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Evaluation of percentage of Value of Work Done for Construction Projects in India using Earned Value Analysis

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Abstract: ***Background/Objectives: To evaluate the Value of Work Done (VoWD) for a Construction project using Earned Value Method (EVA).***

Methods: Ratio of Value of Work Done to the estimated value at completion.

Results/Findings: Can be implemented at construction industry especially for the process plant construction projects.

Conclusion/Application: 'Automation in part of construction activities' can be implemented in construction industries.

Keywords: Definition of Earned Value Analysis (EVA) - a quantitative project management technique for evaluating project performance

I. INTRODUCTION

Effective project management requires controlling all aspects of a construction project like quality of the work, quantity of work, costs, and schedules to ensure the successful completion of the project and to achieve the organization goal. Monitoring the project throughout the entire construction project is critical[1]. There are many ways to measure the project progress such as CPM, Milestones, Cost spent etc. one way of measuring overall performance is by using an aggregate performance measure known as Earned Value.

All work is planned, budgeted, and scheduled in time phased planned value increments constituting a budget part and a schedule measurement baseline. Earned Value is mainly used to monitor the progress of work and compare accomplished work with respect to the planned work. [2]

II. PRESENT METHOD BEING FOLLOWED IN INDUSTRY

During the construction phase it is important to measure the project progress. So how much work was accomplished? This is a common question project managers asks and the Project Control team may not be having a quantitative reply in absence of any proven technique. Too often, progress report is generated in a qualitative manner. Status of the Project would be either "Almost there" or nearing completion." After weeks of reading the same traditional progress report, the project manager or the sponsor begins to doubt about the completion of the project[3].

Quantitative techniques are obviously much better than qualitative (subjective) techniques for measuring projectprogress[4]. Since the types of work packages on a project vary, no single progress reporting method is suitable. The following are the most common methods for reporting project progress.

A. Quantitative progressing techniques

a. Units completed - tasks that involve repeated production of easily measured pieces of work, when each piece requires *approximately* the same level of effort. This is suitable for the repeated works like production of some spare parts in a factory or brick casting in a pre-casting yard of a construction site

b. Incremental milestones - work packages (WP) that can easily be divided into a series of tasks handled in sequence. The work is divided into separate, measurable tasks, and completing each task is considered achieving an "incremental milestone". Progress is earned only when reaching eachmilestone[5].

c. Start-finish - low value and/or short duration activities without readily definable intermediate milestones. Either no or some limited progress is "earned" when the activity is started, and 100percent progress is earned at the completion of the activity. Progress is earned only upon 100 percent completion of the task

B. Qualitative progressing techniques

d. Level of effort (LOE) - used when it's very difficult to measure what work was accomplished for the budget spent. LOE assumes the progress is equal to the actual costs divided by the budget. For example, if the project manager's budget on a project is INR 20,000 Cr and INR 10,000 Cr has been spent to the project, then the progress is calculated as 50 percent[6].

e. Individual judgment - used for complex work not easily measured by other methods. Even though this is subjective, getting multiple opinions on the work accomplished by knowledgeable team members helps determine a more reasonable estimate on progress.

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C. Mixed progressing techniques

f. Combination techniques - good for complex work occurring over a long time period and use two or more of the other progressing techniques. An example would be installing a building foundation. The excavation progress would be units completed (cubic yards of earth removed), the formwork could be incremental milestones and pouring the concrete is start-finish[7]

g. Apportioned Relationship - has a direct intrinsic performance relationship to another discrete work package, which is called the 'measurement base'. For determining progress, the apportioned work package progress is the same value as the measurement base work package[8].

On projects, determining realistic progress for work packages (WP) is usually more difficult, but is essential for ensuring the earned value analysis is accurate and meaningful progress so as to ensure the Project management team can initiate any corrective action if required. Wages and benefits is an important motivators of the employees working in civil construction companies.[13]

Part of Earned value analysis would be used calculate the progress achieved.

III. PROPOSED METHOD TO CALCULATE PERCENT OF VALUE OF WORK DONE (VOWD)

The suggested method is a single project percentage calculation using the Earned Value analysis.

A. Definitions

Definition of Earned Value Analysis (EVA) - a quantitative project management technique for evaluating project performance and predicting final and intermediate project results, based on comparing the progress and budget of work packages to planned work and actual costs.

Definition of Planned Value (PV) is the budgeted cost for the work scheduled to be done. This is the portion of the project budget planned to be spent at any given point in time. This is also known as the budgeted cost of Work scheduled (BCWS)

Definition of Actual Costs (AC) is simply the money spent for the work accomplished. This is also known as the actual cost of work performed (ACWP).

Definition of Earned Value (EV) is the percent of the total budget actually completed at a point in time. This is also known as the budgeted cost of work performed (BCWP). EV is calculated by multiplying the budget for an activity by the percent progress for that activity: EV = % complete x budget

B. Basics of Earned Value Analysis (EVA)

The above Definitions are dealing with the Cost and if we replace the value of Budget by Value of Man-hours, those can be re-written as below

Planned Value (PV)

This is the baseline for analysis, cumulated planned man-hours related to their time of incurrence. Hence this can be expressed as below,[9]

Earned Value (EV)

This is the measure of physical progress of works expressed by cumulated planned cost of works actually done related to time. This can be expressed as below,

Earned Value (EV) = (BMHWP) Budgeted Man-hours of Work Performed

Actual Value (AV)

Cumulated man-hours consumed for works done related to time. This can be expressed as below,

