

Detailed Project Scheduling and Cost Management

A Case Study on Dhaaruni Commercial Complex Bengaluru

Lathan B.S¹, Dr.Srinath Shetty.K²

¹P.G Student, ²Professor & Head
Civil Engineering
NMAM Institute of Technology, Nitte, Karkala
Udupi, Karnataka, India

Abstract – An efficient project planning. Scheduling and cost management is necessary to ensure that the project won't suffer any delays in the schedule and risk of going over budget. The main objectives of this case study are to plan, schedule, and implement a proper cost management system to a commercial project with the help of Project management software, i.e. Primavera and to analyze the results generated. After studying the results the aim is to suggest any changes or improvements to the company for improving their planning methods for similar projects in future.

Keywords – Planning; Scheduling; Tracking; cost management

I. INTRODUCTION

Planning is the very first activity in managing and executing of construction projects. It involves defining of methodologies adopted, estimating the durations of the activities and cost of each of those activities and also the resources and expenses associated with those activities. An excellent construction plan is the basis for preparing the efficient schedule and the budget for the project. Scheduling can be defined as the thorough plan of the project tasks with reference to time. Project cost management contains the methods necessary to make sure that the project is finished well within the permitted budget.

Earned value analysis is the most common tool used for tracking and forecasting the project progress. It helps to measure the performance of the project's schedule, cost and scope.

II. OBJECTIVES OF THE STUDY

- To identify and record the construction sequence for a commercial building using real-time data collection.
- To work out the practical durations required to carry out the scheduled activities with respect to the available resources on site.
- To determine the overall budget of the project considering the schedule, resource availability.
- To develop a Project schedule using PRIMAVERA project planning software.
- To develop an efficient Cost management plan to ensure that the project comes under the estimated budget.
- To track the project performance using Primavera and also to forecast the project features.
- To examine and rectify the flaws in the planning and scheduling process of the organization and propose suitable improvements in the process and methods.

III. METHODOLOGY

A. Data Collection

The first step in the preparation of an efficient schedule is to collect the real time data from the work site. Data's to be collected is the information regarding resource availability on site, working conditions on site, present rate of materials and equipments from the project personnel on site. From the collected data we can proceed to the next step of the process i.e. scheduling.

B. Scheduling

The data collected from the site acts as a main input to the planning and scheduling process. The schedule will be prepared using the data to produce a master schedule. The Project Management software used in this project is Oracle Primavera. The Master Schedule will give all the information with respect to time and cost associated with the project. This master schedule will be used as a baseline to compare the schedule after it is being updated. Duration of the activities is calculated by referring the resource availability and also from the guidelines of the project personnel at site.

C. Project Cost Management

As a part of the case study the cost management of the project has to be done. Project Cost Management is nothing but a process required to make sure that the project is finished within the approved budget. It involves the following steps:

1) **Cost Estimating:** Cost estimation is a process to develop an approximate estimation of the cost needed to complete project activities. In this Project the tool used to estimate the cost is Primavera.

2) **Cost Budgeting:** Cost budgeting is a process of allocating the project cost estimates to individual activities in order to prepare a cost baseline to determine the project performance. Cost estimation, Work Breakdown Structure and Project schedule are the inputs to cost budgeting. The outputs we get from this process is baselines of the project with respect to which the progress will be evaluated.

3) **Cost Control:** Cost control is a process of monitoring the cost performances to detect any variance from the original plan. It is concerned with (a) persuading the factors which create changes to the cost baseline and to ensure that changes are beneficial, (b) to find out whether the cost baseline has changed, and (c) dealing with the actual changes when and as they occur. The inputs to cost control will be cost baseline and performance reports. Cost baseline is prepared by adding estimated costs by updating period and is displayed in the form of an S-curve. Performance reports are nothing but the information collected on the performance of the project activity at certain interval of time which is called updating dates. Here the project progress is noted from the site and is updated in to the software.

D. Tools and Techniques for cost control:

The most important tool used to measure the performance of the project is Earned Value Analysis which is most used tool for this purpose in construction industry.

