

ANALYSIS OF COST ESTIMATION, TRACKING AND EARNED VALUE ANALYSIS OF A G+5 APARTMENT BUILDING BY PRIMAVERA P6

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Abstract: Today, the construction companies are already one of the largest industry sectors which requires very huge resources and time for their successful completion, thus due to such a big scale projects, the corporations are facing the issue of project valuation. Multiple techniques are dealing with this problem. However, it is questioned which one gives the best results. This paper examines the earned value method for project performance valuation. The main purpose of the study is to evaluate the earned value method.

This paper investigates the application of Earned Value Methodology in the Construction projects with a Case study of a G+5 apartment building. Earned Value Management (EVM) is a project management technique for measuring project performance and progress. It is a systematic project management process used to find variances in projects based on the comparison of worked performed and work planned. EVM is used on the cost and schedule control and can be very useful in project forecasting.

Index Terms - Earned Value Analysis, Tracking, Project Management, Monitoring, Scheduling, Primavera P6

I. INTRODUCTION

Earned Value Management (EVM) is the process of measuring performance of project work against a baseline plan. EVM application helps in providing performances standard for the evaluation of progress report project and it also acts as a control device to take care of time and cost schedule by responsibility defined Organization Breakdown Structure (OBS). It gives better execution picture of project and gives better gauge of the last fulfillment cost.

Earned value is an enhancement over conventional method of cost accounting. Customarily budgeted cost is computing the difference between planned cost and actual cost incurred in a project. Earned value uncovers future opportunities and it likewise inspects actual achievement. With help of EVM, project managers get adequate help to have profound natural comprehension into potential risk areas. So that with help of clearer picture of project performances, managers can create risk mitigation plans based on actual cost, schedule and technical progress of work.

1.1 PROJECT MANAGEMENT

Project Management includes the processes involved in planning, estimating, budgeting, and controlling costs so that the project can be completed within the approved budget.

The Project Management processes include the following:

1.1.1 Planning:

Planning is the process of defining goals, creating techniques, and sketching out errands and calendars to achieve the objectives. Project planning is a procedural stride in project management, where required documentation is made to guarantee effective project completion. Documentation incorporates all actions required to define, prepare, integrate and coordinate additional plans. The project plan clearly defines how the project is executed, monitored, controlled and closed.

1.1.2 Cost Estimating:

Building up an estimate of the costs of the resources expected to finish project activities. Estimating schedule activity costs includes building up an approximation of the costs of the resources expected to complete each schedule activity. In approximating costs, the estimator considers the possible reasons for variation of the cost estimates, including risks.

1.1.3 Cost Budgeting:

Cost budgeting involves aggregating the estimated costs of individual schedule activities or work packages to establish a total cost baseline for measuring project performance. The project scope statement provides the summary budget. However, schedule activity or work package cost estimates are prepared prior to the detailed budget requests and work authorization.

1.1.4 Earned Value Analysis:

Earned Value Analysis is an industry standard method of measuring a project's progress at any given point in time, forecasting its completion date and final cost, and analyzing variances in the schedule and budget as the project proceeds. It compares the planned amount of work that has actually been completed, to determine if the cost, schedule and work accomplished are progressing in accordance with the plan. As work is complete, it is considered as "Earned".

1.2 PRIMAVERA PROJECT MANAGEMENT

Project Management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements. The elements of Project Management control include programmed objectives, policy restrictions, resource constraints, government regulations, feedback and revision of objectives.

Primavera is a project, cost, and asset management software that empowers associations to settle on educated choices and enhance their capacity to convey programs and projects on time and on budget through the capture and reuse of best practices. Primavera makes a collective situation through its arrangement of incorporated components with simple to utilize, customized interfaces for all project stakeholders.

1.3 OBJECTIVES OF THE PROJECT

The project cost plays a major role in project success. Past performance is the best indicator of the future performance of the work. Therefore, trend data is used to forecast schedule and cost overruns at an early stage in a project. The most comprehensive trend analysis technique is the Earned Value method. Earned value is a project management technique for estimating how a project is doing in terms of its budget and schedule. The purpose of earned value is to obtain an estimate for the resources that have been used at completion. Planning and initial forecasts are important because even if a job cost more or less, when it ends, its acquired value is what it is initially planned and not the final value.

The main objective of the project is to monitor the progress of construction activities at the site for the following:

- ✓ To suggest the importance and purpose of monitoring the construction work.
- ✓ Earned value analysis & tracking of construction works.
- ✓ To provide the basis to capture work progress assessments against the base line.
- ✓ Relative technical, schedule, and cost performance.

II. LITERATURE REVIEW

EVM is an enhancement over traditional accounting progress measure. Traditional methods focus on planned accomplishment (expenditure) and actual cost. Earned Value Analysis goes one step further and examines actual accomplishment. This gives to project team a greater insight into potential risk areas.

Sufficient literature are available on the Earned Value Analysis (EVA), Earned Schedule (ES) and Earned Value Management (EVM) and there are different ways to apply them in construction industry. Among them many are from different countries and very few are from India.

