Application of Variance Analysis in Construction Cost Monitoring and Controlling

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Abstract--The absence of a well conventional effective system for monitoring and controlling project cost has caused failures to many contractors in the construction industry. Due to that condition clients in construction industry have become increasingly dissatisfied. This study therefore was carried out to found the most effective system for monitoring and controlling project cost in the construction industry by applying variance analysis. The use of excel spread sheet to calculate types of cost variances such asto measure quantity variance, price variance and productivity variance,instead of using costly software. By considering the actual and planed final state of project, it is possible to build a quite detailed picture of the project. An extension of the idea of the method of variances is the Earned Value Analysis technique. This technique is relatively popular which help to cost analysis and calculate Schedule variance, Cost variance, Time variance etc.

Keywords-Excel spread sheet, Earned value analysis. quantity variance, price variance, productivity variance.

I.INTRODUCTION

Effective cost monitoring and controlling has received much attention in the construction industry due to excessive cost growth and woefully profit margin of some contractors. In a project, plans are usually drawn to ensure that work is carried out to the preferred quality in the allowed time, and according to budget. As project grows in size and complexity, the ability to plan, monitor and control them has become a key project management function. Like any other business, builders, contractors and developers have to plan and organize their day-to-day activities in order to manage effectively. Monitoring and controlling are universal activities indispensable to effective and efficient operation of the control cycle. According to Al-jibouri (2003), within construction, divergences from the original plan will occur; therefore Project should have a control cycle as follows with the aim of completing project within acceptable time and budget:

1. Make a plan
2. Implement the plan
3. Monitor the actual output and record it.
4. Report the actual, the planned parameters and their variations.
5. Take corrective action on the variation

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. Monitoring provides quantitative information on which control action may be based. It will always fall short of accuracy and the possible size error should be borne in mind when control action is taken. When controlling project performances, it is important to monitor cost and time variances for the actual project progress.

This paper gives an idea about calculation of cost variance and its components using excel spreadsheets. For these calculations first it is necessary to know about project, project control process, and then knowing about what is variance and its components. After knowing all these one by one finally how spreadsheets can be used for calculating variances is explained.

II.LITERATURE REVIEW

Cost, schedule, and quality are three major measures for construction project performance appraisal. Among these three measures, cost and schedule are objective and quantitative, while quality is somewhat subjective and qualitative. In addition, cost and scheduling are closely interrelated, because they share a lot of common data in their controlling processes. Therefore, integrating cost and schedule control functions provides an effective tool for monitoring the construction process.

Earned Value is a project control technique which provides cost and schedule performance measurements. It compares actual accomplishment of scheduled work and associated cost against an integrated schedule and budget plan. The earned value technique is a proven method to evaluate work progress in order to identify potential schedule slippage and areas of budget overruns. Value earned for a given task is computed as budgeted cost of work performed and is a function of time, work completed, and budget. Budgeted cost of work performed is compared against actual cost of work performed and budgeted cost of work scheduled to assess cost and schedule variances, respectively. Several authors have published papers for calculation of cost, schedule and time Variances.
[1] Alberto De Macro, Diego Briccarello, Carlo Rafele.

(2009). "Cost and Schedule Monitoring of Industrial Building Project:- Case Study" overcomes the problem of practicability and predictability of traditional estimates at completion based on early progress measurement by presenting the empirical results from the construction project of an industrial facility.

[2] Andrew Fernans Tom, Sachin Paul. (2013). "Project Monitoring and Control using Primavera" present study deals with the project   monitoring process of "Standard Design Factory", a four storied (G+3) factory building whose construction is in progress at Cochin, Kerala. A comparison between the planned progress of construction work and actual progress is performed in this study using project management software Primavera P6.

[3] Mee-Edoiye M. Andawei. (2014). "Project cost monitoring and control: A case of cost/time variance and earned value analysis" The paper therefore encourages the use of variance and earned value analysis to ensure cost and time compliance of all project activities. The comprehensive status framework provided by the variance and earned value analysis.

[4] WillianRasdorf, Osama.Abudayyeh. (1991). "Cost and Schedule-Control Integration: Issues and Needs" This Paper Provides an Over view of cost and schedule control functions and Number of integrated cost and schedule control data model.WBS and CBS models.

[5] Robert Carr. (1993). "Cost, Schedule and Time Variances and Integration" presents detailed equations that describe parallel hierarchical cost and schedule control systems that calculate cost, schedule and time variances at different levels of detail. The writer presents a cost-control relationship at the activity/cost-account level using generic microcomputer software to budget, track and control projects.

When cost, schedule and time variances share a common WBS in an integrated view, the elements quantity, rate, productivity, start and resource variances can be represented in earned value units.