1) **Earned Value Analysis/ Management:** Earned Value analysis is a well established tool in the construction industry which utilizes the data regarding the cost, schedule and project performance to establish the current status of the project. The analysis needs the following inputs:

- Planned Value (PV) – Planned value is nothing but the budgeted cost of the schedule prepared at the beginning of the project. This acts as a baseline cost to measure the cost performance of the project.
- Earned Value (EV) – Earned value is simply the cost occurred for what that has been physically constructed.
- Actual Cost (AC) – Actual cost is the total cost incurred to the actual work completed to data date. Here data date refers to the updating date.

After obtaining the above inputs the next step is to determine the status of the project. The following are the parameters which will point out the status of the project.

- Cost Variance (CV): Cost Variance is nothing but the difference between Earned Value and Actual cost of work done till the data date i.e. the updating date. If CV comes negative it indicates that the project is over budget.

$$CV = EV - AC \quad (1)$$

- Schedule Variance (SV): Schedule Variance is nothing but the difference between Earned Value and Planned Value. If SV comes negative it indicates a delay in the project.

$$SV = EV - PV \quad (2)$$

- Cost Performance Index (CPI): Cost Performance Index evaluates the cost efficiency of the project. If the CPI value is greater than 1 then it indicates the project is saving cost but if the value is less than budget it indicates that the project is over budget and requires immediate attention.

$$CPI = EV/AC \quad (3)$$

- Schedule Performance Index (SPI): SPI indicates the time efficiency of the project. If SPI value is greater than 1 it indicates that the project is ahead of planned schedule and if less than 1 it indicates the project is delayed and requires immediate action.

$$SPI = EV / PV \quad (4)$$

After calculating the project status parameters the next step is to determine the project forecasting parameters. The following are the project forecasting parameters.

- Budgeted Actual Cost (BAC): It's nothing but the total allocated budget of the project.
- Estimate at Completion (EAC): It is required to predict or forecast the total cost of the project at the time of completion.

$$EAC = BAC / CPI \quad (5)$$

- Estimate to Completion (ETC): Estimate to completion helps us to calculate the amount required to finish the project from the data date i.e. updating date.

$$ETC = AC - EAC \quad (6)$$

E. Updating Methodology

Once the project is started, we need to update the actual schedule information and resource usage at regular intervals. In this case study, the updates will be done twice a month based on the real time data collected from the project site.

IV. CASE STUDY

Dhaaruni Commercial complex is the project selected for the case study. The project is coming up in Mahadevapura, east Bengaluru, Karnataka. The commercial building has Basement + Ground + 4 floors. Plot Area is 1773.88 sqm. Total super built up Area is 4769 sqm with ground floor equals to 756.74 sqm and typical floors having 1003.14 sqm. Basement is provisioned for parking.

The case study was conducted for a period of 6 months from 01-Dec-2016 to 01-May-2016. The details which were essential for the cost estimation and schedule preparation were collected from site as a part of real time data collection during the first month of the project. The schedule was prepared using Primavera with reference to the resources available at site and the present rate analysis values. The Details of the Project is shown in Table 1

Table 1 Project Details

Description	Details
Organization	Saakara Associates
Project Name	Dhaaruni
Site Location	Bengaluru
Estimated Duration	19 Months
Estimated Budget	6,14,95,580/-
Project Start	05-Jan-2016

A. Steps involved in Creating a Project Schedule:

The following are the steps involved in creating a project schedule with respect to the available resources at site.

1) **Creating a WBS:** The first step of the project is to create a Work Breakdown Structure. WBS will allow the project to be divided into manageable parts, the activities can then be added to the WBS.

