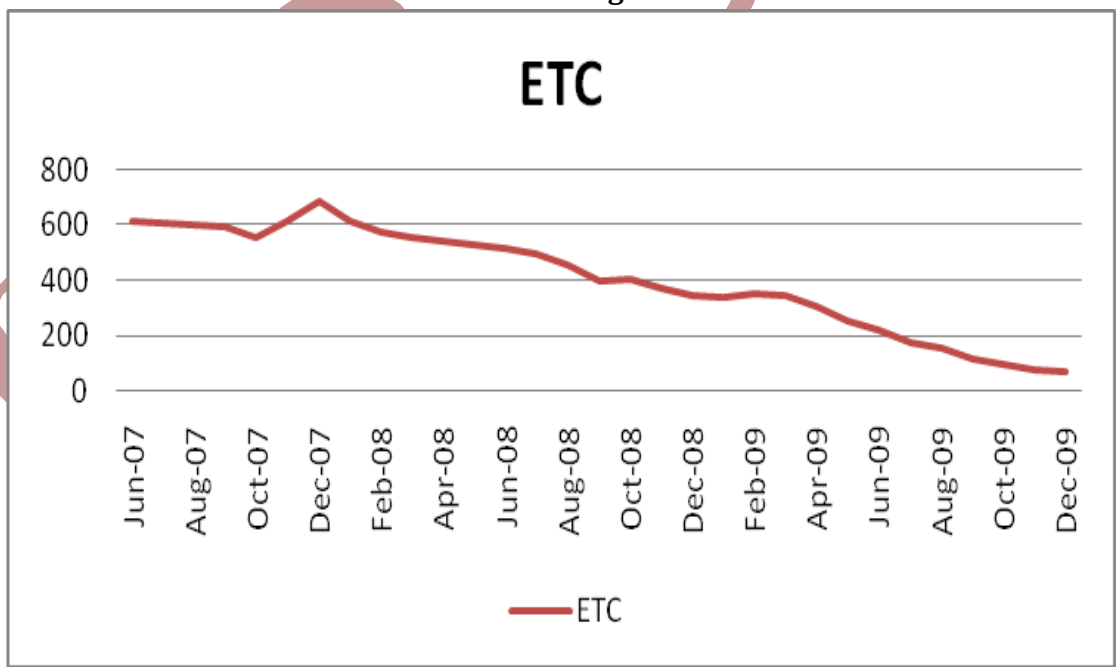
Figure 8



i) Fig. 8 shows the quarterly estimates of the future project cost i.e. Estimate at Completion (EAC). The reporting data is plotted by dividing total cumulative budget of the project with its corresponding performance index value (i.e. CPI) for each quarter. From the EAC graphical curve, it is clear that efficiency of project team resource use mainly affect the final estimated cost of the project. For example, for Dec-07 CPI is 0.77 and its corresponding EAC is about 820 million USD whereas for Oct-09 CPI is 1 and its corresponding EAC is 630 million which is equal to the original project budget. It proves that as the value of CPI decreases final project budget increases.

ii) The remaining cost of the project is determined by Estimate to Complete (ETC) factor. Fig. 9 shows the decreasing trend of ETC.

Figure 9



CONCLUSIONS

Cost monitoring through EVA is an effective approach for finance management of construction projects. The calculation of EV performance variances and indices from the case study make it possible to examine the current and future cost performances of projects in many ways. With EVA, it is possible to monitor and forecast the cash flows and points out cost overruns which may happen during the project cycle. Therefore, this approach provides early warning signs for any cost divergence from the project baseline and helps the project team to carry out any contingency strategies to ensure the successful completion of project.

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