Following are the various authors who have performed their work and reviewed on EVA.

Lipke Walt et al (2007), In Project Management Institute (USA), Earned Value and Earned Schedule was applied and study was carried out by Lipke Walt. Author with a detailed study concluded that EVM with ES provides incredible management information. The author applied a Decision Logic Diagram as a tool that gives the good connection of EV with the project status indicators of EV.

Agata Czarnigowska et al (2011) overviewed the recent work and concluded that Earned Value (EV) alone is not effective. By combining it with any other tool facilitates monitoring the project status, identification of potentially negative signals and a generalized appraisal of their combined effect on the project's outcome.

Kendrick et al (2004) said that EVM seem complex but it has a simple foundation. It helps in tracking the performance of a project by simple arithmetical calculations. For larger projects these calculations become to tedious, so use of MSP, Primavera and other software is the solution. Author compared the three software and found accuracy by all the methods and concluded that by use of software in the construction project, EV work as a predictor within less duration of time.

Harold Kerzner et al (1998) considered EVA a relevant maturity differential in project management. Managing costs using EVA is referred to as "managing with open eyes" because the manager can clearly see what was planned, what was performed and the actual costs. This is a powerful tool in the decision making process. In the day-to-day activities of the project manager, EVA provides "alarm" signals and facilitates decisions that keep the project on time and on budget.

Westney (1997) proposes that for a project to be successful it is very important to control its costs. It is underlined that projects are under control only if four basic elements are under control. Those are the schedules, progress, budgets, and incurred costs. One possible tool to control projects is the earned value method. This concept integrates cost and schedule for measuring over-all project performance in their ongoing phase. It requires computerization, which helps to deal with the additional data elements that are required. The basic fundamentals are relatively simple. However, in order to use the earned value method major system acquisitions are required to fulfill the need for very detailed and formal instructions and documentation

According to the **PMBOK®** Guide the earned value method enables organizations to employ a single technique of project performance measurement. However, it could only be implemented after the crucial decision that a project is going to be undertaken. The same source provides information about additional advantages of the method. It is said that the earned value provides with accurate measures for the project cost and time schedule, given the planned value and time to completion.

Fleming & Koppelman (2000) publish for the first time the ten benefits of using the earned value method. Some of the benefits such as:

- EVM keeps the management on their toes. As EVA is done periodically, management tries to make sure that all the project parameters are on track.
- It is probably the only system used at present which tracks the project in terms of work, time and money.
- Timely performance measurement makes sure that steps can be taken to the bring project back on track before it's too late.

Among others, *Brandon (1998)*, *Christensen (1998)*, *Fleming & Koppelman (2004)*, *Howes (2000)*, and *Ruskin (2004)* are examining the disadvantages from using the earned value. Some of the above authors are even suggesting ways of overcoming those problems. Thus, it is proved that, even though the earned value method bears disadvantages, it is possible to overcome them, which makes a good technique for project performance valuation.

III. EARNED VALUE MANAGEMENT

In today's highly competitive worldwide markets, the future of all companies depends upon their ability to undertake correct financial decisions. Many international corporations deal with projects on an everyday basis, which makes it a major part of their businesses. Thus, one can foresee the need of making the right financial decision when the issue of undertaking and executing a project is in question.

Earned Value Management (EVM) is a program management technique that is used for "work in progress" to indicate what will happened to work in the future. EVM is an enhancement over traditional accounting progress measure. Traditional methods focus on planned accomplishment (expenditure) and actual cost. The earned value method is a method for project performance valuation. It can also be seen as a method for cost and schedule control, as well as a project-monitoring tool. One typical description of the EV is that it is used for project in their ongoing phase.

3.1 ELEMENTS OF EARNED VALUE

With the introduction of earned value data, the three primary elements for deriving performance in earned value project management can be defined. The three elements are:

1. Planned Value → Budgeted Cost for Work Scheduled (BCWS)
2. Actual Costs → Actual Cost of Work Performed (ACWP)
3. Earned Value → Budgeted Cost of Work Performed (BCWP)

3.1.1 Budgeted Cost For Work Scheduled (Planned Value):

The BCWS, or "Planned Value", is the sum of the budgets, usually expressed in Rupees or man-hours, for all planned work scheduled to be accomplished within a given period.

3.1.1.1 Budget at Completion:

Budget at Completion (BAC) is the cumulative sum for all Budgeted Costs of Work Scheduled and represents the original estimate of the cost for a project. It denotes the endpoint of the time-phased PMB curve.

3.1.2 Actual Cost Of Work Performed (Actual Costs):

The ACWP or "Actual Costs" are the costs, usually in terms of Rupees or man-hours, actually incurred and recorded for accomplishing the tasks performed on a project within a given time period. This includes charges for goods and services received and other assets acquired, such as invoices for work, material delivered, progress payments and fees/profit allocable to the contract.

3.1.3 Budgeted Cost Of Work Performed (Earned Value):

It is commonly referred to as the "Earned Value", is the sum of the approved budgets, usually in terms of Rupees or man-hours, for activities or portions of activities completed during a given period.

