

Forecasting Project Performance using Earned Value Analysis

Tania Deena Alex

Toch Institute of Science and Technology

Sahimol Eldhose

Toch Institute of Science and Technology

Abstract- Delays are the most common problem that is faced by construction industry. It is caused by over budget and project lag. These problems can be rectified by the technique Earned Value Analysis. Earned Value Management (EVM) is the process of measuring project performance against a baseline schedule. It enables project managers to identify and control problems by measuring project performance at construction site on time. The paper deals with planning, scheduling and cost management of a multi-storey building. Planning phase include identifying all activities necessary to complete the project and calculation of duration of each activity with respect to the resource availability. Scheduling includes determination of sequential order of activities, assigning planned duration and also determining the start and finish dates of each activity. Primavera P6 software is used for the calculation of earned value, schedule variance, cost variance, schedule performance index and cost performance index. This technique helps to measure the project progress and enables comparison of budgeted cost of work and actual cost.

Keywords: Earned Value Management, Primavera P6, Scheduling

I. INTRODUCTION

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. It provides project managers a greater insight into potential risk areas. Managers can create risk mitigation plans based on actual cost, schedule and technical progress of the work. Earned value analysis calculations are done by using the software Primavera P6. Primavera is a cost, resource and project management software that enables organizations improve their ability to deliver projects on time and within budget.

II. PLANNING AND SCHEDULING

The first stage in a project is planning. Planning is the process of identifying all activities necessary to complete the project and calculation of duration depending on the resource availability. Duration can be calculated by considering the quantity of work and number of laborers.

$$\text{Duration} = \frac{\text{Total quantity of work}}{\text{Quantity of work done per labour per day} * \text{Resources}}$$

(Quantity of work done per labour per day* Resources)

Scheduling which is the second stage is the process of determining the sequential order of activities and assigning planned duration.

Table I: Planning

Sl. No	ACTIVITY	DURATION (in days)	RESOURCE	COST (in Rs.)
1.	Clearing the site	16	40	74,200
2.	Soil investigation & lab test	2	1	369,800
3.	Earthwork excavation in loose soil	5	7	308,750
4.	RCC Single under-reamed piles & reinforcement -t 37.5cm dia pile	26	10	106,140
5.	RCC Single under-reamed piles & reinforcement t 45cm dia pile	13	12	103,140
6.	RCC Single under-reamed piles & reinforcement t 50cm dia pile	12	8	15,120
7.	Pile chipping for 37.5cm dia piles	5	5	12,000
8.	Pile chipping for 45cm dia piles	2	3	11,360
9.	Pile chipping for 50cm dia piles	1	12	21,250
10.	PCC 1:5:10 for foundation	4	5	18,200
11.	Reinforcement work for pile cap	6	10	4,160
12.	RCC for pile	2	7	4,160

	cap			
13.	Reinforcement for plinth beam	6	10	189,000
14.	RCC for plinth beam	4	4	13,120
15.	Filling the basement	2	5	11,352
16.	Brickwork masonry for super structure walls	3	3	25,200
17.	Bar bending for columns and beams	2	5	18,000

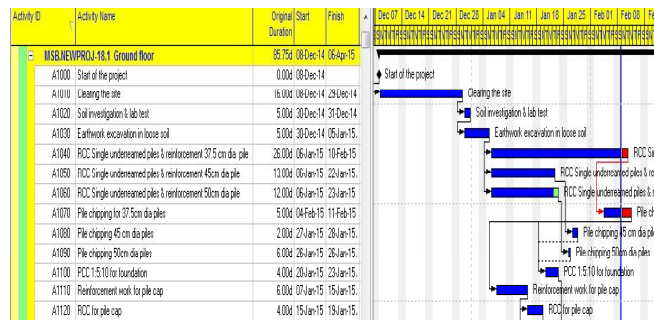


Fig.1: Schedule run in Primavera P6

III. EARNED VALUE

Earned value is a management technique which indicates what will happen to work in future. The project cost and schedule performance are expressed in terms of cost. Certain parameters are used to evaluate the project performance. They are Budgeted Cost of Work Scheduled (BCWS) or Planned Value (PV), Budgeted Cost of Work Performed (BCWP) or Earned Value (EV), Actual Cost of Work Performed (ACWP) or Actual Cost (AC), Cost Variance (CV), Cost Performance Index (CPI), Schedule Variance (SV) and Schedule Performance Index (SPI).