III.OBJECTIVES OF STUDY

This paper aims to investigate the effectiveness of commonly used monitoring and controlling systems in the construction industry. The specific objectives of this paper are:

- To identify project monitoring systems for controlling cost in the construction industry.
- To determine whether the implemented system have the ability to indicate on-going cost status of each work item.
- Development of user friendly worksheet to prepare budget, track progress and compute variance at component level.

IV. METHODOLOGY

Fig.1 Methodology flow chart

1. Literature Review

- Literature relating to project monitoring and cost control.
- Literature on variance and its components.
- Literature on earned value technique.

2.Data collection

- Data collected of a project would comprise of:
- Project plan, schedule and budget.
- Base rates of resources considered during rate analysis(as per DSR-14-15)
- Actual costs for activity executed.
- Actual quantities for activity executed.

3. Data analysis:

Data analysis consists of calculation of cost variance and its components. Cost variance is divided into three components namely:

1. Cost Quantity Variance
2. Cost Price Variance
3. Cost Productivity Variance

V.RESULT AND DISSCUSION

In this paper explain by using an example of variance analysis of Elevated Service Reservoir project which is located in Satara City (Maharashtra).

To calculate cost variance and its components, following data is required:

1. Project plan, schedule and budget.
2. Base rates of resources to be considered during rate analysis.
3. Actual quantities of activity executed.
4. Actual cost for activity executed.

From the project plan, a schedule of activities which are to be executed is prepared as shown in Table 1.Duration of activities is taken in terms of weeks. Rate analysis is done for activity no.3 shown in Fig.2. After rate analysis is done, the first step is to prepare budget sheet where how much work should be done in a week is given as per schedule.

The steps are as follows:

a) The budget quantity sheet is prepared.

b) From the total budgeted quantity(Q_{tb}), the budgeted material quantity(Q_{bm}) calculated as Budgeted Material Quantity (Q_{bm}) = Total budgeted quantity (Q_{tb}) * Unit Material Quantity (Q_{um})

c) Similarly, from the total budgeted quantity(Q_{tb}) the budgeted labour quantity is calculated as Budgeted Labour Quantity (Q_{bl}) = Total budgeted quantity (Q_{tb}) * Unit Labour Quantity (Q_{ul})

d) After calculating the quantities, the budgeted material rate (R_{bm}) and budgeted labour rate (R_{bl})

e) The budgeted cost of material and labour The budgeted material cost (C_{bm}) is calculated by formula given asunder: Budgeted Material Cost (C_{bm}) = Budgeted Material Quantity (Q_{bm}) * Budgeted Material Rate (R_{bm}) similarly, the budgeted labour cost (C_{bl}) is calculated by formula given as under:
Budgeted labour cost (C_{bl}) = Budgeted labour Quantity (Q_{bl}) * Budgeted Material Rate (R_{bl})

f) Now, after actual execution of work, the total actual quantity (Q_{ta}) is noted in actual quantity sheet.

g) After actual execution of work, the actual material quantity (Q_{am}) and actual labour quantity (Q_{al}) are noted.

h) The actual material rate (R_{am}) and actual labour rate (R_{al}) are noted.

i) The actual material cost (C_{am}) is calculated by formula given as under:
Actual Material Cost (C_{am}) = Actual Material Quantity (Q_{am}) * Actual Material Rate (R_{am})
Similarly, the actual labour cost (C_{al}) is calculated by formula given as under:
Actual labour cost (C_{al}) = Actual labour Quantity (Q_{al}) * Actual Material Rate (R_{al})

j) The total cost of material and labour are summed and it is noted as Actual Cost of particular Item

k) The cost variance(CV)) which is difference between budgeted cost and actual cost is as shown in formula below:

Cost Variance (CV) = Budgeted Cost – Actual Cost
S-Curve Fig.3 shows Budgeted cost Vs actual cost comparision.

l) Cost variance is further broken down into its 3 components as follows:

*Cost Quantity Variance:*Cost quantity variance iscalculated as formula is given below:
Cost quantity variance (CV_{quant}) = (Total budgeted Quantity (Q_{tb}) - Total actualQuantity (Q_{ta})) * Unit quantity (Q_u) * Unit rate (R_u)

*Cost Price Variance:*Cost Price variance is calculatedas formula is given below:
Cost price variance (CV_{price}) = (Budgeted Rate (R_b) – Actual Rate (R_a)) * Totalbudgeted quantity (Q_{tb})