3.2 VARIANCES

It is safe to say that no plan, schedule or estimate is exact and thus variances are certain to occur. A variance is the difference between the planned, scheduled, or actual costs. "Typical causes of variances include poor initial planning or budgeting, changes to the project's scope, changes in technology related to the project, changes to the delivery schedule, changes to labor contracts, changes to material costs, inflation, and measurement error." The presence of significant variance notifies management that something needs to be examined and proper corrective action taken. With earned value analysis, two main variances can be determined, i.e., Schedule Variance and Cost Variance.

3.2.1 Schedule Variance (SV)

Schedule variance provides a representation of schedule status, indicating whether budgeted work is being accomplished as planned. It is the difference between the earned value and the planned value as indicated below:

$$SV = \text{Earned Value} - \text{Planned Value} = BCWP - BCWS$$

A *positive* variance indicates favorable schedule performance since the amount of work performed is greater than what was scheduled. Conversely, a *negative* variance means less work was performed than planned and the project is behind schedule. It is important to note, however, that at contract completion the schedule variance is always *zero* because all scheduled work has been performed.

3.2.2 Cost Variance (CV)

Cost Variance measures the difference between the cost that was planned for a given task and the cost that was actually incurred in performing the task. As such, it is the difference between the earned value and the actual costs as shown in below:

$$CV = \text{Earned Value} - \text{Actual Costs} = BCWP - ACWP$$

As with the schedule variance, the cumulative cost variance is most often used for analysis purposes. A *positive* cost variance indicates that the contractor is accomplishing work for less than was budgeted. On the other hand, a *negative* cost variance means more money was spent for the work accomplished than was originally planned.

3.3 PERFORMANCE INDICES

"Performance indices show the percentage of variation, between planned and actual performance, for the current period, cumulative to date, and at the completion of a task." The Schedule Performance Index and the Cost Performance Index are calculated to provide an efficiency factor for the work accomplished in either the current period or a cumulative timeframe. The analysis techniques that produce these two performance indices are described below.

3.3.1 Schedule Performance Index (SPI)

The SPI indicates the ability of the contractor to control the project schedule and compares the budget for those tasks scheduled to be accomplished as of the status date with the budget for the work that was actually accomplished as of that date. It is calculated as the ratio of earned value to planned value as shown below:

$$SPI = \frac{\text{Earned Value}}{\text{Planned Value}} = \frac{BCWP}{BCWS}$$

An SPI of 1.0 indicates that the project is on schedule and performing at 100% efficiency. An index *greater* than 1.0 shows an ahead of schedule situation, while one *below* 1.0 reflects a behind schedule condition.

3.3.2 Cost Performance Index (CPI)

The CPI indicates the ability of the contractor to control cost and compares the budget for those tasks that have been accomplished with the actual cost of accomplishing the tasks. It is calculated as the ratio of earned value to actual costs as shown below:

$$CPI = \frac{\text{Earned Value}}{\text{Actual Cost}} = \frac{BCWP}{ACWP}$$

The CPI measures the cost efficiency with which work has been accomplished. A CPI of 1.0 indicates that for every actual Rupee spent, a Rupee's worth of work was accomplished. An index *above* 1.0 indicates a cost under run or higher efficiency, while an index below 1.0 reflects performance below what was expected. "A CPI *less* than 1.0 is rarely improved upon, and usually proves to be unrecoverable."

IV. CASE STUDY AND METHODOLOGY (SEQUENTIAL STEPS IN PRIMAVERA)

4.1 CASE STUDY

The case study for the Project is a Commercial Apartment building which serves 2BHK flats for its residents, the building is RCC framed structure. It is a Residential Apartment named as "PJ Residency" which is being constructed under the consultation of "Sherrieff Builders and Consultants, Kalaburagi" at Vidya Nagar Colony, Kalaburagi.

The useful information has been taken from actual project such as Bill of Quantities and abstract sheets provides necessary data for the project cost and scheduling activities, and is used in the Primavera P6 Software.

The necessary details about the Project site and structure (PJ Residency), its location, the construction details etc. are as follows:

Name of the Project	:	PJ Residency
Purpose of the Project	:	Commercial Apartment Building
No of Floors	:	G+5
Total cost of the Project	:	6 Crore (Approx)
Proposed Start time of the project	:	2015
Total Area	:	9977 Sq. ft.
Built up Area of each Floor	:	7825 Sq. ft.



Figure-4.1: Proposed 3D view of PJ Residency after completion.