IV. CALCULATION OF EARNED VALUE USING PRIMAVERA P6

- List the tasks required to complete the project

Activity ID	Activity Name
MSB-1 MULTI- STOREY BUILDING	
MSB-1.NEWPROJ-18 Multi-storey building	
MSB-1.NEWPROJ-18.1 Ground floor	
A1000	Start of the project
A1010	Clearing the site
A1020	Soil investigation & lab test
A1030	Earthwork: excavation in loose soil
A1040	RCC Single underreamed piles & reinforcement 37.5 cm dia pile
A1050	RCC Single underreamed piles & reinforcement 45cm dia pile
A1060	RCC Single underreamed piles & reinforcement 50cm dia pile
A1070	Pile chipping for 37.5cm dia piles
A1080	Pile chipping 45 cm dia piles
A1090	Pile chipping 50cm dia piles

- Identify the resources required to perform each task

Resource Name	Resource Type
Site Clearing Crew	Labor
Coarse aggregate	Material
Driver	Labor
Filter	Labor
Mason	Labor
Tiles	Material
M. sand	Material
Steel reinforcement	Material
Portland Cement	Material
Helper	Labor
Painter	Labor
Site engineer	Labor
Concrete mixer	Labor
Bar bender	Labor
Carpenter	Labor
Excavator	Labor
Field Engineer	Labor

3. Determine the amount of each resource that will be required for each task

Resource Name	Budgeted Units
Site engineer	2.00

4. Ascertain the unit cost for each resource

Resource Name	Price / Unit
Site engineer	Rs500.00/d

- Determine the expected cost to perform each task
 - Multiply the unit rate with the total duration required for each resource
 - Total this product for all required labor resources
 - Calculate the total cost of materials required to complete the task
 - Total is the budgeted cost for the task

Resource Name	Price / Unit	Budgeted Units	Budgeted Cost
Site Clearing Crew	Rs4,000.00/d	16.00	Rs64,000.00

- Estimate the length of time each task will take
 - This is the elapsed time to complete the task

Activity ID	Activity Name	Original Duration
MSB	Updated MULTI- STOREY BUILDING	174.52d
MSB.NEWPROJ-18	Multi-storey building	174.52d
MSB.NEWPROJ-18.1	Ground floor	82.52d
A1000	Start of the project	0.00d
A1010	Clearing the site	15.00d
A1020	Soil investigation & lab test	5.00d
A1030	Earthwork: excavation in loose soil	5.00d
A1040	RCC Single underreamed piles & reinforcement 37.5 cm dia pile	15.00d
A1050	RCC Single underreamed piles & reinforcement 45cm dia pile	13.00d
A1060	RCC Single underreamed piles & reinforcement 50cm dia pile	12.00d
A1070	Pile chipping for 37.5cm dia piles	5.00d

7. Identify the prerequisites for each task

- The prerequisites are the tasks that must be completed before the given task can be started

Activity ID	Activity Name	Predecessors
A1010	Clearing the site	A1000
A1020	Soil investigation & lab test	A1010
A1030	Earthwork: excavation in loose soil	A1020
A1040	RCC Single underreamed piles & reinforcement 37.5 cm dia pile	A1030
A1050	RCC Single underreamed piles & reinforcement 45cm dia pile	A1030
A1060	RCC Single underreamed piles & reinforcement 50cm dia pile	A1030
A1070	Pile chipping for 37.5cm dia piles	A1040
A1080	Pile chipping 45 cm dia piles	A1050
A1090	Pile chipping 50cm dia piles	A1060

8. Determine the start and finish dates of each task

Activity ID	Activity Name	Start	Finish
MSB	Updated MULTI- STOREY BUILDING	08-Dec-14	07-Aug-15
MSB.NEWPROJ-18	Multi-storey building	08-Dec-14	07-Aug-15
MSB.NEWPROJ-18.1	Ground floor	08-Dec-14	01-Apr-15
A1000	Start of the project	08-Dec-14	
A1010	Clearing the site	08-Dec-14	23-Dec-14
A1020	Soil investigation & lab test	30-Dec-14	31-Dec-14
A1030	Earthwork: excavation in loose soil	30-Dec-14	05-Jan-15
A1040	RCC Single underreamed piles & reinforcement 37.5 cm dia pile	06-Jan-15	10-Feb-15
A1050	RCC Single underreamed piles & reinforcement 45cm dia pile	06-Jan-15	22-Jan-15
A1060	RCC Single underreamed piles & reinforcement 50cm dia pile	06-Jan-15	21-Jan-15
A1070	Pile chipping for 37.5cm dia piles	04-Feb-15	13-Feb-15
A1080	Pile chipping 45 cm dia piles	27-Jan-15	28-Jan-15