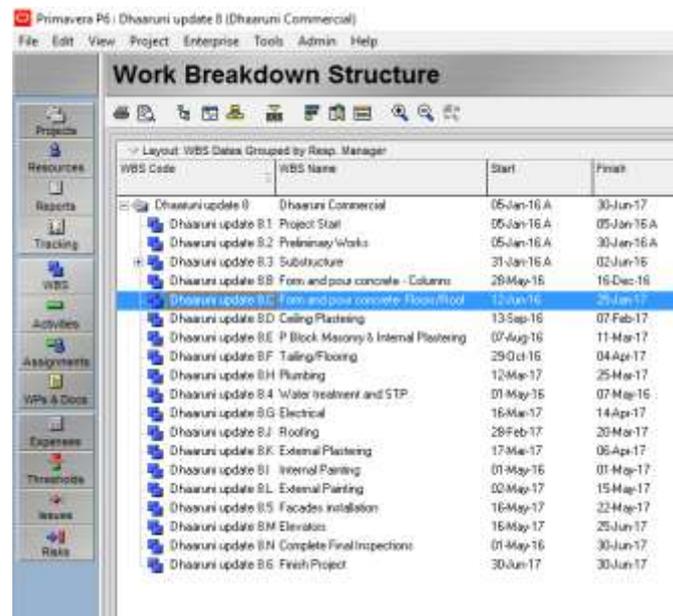


Fig 1: Creating a Work Breakdown Structure

2) **Adding activities and creating relationships or logic between activities:** The first step of the project is to create activities required to complete the project. Then the logic between the activities are assigned.



Fig 2: Assigning Activities and Relationships

3) **Add Resources to the Activity:** The next step is to add resources and expenses to each activity to determine the total budgeted value or Planned value of the project.



Fig 3: Assigning Resources to the activities

4) **Assigning a Baseline to the project:** The next step is to assign a baseline to the project. The master schedule prepared will be assigned as a baseline to the project and then it will be updated twice a month. Assigned baseline will act as a replica with which all the comparison regarding the cost and schedule progress is made. Creating a baseline is an important step in order to update the project in the future.

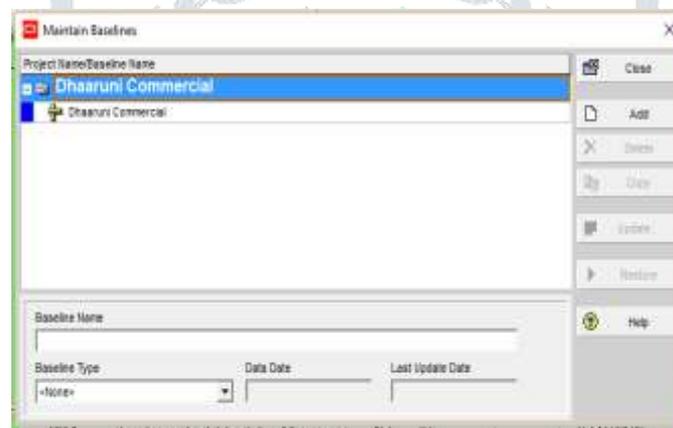


Fig 4: Assigning Baseline

5) **Updating the activity:** The next important step is to update the activity at a regular intervals, in this case study the project is updated twice a month, i.e. 1st of every month and 15th of every month. This is done by collecting the datas at site about the project's progress like the actual cost and duration incurred for an activity. Here the project is updated considering three parameters, i.e percent physical complete, resource actual units and Expenses.

Activity ID	Activity Name	Original Duration	Actual Duration	Actual Start	Actual Finish	Planned Start	Planned Finish	Activity % Complete
000	Project Start	0d	0d	04-Jan-15	05-Jan-15	04-Jan-15	05-Jan-15	100%
001	Preliminary Works	15d	25d	05-Jan-15	30-Jan-15	05-Jan-15	30-Jan-15	100%
002	Structural Consultancy & Drawing	2d	2d	05-Jan-15	06-Jan-15	05-Jan-15	06-Jan-15	100%
003	Site Clearance	2d	2d	07-Jan-15	08-Jan-15	07-Jan-15	08-Jan-15	100%
004	Site Marking	1d	1d	08-Jan-15	09-Jan-15	08-Jan-15	09-Jan-15	100%
005	Construction of walls	7d	17d	09-Jan-15	20-Jan-15	09-Jan-15	20-Jan-15	100%
100	Substructure	115d	123d	21-Jan-15	29-Mar-15	21-Jan-15	29-Mar-15	100%
101	Footings and Retaining Walls	74d	123d	21-Jan-15	29-Mar-15	21-Jan-15	29-Mar-15	100%
102	Footings and Foundations and Retain...	71d	79d	21-Jan-15	28-Feb-15	21-Jan-15	28-Feb-15	100%
A2342	PCU for Footing	3d	3d	21-Jan-15	02-Feb-15	21-Jan-15	02-Feb-15	100%
A2343	Setting of footing column and Retaining wall	1d	1d	04-Feb-15	04-Feb-15	04-Feb-15	04-Feb-15	100%
A2344	Set reinforcement for footings and Columns	5d	5d	05-Feb-15	09-Feb-15	05-Feb-15	09-Feb-15	100%
A2345	Form Footings and PIV Decks	5d	5d	10-Feb-15	14-Feb-15	10-Feb-15	14-Feb-15	100%
A2346	Footings Columns	1d	1d	15-Feb-15	15-Feb-15	15-Feb-15	15-Feb-15	100%