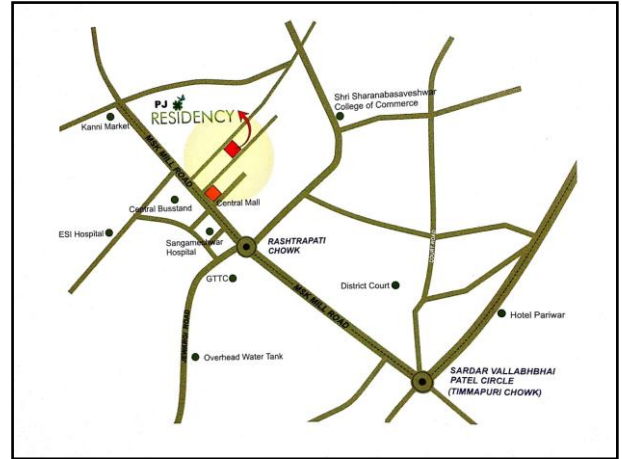
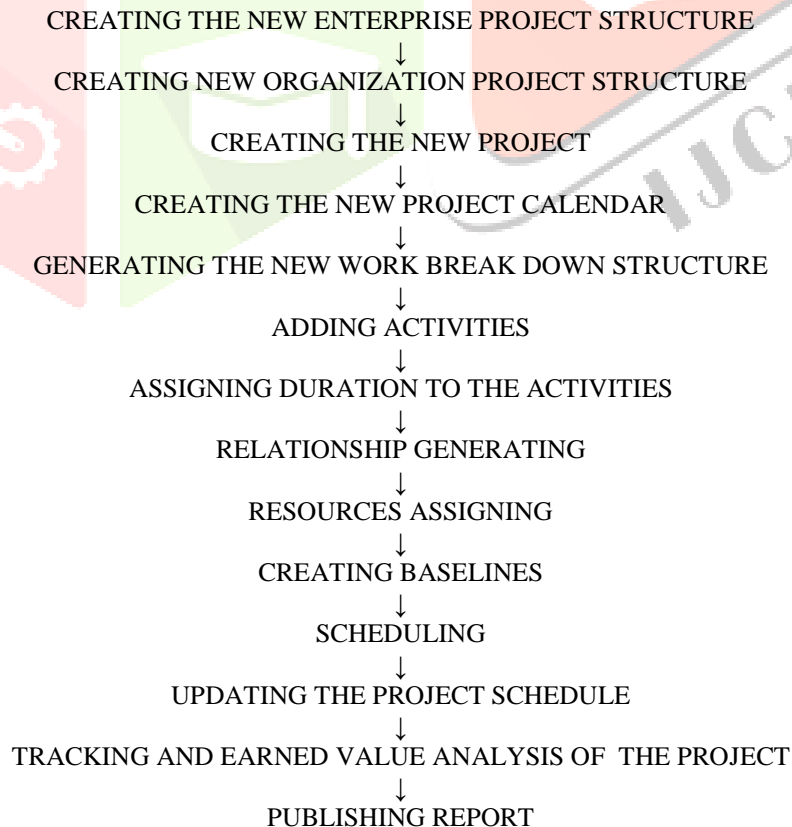


Figure-4.2: Location map of the Project site.