9. Determine the Actual Cost of Work Performed

Activity ID	Activity Name	Actual Cost
MSB	Updated MULTI- STOREY BUILDING	Rs160,231.75
MSB.NEWPROJ-18	Multi-storey building	Rs160,231.75
MSB.NEWPROJ-18.1	Ground floor	Rs160,231.75
A1000	Start of the project	Rs0.00
A1010	Clearing the site	Rs64,000.00
A1020	Soil investigation & lab test	Rs1,626.80
A1030	Earthwork: excavation in loose soil	Rs6,952.05
A1040	RCC Single underreamed piles & reinforcement 37.5 cm dia pile	Rs20,046.00
A1050	RCC Single underreamed piles & reinforcement 45cm dia pile	Rs8,801.00
A1060	RCC Single underreamed piles & reinforcement 50cm dia pile	Rs25,348.00

10. Calculate the Budgeted Cost of Work Scheduled

- Identify the tasks scheduled to start before the project status date, but not scheduled to finish before the project status date.
- These are the scheduled work in progress tasks (WIP).
- Determine the percentage of each scheduled work in progress task that should be completed by the project status date.

- The total budgeted cost is multiplied by the percentage for each task to get the Budgeted Cost of Work Scheduled (BCWS).

Activity ID	Activity Name	Planned Value Cost
MSB	Updated MULTI- STOREY BUILDING	Rs57,475.25
MSB.NEWPROJ-18	Multi-storey building	Rs57,475.25
MSB.NEWPROJ-18.1	Ground floor	Rs57,475.25
A1000	Start of the project	Rs0.00
A1010	Clearing the site	Rs6,032.00
A1020	Soil investigation & lab test	Rs6,507.20
A1030	Earthwork: excavation in loose soil	Rs6,552.05
A1040	RCC Single underreamed piles & reinforcement 37.5 cm dia pile	Rs20,046.00
A1050	RCC Single underreamed piles & reinforcement 45cm dia pile	Rs8,801.00
A1060	RCC Single underreamed piles & reinforcement 50cm dia pile	Rs8,124.00

11. Calculate the Budgeted Cost of Work Performed

- Identify tasks that have been started, but not yet completed.
- Estimate the percent completed for each tasks and multiply the budgeted cost of each task by the percentage completed.

Activity ID	Activity Name	Earned Value Cost
MSB	Updated MULTI- STOREY BUILDING	Rs89,920.15
MSB.NEWPROJ-18	Multi-storey building	Rs89,920.15
MSB.NEWPROJ-18.1	Ground floor	Rs89,920.15
A1000	Start of the project	Rs0.00
A1010	Clearing the site	Rs6,032.00
A1020	Soil investigation & lab test	Rs6,507.20
A1030	Earthwork: excavation in loose soil	Rs6,552.05
A1040	RCC Single underreamed piles & reinforcement 37.5 cm dia pile	Rs20,046.00
A1050	RCC Single underreamed piles & reinforcement 45cm dia pile	Rs8,801.00
A1060	RCC Single underreamed piles & reinforcement 50cm dia pile	Rs8,124.00
A1070	Pile chipping for 37.5cm dia piles	Rs2,001.75

12. Calculate the Schedule Variance & Schedule Performance Index

- $SV = BCWP - BCWS$
- Positive schedule variance indicates the project is ahead of schedule
- $SPI = BCWP/BCWS$
- $CV = BCWP - ACWP$
- $CPI = BCWP/ACWP$

Activity ID	Activity Name	Schedule Variance	Schedule Performance Index	Cost Performance Index	Cost Variance
MSB	Updated MULTI- STOREY BUILDING	Rs32,444.90	1.56	0.96	(Rs70,311.60)
MSB.NEWPROJ-18	Multi-storey building	Rs32,444.90	1.56	0.96	(Rs70,311.60)
MSB.NEWPROJ-18.1	Ground floor	Rs32,444.90	1.56	0.96	(Rs70,311.60)
A1000	Start of the project	Rs0.00	0.00	0.00	Rs0.00
A1010	Clearing the site	Rs0.00	1.00	0.09	(Rs57,568.00)
A1020	Soil investigation & lab test	Rs0.00	1.00	4.00	Rs4,880.40
A1030	Earthwork: excavation in loose soil	Rs0.00	1.00	1.00	Rs0.00
A1040	RCC Single underreamed piles & reinforcement 37.5 cm dia pile	Rs0.00	1.00	1.00	Rs0.00
A1050	RCC Single underreamed piles & reinforcement 45cm dia pile	Rs0.00	1.00	1.00	Rs0.00
A1060	RCC Single underreamed piles & reinforcement 50cm dia pile	Rs0.00	1.00	0.32	(Rs17,224.00)
A1070	Pile chipping for 37.5cm dia piles	Rs2,001.75	0.00	1.00	Rs0.00

13. Compute the budgeted cost for the entire project by adding the BCWS for all project task

- The resulting total is known as the Budget at Completion (BAC).
- The total cost of the project at its completion is the Estimate at Completion (EAC).