Fig 5: Updating the activities

6) **Tracking the Project:** After updating the percent complete, resources and expenses the next step is to track the activity with which the values required for the EVA analysis were recorded. The parameters which were recorded were Planned Value, Earned Value, Actual Cost, Cost Variance, Budget at Completion. Using these values the overall Cost and Schedule Performance Index were then calculated.

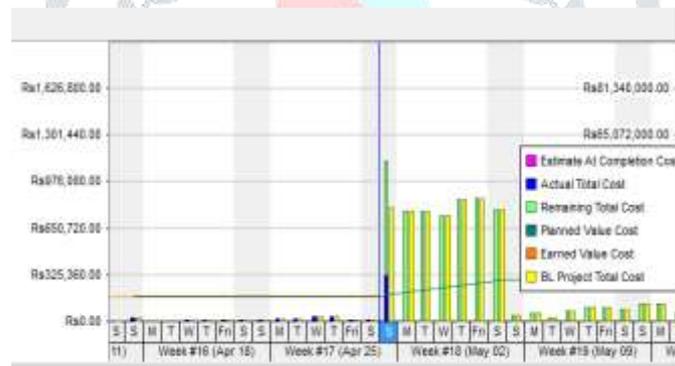


Fig 6: Tracking the Project Progress

The values are then arranged in Microsoft Excel and are then shown in the following tables; this step is done just to provide better visibility of the data.

Table 2 Project Cost Details

Sl No.	Description	Cost (Rs)
1	Preliminary Works	1295600
2	Structural Works	32460790.79
3	Ceiling Plastering	848575
4	P Block Masonry & Plastering	2175120.5
5	Flooring and Tiling	3111500
6	Plumbing	400000
7	Water Treatment and STP	5000000
8	Electrical Work	5750000
9	Roofing	95250
10	External Plastering	347770
11	Painting	185973.88
12	Facades	5000000
13	Elevators	4400000
14	Final Inspection	425000
	Total Amount(Rs)	61495580.17

Cost incurred to each WBS activities during the planning stage is shown in the above table. Cost estimation is done with reference to the resource available at site and according to the present market rate of materials.

Table 3 Project Schedule Details

Task	Start	Finish
Total Duration (517 days)	05-Jan-16	04-Jun-17
Start of the Project	05-Jan-16	
Preliminary Works	05-Jan-16	23-Jan-16
Structural Works	24-Jan-16	30-Dec-16
Ceiling Plastering	18-Aug-16	12-Jan-17
P Block & Internal Plastering	12-Jul-16	13-Feb-17
Tiling / Flooring	03-Oct-16	09-Mar-17
Plumbing	14-Feb-17	27-Feb-17
Water Treatment and STP	28-Feb-17	06-Mar-17
Electrical	18-Feb-17	19-Mar-17
Roof Works	02-Feb-17	22-Feb-17
External Plastering	19-Feb-17	11-Mar-17
Painting	06-Apr-17	19-Apr-17
Facades Installation	20-Apr-17	26-Apr-17
Elevators	20-Apr-17	30-May-17
Final Inspection	31-May-17	04-Jun-17
Finish of the Project		04-Jun-17

Activity durations of each activity is calculated by considering the productivity of the resource available at site and also with the suggestions taken by the experienced professionals at site