4.2 METHODOLOGY (SEQUENTIAL STEPS IN PRIMAVERA)



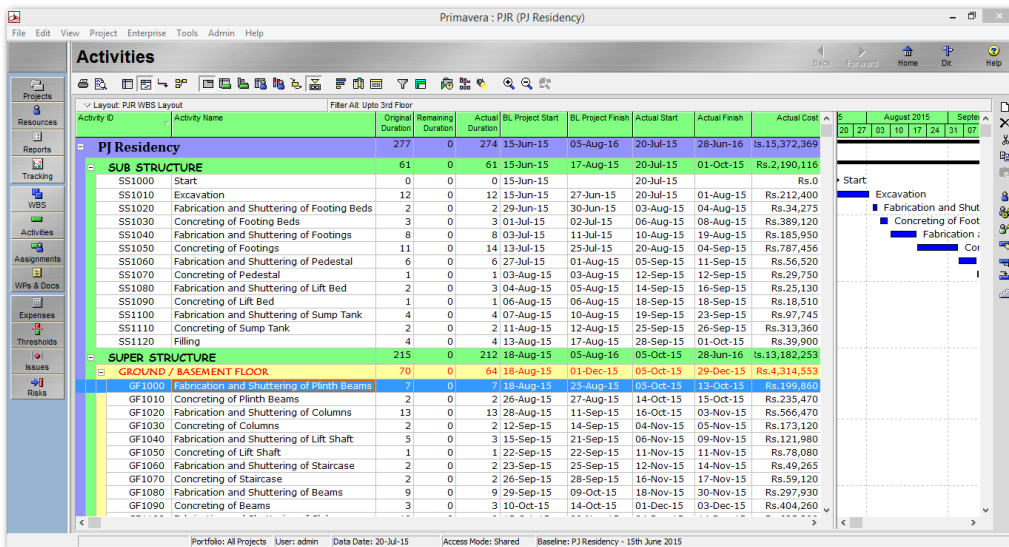


Figure-4.3: Activities, Duration and their Budgeted cost in Primavera P6

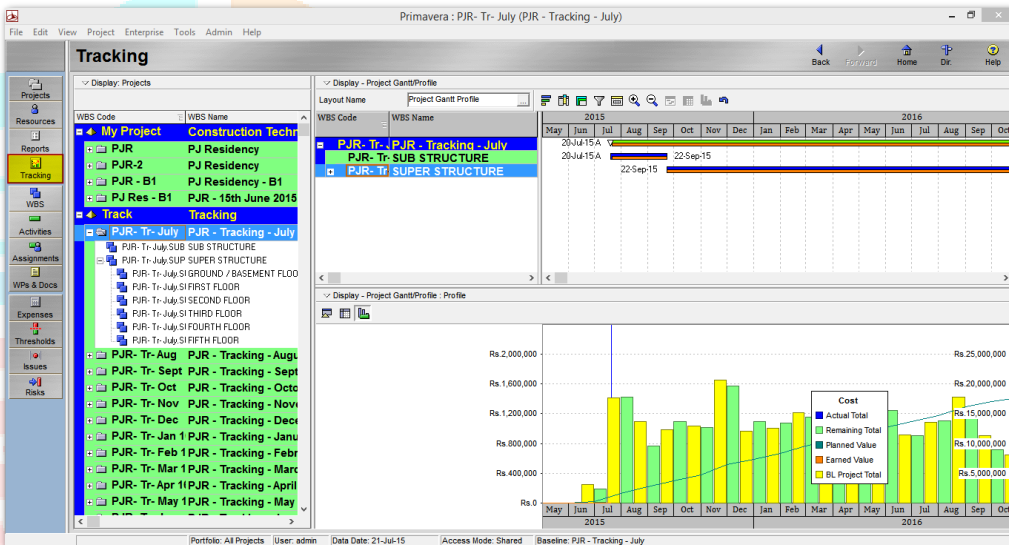


Figure-4.4: Tracking of the Project in Primavera P6

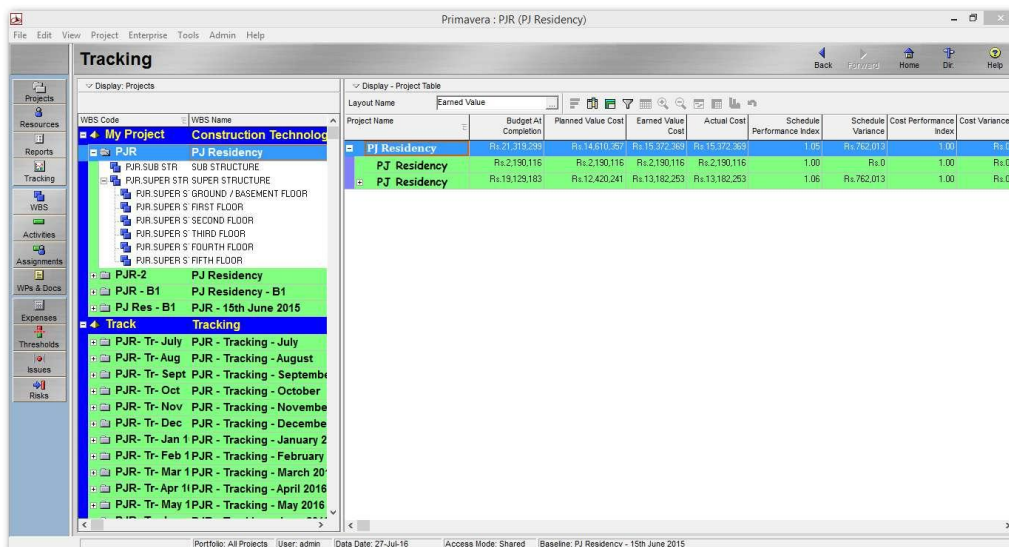


Figure-4.5: Earned Value Analysis in Primavera P6

V. RESULTS AND DISCUSSIONS

In this we will discuss about the Result/Output obtained from the Primavera P6 software after analyzing and tracking the project from time to time on regular interval. Usually the projects are tracked on a weekly basis and reports of the progress is submitted, But as the project building taken for the case study is of smaller magnitude and also the weekly reports and their graphs will make this report a bit lengthy and clutter up. So in order to avoid such confusion I have included the graphs and progress report on alternate months basis.

The result/output obtained from the Primavera P6 is shown in the graphical form and three types of graphs (analysis) have been shown/done to see how the project is performing in actual in terms of schedule (time) and cost to that of planned and the following analysis shows the same:

- ✓ Earned Value Analysis
- ✓ Performance Indices
- ✓ Variance Analysis

The first thing which is important in any project is the Planned value cost of the project which acts as a reference till the completion of project, So before analyzing the Project, the Planned Value Cost of the project should be required which is shown below in the graphical form as per the planned data.