Cost Productivity Variance: Cost Productivity Variance is in case of labouronly calculated as given below:
Cost Productivity variance (CV_{prod}) = (Total Actual Quantity (Q_{ta}) * Unit labour quantity (Q_{ul}) – Actual

labour quantity (Q_{al})) * Budgeted labour rate (R_{bl})
Above variances shown in Fig.5

TABLE I
ESTIMATED SCHEDULE AND QUANTITY

Item No.	Description of Item	Qty	Unit	Duration (week)	Start	Finish
1	Excavation in soft Strata(murum)	71.0	Cu.m.	3	0	3
2	Excavation in hard Strata(murum)	218.6	Cu.m.	8	3	11
3	PCC Bedding in footing (1:2:4)	10.93	Cu.m.	1	11	12

Activity no.3: Plain Cement ConcreteM-15 in foundation(for 1cum)					
(considering 52% extra)			1 bag=0.035 cu.m cement		
A	MATERIAL	Quantity	Unit	Rate	Amount
1	Cement	0.22	cu m		
		5.90	bags	300	1770.00
2	Sand	0.45	cu m	1010	454.50
3	Agg.	0.87	cu m	710	617.70
	Total (A)=				2842.20
B	LABOUR				
1	mate	0.1	No.	302	30.20
2	Mason	0.2	No.	298	59.60
3	Mazdoor (M)	0.6	No.	294	176.40
4	Coolie (F)	1	No.	290	290.00
5	Waterman	0.25	No.	150	37.50
	Total (B)=				593.70
	Total(A + B)=				3435.90
	Add Sundries & Cont.			3%	103.08
	Add Water Supply & ele.			1.5%	51.54
	Extra lead charges for 45 km				120.00
	Add Profit			10%	343.59
				Total	4054.11
	Cost for 1 Cu.M=			Rs	4054.11

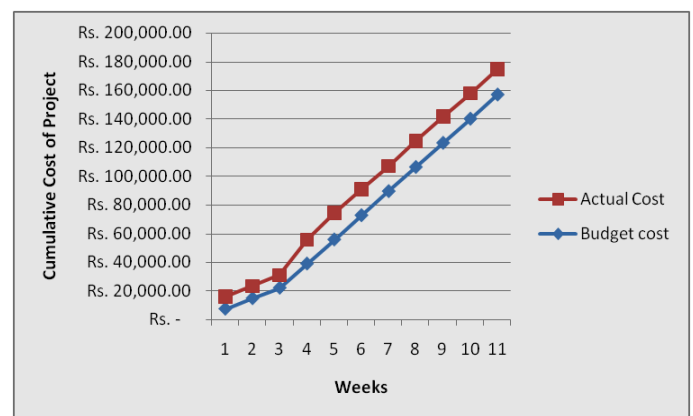Fig.2 Rate Analysis of activity No3 (PCC1:2:4)

Fig.4 Shows Cumulative Budgeted and Actual Cost

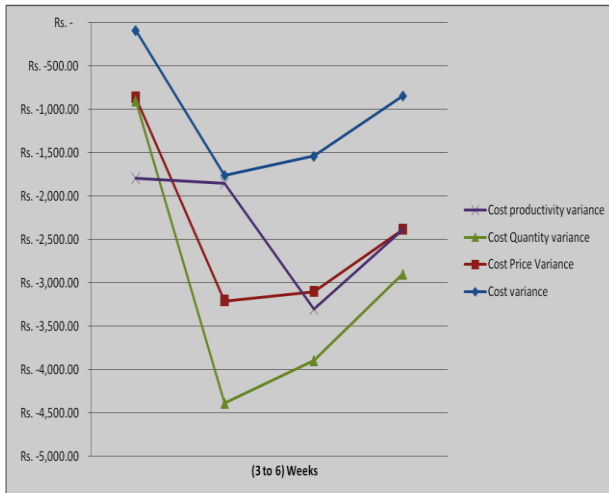Fig.5 Graph shows 3rd to 6th weeks Various types of Variance (Cost Variance, Cost Price variance, Cost Quality variance, Cost Productivity Variance)

VI. CONCLUSION

Time, Cost and Quality are the three parameters which have to be monitored during the project. Variations from the budgeted values of time, cost, and quality are very common on construction projects from these variances; one can know how much variance is occurring with respective activity. Variances are calculated from the contractor's point of view.

After variance analysis, it can be seen that the variances if calculated at early stage can reduce further costs overruns of the project. It can be seen that by knowing the factors of variances, one can identify potential problems and can take corrective action accordingly which serves as a key element of a project's risk management process.

It allows better and more effective management decision making to minimize adverse impacts to the project. It ensures a clear definition of work prior to beginning that work. It presents a logical plan for accomplishing the work.

Excel spread sheet help to calculate all variances described above and monitoring changes of week to week.

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