Activity ID	Activity Name	Planned Value Cost	Budget At Completion	Estimate At Completion Cost
MSB	Updated MULTI-STOREY BUILDING	Rs.57,475.25	Rs.1,470,866.25	Rs.1,541,473.95
MSBNEWPROJ-18	Multi-storey building	Rs.57,475.25	Rs.1,470,866.25	Rs.1,541,473.95
MSBNEWPROJ-18.1	Ground floor	Rs.57,475.25	Rs.2,463,046.25	Rs.2,516,487.85
A1000	Start of the project	Rs.0.00	Rs.0.00	Rs.0.00
A1010	Closing the file	Rs.6,032.00	Rs.6,032.00	Rs.6,032.00
A1020	Soil investigation & lab test	Rs.6,507.20	Rs.6,507.20	Rs.6,526.80
A1030	Earthwork excavation in loose soil	Rs.6,552.05	Rs.6,552.05	Rs.6,552.05
A1040	RCC Single unreinforced piles & reinforcement 37.5 cm dia pile	Rs.20,046.00	Rs.20,046.00	Rs.20,046.00
A1050	RCC Single unreinforced piles & reinforcement 45cm dia pile	Rs.6,801.00	Rs.6,801.00	Rs.6,801.00
A1060	RCC Single unreinforced piles & reinforcement 50cm dia pile	Rs.6,124.00	Rs.6,124.00	Rs.25,346.00

V. RESULTS

The results obtained are as follows:

Table II: Results Obtained

ITEM	
NAME OF PROJECT	MAHIMA APARTMENTS
LOCATION OF PROJECT	KADUNGAMANG-ALAM
TOTAL DURATION (in days)	852
TOTAL COST (in Rs.)	17,320,805
RESOURCE USED	LABOUR AND NON-LABOUR
CALENDAR CREATED	STANDARD 5-DAY CALENDAR
RELATIONSHIP USED	START TO START & FINISH TO START

The project was updated on 9th Feb '15.

Table III: Output

PARAMETERS	VALUES	REMARKS
Planned Value	Rs.57,475.25	
Earned Value	Rs.89,920.15	
Actual Cost	Rs.160,231.75	
Total Budgeted Cost	Rs.1,542,873.45	
Schedule Variance	Rs.32,344.90	Positive value ie, ahead of schedule

Cost Variance	-Rs.70,311	Negative value ie, over budget
Schedule Performance Index	1.56	Greater than 1. ie, Project is ahead of the schedule
Cost Performance Index	0.56	Less than 1. ie, project is over budget

VI. CONCLUSION

Project monitoring and control is made easier by earned value method using primavera P6. It can be inferred that the project is ahead of the schedule and over budget from schedule performance index and cost performance index respectively. Therefore, earned value analysis is a method which should be used by all project managers in order to understand the project performance well in advance.

REFERENCES

- [1] A. Prasanth, T. Raja. Analysis of cost and schedule performance of residential building projects by EVM technique. *Journal of Construction Engineering, Technology and Management*, 2014, 4(1), 1-7.
- [2] A. Verma, K. K. Pathak, R. K. Dixit. Earned value analysis of construction project at Rashtriya Sanskrit Sansthan, Bhopal. *International Journal of Innovative Research in Science, Engineering and Technology*, 2014, 3(4), 11350-11355.
- [3] R. Gupta. Earned value management system. *International Journal of Emerging Engineering Research and Technology*, 2014, 2(4), 160-165.
- [4] S. M. Masood, R. Devanand, H. N. Harsha. An analysis on resource planning, cost estimation and tracking of project by earned value management. *International Journal of Engineering and Innovative Technology*, 2014, 4(4), 42-48
- [5] T. Subramani et al. Analysis of cost controlling in construction industries by earned value method using primavera. *International Journal of Engineering Research and Applications*, 2014, 4(6), 145-153.