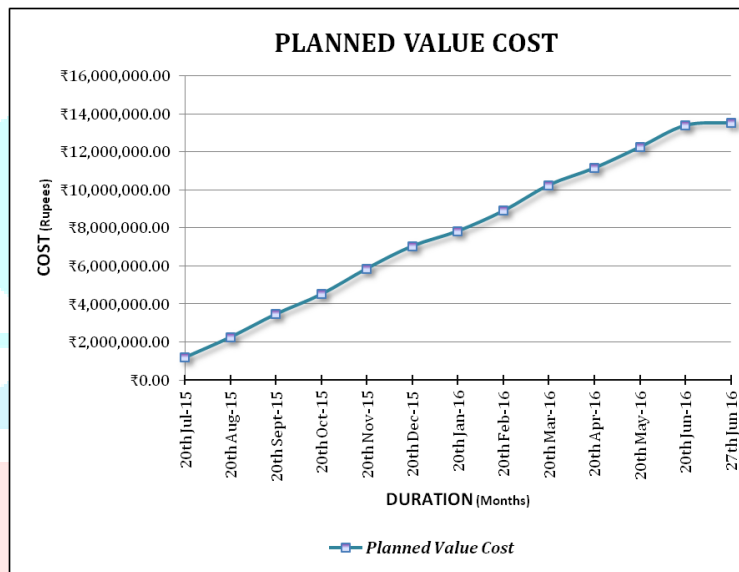


Figure-5.1: Graph showing the Planned Value Cost of the Project

5.1 EARNED VALUE ANALYSIS

The project was tracked and monitored for a period of about 11 months on 20th of every month and scheduled in the Primavera P6 by taking Data date as 20th for the respective month from 20th July 2015 to 27th June 2016.

Finally the result obtained from the Primavera P6 for the Earned Value Analysis is tabulated as below:

DURATION (Months)	BUDGET AT COMPLETION (BAC) (Rs.)	PLANNED VALUE (PV) COST (Rs.)	EARNED VALUE (EV) COST (Rs.)	ACTUAL COST (AC) (Rs.)
20th Jul-15	21,319,299	1,179,680	10,620	10,620
20th Aug-15	21,319,299	2,247,219	900,491	821,745
20th Sept-15	21,319,299	3,462,620	1,763,548	1,836,856
20th Oct-15	21,319,299	4,507,313	2,710,417	2,625,446
20th Nov-15	21,319,299	5,860,857	3,733,067	3,971,411
20th Dec-15	21,319,299	7,041,843	6,021,810	5,538,951
20th Jan-16	21,319,299	7,836,549	7,524,519	7,524,519
20th Feb-16	21,319,299	8,895,786	9,472,259	9,472,259
20th Mar-16	21,319,299	10,252,899	10,486,559	10,486,559
20th Apr-16	21,319,299	11,150,493	11,996,715	11,887,319
20th May-16	21,319,299	12,251,973	13,397,865	13,395,379
20th Jun-16	21,319,299	13,395,379	14,995,650	11,576,093
27th Jun 16	21,319,299	13,539,048	14,995,650	11,576,093

Table-5.1: Table showing the BAC, PV, EV and AC

From the above table, EVA of all activities of the project was done for the alternate months and is represented graphically as below:

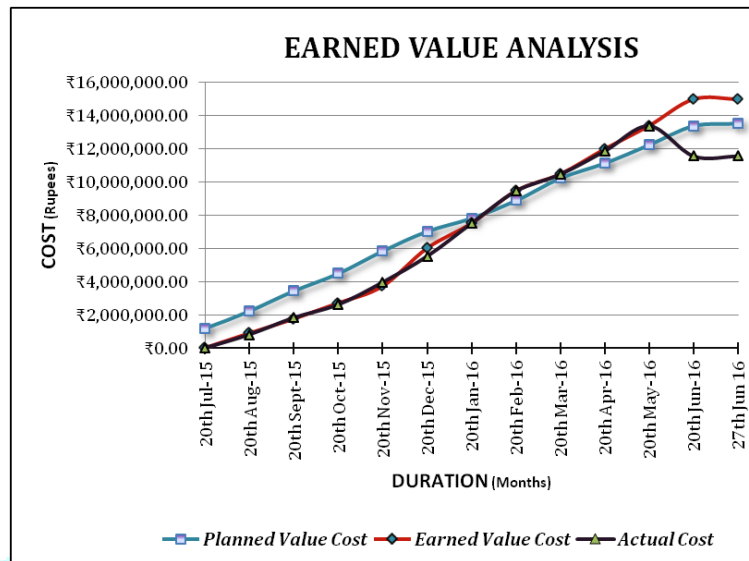


Figure-5.2: EVA graph of 27th June 2016 tracking

After getting the output data from the Primavera P6 and analyzing the PV, EV and AC; it can be seen that until the month of January 2015 the project was running behind as the EV and AC is lesser than PV which indicates that the project is not proceeding as per the planned schedule but after the month of January 2015 there was an improvement in the performance of work as the EV and AC are more than PV which indicates that the project is ahead of the planned schedule.

5.2 PERFORMANCE INDICES

Performance indices show the percentage of variation, between planned and actual performance, for the current period, cumulative to date, and at the completion of a task. The Schedule Performance Index and the Cost Performance Index are calculated to provide an efficiency factor for the work accomplished in either the current period or a cumulative timeframe.