Table 4 Values of AC, EV, PV

Months	Cum. Actual Cost (AC) Rs	Cum. Earned Value (EV) Rs	Cum. Planned Value (PV) Rs
15-Jan-16	838400	838400	909885.71
01-Feb-16	1396713.64	1346713.64	1448956.25
15-Feb-16	2654146.92	2596760.92	2600760.92
01-Mar-16	5835380.65	5672938.5	5672944.65
15-Mar-16	7166421.12	7044357.72	7044363.87
01-Apr-16	8036732.31	7840034.81	8191785.17
15-Apr-16	8596984.54	8379724.25	8700734.75
01-May-16	8790245.38	8571502.12	8892512.62

Table 5 Values of CV, SV, CPI, and SPI

Months	Cost Variance (CV)Rs	Cost Performance Index(CPI)	Schedule Variance (SV)Rs	Schedule Performance Index(SPI)
15-Jan-16	0	1.00	-71485	0.92
01-Feb-16	-50000	0.96	-102242	0.93
15-Feb-16	-57386	0.98	-4000	1.00
01-Mar-16	-162442	0.97	-6.15	1.00
15-Mar-16	-122063	0.98	-6.15	1.00
01-Apr-16	-196697	0.98	-351750	0.96
15-Apr-16	-217260	0.97	-321010	0.96
01-May-16	-218743	0.98	-321010	0.96

The forecasting parameters which will determine where the project will stand in the future with respect to the cost and schedule is then calculated using tracking parameters, i.e CV, SV, CPI, SPI.

Table 6 Forecasting Values

Months	Estimate At Completion (EAC) RS	Variance at Completion (VAC) Rs	Estimate To Completion (ETC) Rs
15-Jan-16	61485080.17	0	60646680.2
01-Feb-16	61535080.17	-50000	60138366.5
15-Feb-16	61592466.17	-107386	58938319.3
01-Mar-16	61647522.32	-162442.15	55812141.7
15-Mar-16	61679599.82	-194519.65	54513178.7
01-Apr-16	61695447.17	-210367	53658714.9
15-Apr-16	61707009.96	-221929.79	53110025.4
01-May-16	61708492.93	-223412.76	52918247.6

The Estimate at Completion (EAC) provides us the forecasted value of the project when it is completed. It tells us how much we may have to spend to finish the project. In other terms we can say that it is the amount of money that the project will cost us at the end. The Estimate to Completion (ETC) is a forecasting tool that ensures us the expected amount of money that will be used up to complete the remaining part of the project.

V. RESULTS

Planned value (PV), Earned Value (EV), and Actual Cost (AC) along with tracking and forecasting values are required to evaluate the progress of the project using Earned Value Analysis. The data collected from the site for a period of 6 months from December 1st to May 1st were used to update the progress of the project from which the following results were generated and studied. The project has been updated for a total of 8 times, the dates of which are mentioned in all of the tables above. The Schedule Performance Index (SPI) of the project at the end of last updating period, i.e. 01-May-2016 was 0.96 which indicates that the project is progressing at the rate of 96% when compared to the Baseline. It indicates that the project is clearly behind the schedule. The Cost Performance Index shows the value of 0.98 which shows that the project is over the budget by 2% i.e. the project is over budget by Rs. 2,23,412.76. With reference to the performance of the project till 1-May-2016 shows that Estimation at Completion will be Rs. 61708492.3 which is Rs. 223412.76 more than the original planned cost. And also the amount required to complete the project will be Rs. 52918247.6 which is the Estimation to completion.

VI. CONCLUSION

Scheduling, Cost management along with efficient cost control tool such as earned value analysis is very important to finish the project within the stipulated budget and time. Activities on the site with respect to execution of the commercial project are thoroughly observed and comparison is made between planned and actual executed schedule. From the data collected from site and from the calculated results we can conclude that the project is off schedule and over budget as of now. Based on the results the Project Engineer can take corrective measures to bring back the project on schedule and on budget.

Major reasons for delay are related with the shuttering contractor's performance such as lack of manpower and materials at site. Another reason for the delay is the weather and hard working conditions at site which led to the delay in excavation works which affected the project's overall duration.

After the study, the organization has also found that monitoring and tracking the project using Project Management Software is helpful to keep more precise watch on the projects and also the sub contractor's performance. The organization has modified their planning and scheduling methods by setting weekly targets to sub contractors instead of monthly targets. And have also decided to consider the risks during scheduling process.

VII. ACKNOWLEDGEMENT

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