Now the result obtained from the Primavera P6 for the *Performance Indices* is tabulated as below:

DURATION (Months)	SCHEDULE PERFORMANCE INDEX ($SPI=EV/PV$)	COST PERFORMANCE INDEX ($CPI=EV/AC$)
20th Jul-15	0.01	1
20th Aug-15	0.4	1.1
20th Sept-15	0.51	0.96
20th Oct-15	0.6	1.03
20th Nov-15	0.64	0.94
20th Dec-15	0.86	1.09
20th Jan-16	0.96	1
20th Feb-16	1.06	1
20th Mar-16	1.02	1
20th Apr-16	1.08	1.01
20th May-16	1.09	1
20th Jun-16	1.12	1.3
27th Jun 16	1.11	1.3

Table-5. 2: Table showing the SPI and CPI

From the above table, Performance Indices of all activities of the project was done for the alternate months and is represented graphically as below:

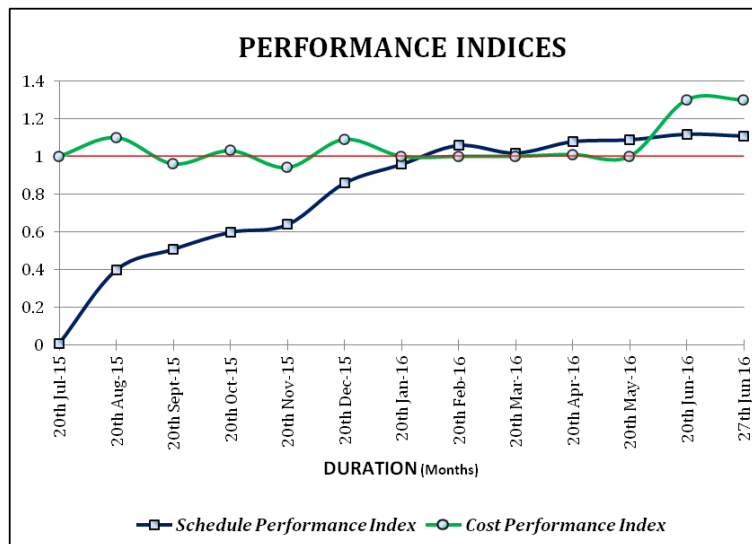


Figure-5.3: Performance Indices graph of 27th June 2016 tracking

Schedule Performance Index (SPI) of 1.0 indicates that the project is on schedule and performing at 100% efficiency. An SPI greater than 1.0 shows an ahead of schedule situation, while one below 1.0 reflects a behind schedule condition.

Similarly CPI measures the cost efficiency with which work has been accomplished. A CPI of 1.0 indicates that for every actual Rupee spent, a Rupee's worth of work was accomplished. A CPI above 1.0 indicates a cost under run or higher efficiency, while an index below 1.0 reflects performance below what was expected.

After getting the output data from the Primavera P6 and analyzing, visually it can be seen that until the month of January 2015 the project was running behind the planned schedule and performance was also very poor but after the month of January 2015 there was a significant improvement in the performance of work and hence it resulted into project running behind schedule to project to be on time (apparently we can even say ahead of schedule).

5.3 VARIANCE ANALYSIS

It is safe to say that no plan, schedule or estimate is exact and thus variances are certain to occur. A variance is the difference between the planned, scheduled, or actual costs. The presence of significant variance notifies management that something needs to be examined and proper corrective action taken.

With earned value analysis, two main variances i.e. *Schedule Variance (SV)* and *Cost Variance (CV)* can be determined, and the result obtained from the Primavera P6 for the *Variance Analysis* is tabulated as below:

DURATION (Rs.)	SCHEDULE VARIANCE (SV=EV-PV)	COST VARIANCE (CV=EV-AC)
20th Jul-15	-1,169,060	0
20th Aug-15	-1,346,728	78,746
20th Sept-15	-1,699,073	-73,309
20th Oct-15	-1,796,897	84,971
20th Nov-15	-2,127,790	-238,344
20th Dec-15	-1,020,032	482,859
20th Jan-16	-312,030	0
20th Feb-16	576,473	0
20th Mar-16	233,660	0
20th Apr-16	846,222	109,396
20th May-16	1,145,893	2,486
20th Jun-16	1,600,271	3,419,557
27th Jun 16	1,456,602	3,419,557

Table-5.3: Table showing the Schedule variance and Cost variance

From the above table, Variance Analysis of all activities of the project was done for the alternate months and is represented graphically as below:

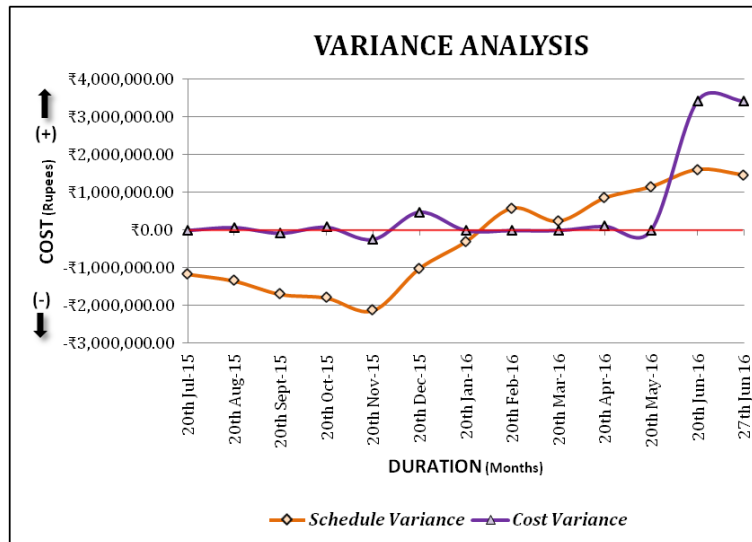


Figure-5.4: SV and CV graph of 27th June 2016 tracking

As it was explained in the Chapter-3 that Schedule variance (SV) provides a representation of schedule status, indicating whether budgeted work is being accomplished as planned. A positive SV indicates the project is ahead of schedule and a negative SV means behind schedule.

Cost Variance (CV) is the difference between the cost that was planned for a given work and the cost that was actually incurred in performing that work. A positive CV indicates the project is under budget and a negative CV means over budget.

After getting the output data from the Primavera P6 and analyzing, similarly as it has happened in Performance Indices analysis, it can be seen that until the month of January 2015 the project was running behind the schedule and in performance but after the month of January 2015 it improved which resulted the project to be on time and within the budget.

After carrying out the Earned Value analysis, Performance Indices analysis and Variance analysis we have almost got the result that how is the performance of the project in terms of cost and time. However, in order to sum up the result and to conclude this Chapter let us have a look at the graph of Schedule % Complete and Performance % Complete below.

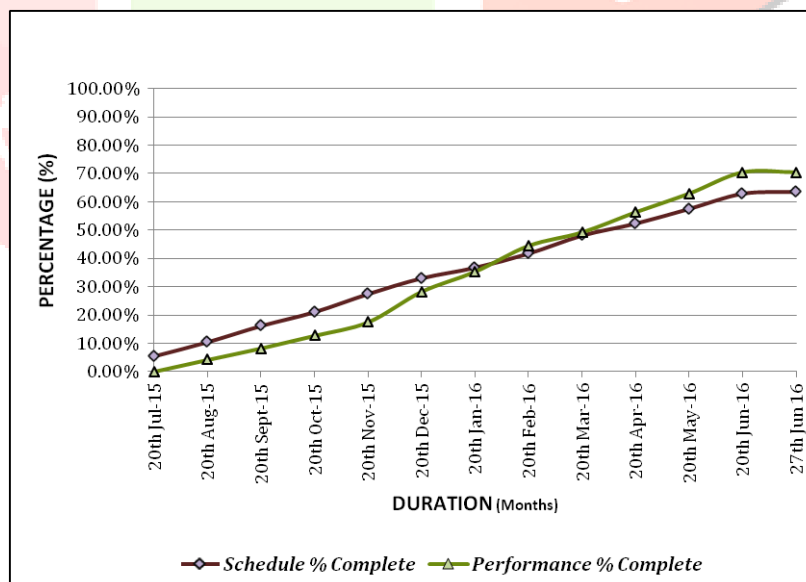


Figure-5.5: Graph showing Schedule % Complete and Performance % Complete

The graph shows that the performance of the project was not proceeding as it was supposed and was lagging behind the planned schedule in the initial few months of the start of project (until Jan-2016). As the work proceeded further the performance was improved and project was on the schedule (or we can say ahead of schedule) as per the planned schedule (after Jan-2016).

VI. CONCLUSION

After carrying out the Earned Value Analysis (EVA) of the Case study, it leads to the following conclusion below:

- The actual construction of the project was started with a delay of about two weeks from the planned date.
- The output from the workers was also at slower during the initial days of the commencement of project which eventually affected the project's planned schedule.
- After analysis it can be seen that, In *July* (project commencement) month, the project has an SPI of **0.01** and as we have learned in the previous chapters that, if a project has an SPI<1 indicates it is behind the schedule.
- Also, In *July* month, the project has a CPI of **1.0** and as we know that, if a project has an CPI<1 indicates the project is over budgeted, However the project is under budget.
- As the project was delayed initially and impact of this has affected the project for the next few months; due to this the project was behind the schedule until *January 2016* but however, the impact of delay on the project cost was negligible.
- Fortunately, as the project progressed further it was seen that from the month of *February 2016* the project was on schedule and also the project was under the budget.
- The analysis showed that the maximum SPI of the project was **1.12** during the month of *June 2016*, which indicates that during this month the efficiency of the project was highest which made the project to be ahead of the schedule.
- Also the analysis showed that the maximum CPI of the project was **1.3** during the month of *June 2016*, which indicates that during this month, the resources were used most efficiently which resulted the project to be under budget.
- From the above results obtained from the Earned Value Analysis we can say that Earned Value Management is a powerful tool that can assist in the management of construction projects. It enables the project team to identify problems and trends at an earlier stage, thereby allowing appropriate action to be taken. While it cannot be viewed as a solution to all project issues, it does provide a means to manage a project in an efficient way.
- EVA is a better method of program/project management because it integrates cost and schedule, can be used to forecast future performance and project completion dates.
- It is an "early warning" program/project management tool that enables managers to identify and control problems before they become insurmountable. It allows projects to be managed better on time, on budget.

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