Actual Value (AV) = (AMHWP) Actual Man-hours of Work Performed

Planned Value (PV) = (BMHWS) Budgeted Man-hours of Work Scheduled

Duration (T)

Duration (T) = Total Project duration

Budgeted Value at Completion (BVAC)

Total planned cost of the whole project, it equals BMHWS at the planned finish. This can be expressed as below,

Budgeted Value at Completion (BVAC) = (TBMH) Total budgeted Man hours of the whole project

Planned Percentage (PP)

A measure of performance and this can be calculated as below

Planned Percentage (PP) = Planned Value (PV) / Budgeted value at Completion (BVC)

Value Variance (VV)

A measure of deviation between planned and actual man-hours of works done until the date of recording progress. If negative, it indicates that the project is over man-hour consuming. This can be expressed as below,

Value Variance (VV) = Difference between Earned Value (PV) and Actual Value (AV) Equals To AV-EV = AV-EV = AMHWP-BMHWP

% of Value Variance (%VV)

To capture the scale of deviation, it is often expressed as a fraction of the budgeted Man-hours of works performed. This can be calculated as below,

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% of Value Variance (%VV) = VV/EV=Value Variance/Earned Value =Value Variance/ (BMHWP) Budgeted Manhours

Schedule Variance (SV)

A measure of deviation between the actual progress and the planned progress. Though it is interpreted as time deviation, it is expressed in man-hour units. In other words, it is the difference between the planned man-hour of works that have been done and planned man-hour of works that should have been done by the reporting date. If negative, it indicates a delay. This can be calculated as below,

Schedule Variance (SV) =Earned Value (EV) - Planned Value (PV)

= Difference between budgeted and man-hours for Work

% of Schedule Variance (%SV)

To address any distortion caused by the relative value of activities, it is expressed as a fraction. This can be calculated as below,

% of Schedule Variance (%SV) = SV/PV

= Schedule variance/Planned Value

= Schedule Variance/ (BMHWS) Budgeted Man-hours of Work Scheduled

Value Performance index (VPI)

This index compares the planned and actual value of works done, if less than 1, it indicates that the project has consumed more man-hours than planned, if greater than 1, there have been savings. This can be calculated as below,

Value Performance index (VPI) = EV/AV

= Earned Value / Actual Value

= (BMHWP) Budgeted Man-hours of Work Performed / (AMHWP) Actual Man-hours of

Schedule Performance Index (SPI)

This index compares the planned man-hours of works done with planned man-hours of works planned; if less than 1, it indicates a delay. This can be calculated as below,

Schedule Performance Index (SPI) = EV/PV

= Earned Value/Planned Value

= (BMHWP) Budgeted Man-hours of Work Performed / (BMHWS) Budgeted man-hours of Work scheduled

All of the above formulas are not being used in the Indian project context and the contract value or respective budget line items represents weightage of the particular activity and it becomes basis for measurement of the project progress.

C. Calculation of Value of Work Done (VoWD)

a. Basic Concept-Weighted addition of tasks to formulate the system

This is the method presently used in the industry in which major activities are identified and weightage is assigned to each activities and overall progress is calculated in weighted average method. Preparation of Progress Monitoring Tool mainly consists of the following steps,

1. Estimation of Scope of various disciplines
2. Activities to be carried out to liquidate the Scope quantities
3. Estimation of Man-hours to liquidate the Scope quantities
4. Estimation of Total man-hour required for the project
5. Assigning weightages to individual WBS and activities
6. Distributing period wise quantity to be completed
7. Calculating period wise planned progress Percentages

b. Estimation of Total man-hour required for the project

Breaking all activities required to complete the project to be of least level which will provide the perfect estimation of total man-hours required. By adding all the man-hours requirement on each of the activities with respect to the previously estimated norms will yield the total man-hours requirement for the project. The man-hours mainly indicate the overall picture of the project. By seeing the man-hour value one can estimate the duration of the project or resource requirement.

Man-hour (activity) = [Quantity of work] x [Man-hour/Unit of work]

Man-hour (Project) = Σ [Quantity of work] x [Man-hour/Unit of work]

c. Assigning weightages to individual WBS and activities

Based on the man-hour requirement for individual activities and the total man-hours the weightages for individual activities and their WBS can be calculated

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Weightage (activity) = Man-hour (activity) / Man-hour (project)

Weightage (WBS) = Σ Weightage (activities) = Man-hour (WBS)/ Man-hour (Project)

This helps in finding out the critical path or critical area or Critical activity of the project which is affecting primarily on the entire project progress. With this type of weightages even the dynamic conditions such as scope change, work rate change, conditions change; sequences change etc. can be easily taken care.

d. Calculation of Planned Progress and Actual Progress or percent of VoWD

Here in this section, we can use some simple formulas which can be used in the construction project. Initial estimate of Total Man-hours required for completing the project. This can be illustrated in simple form as below for a project which is having 'm' number of least breakable activities.

$$Y^{(0)}=X^{(0)}{}_1H^{(0)}{}_1+X^{(0)}{}_2H^{(0)}{}_2+X^{(0)}{}_3H^{(0)}{}_3+....+X^{(0)}{}_m H^{(0)}{}_m \qquad (1)$$

As explained earlier this is simple total of multiples of all activities and their respective man-hours required for unit quantity. This can be even simplified as below.

$$Y^{(0)}=\Sigma\ (X^{(0)}{}_i\ H^{(0)}{}_i) \qquad (2)$$

Where,

$Y^{(0)}$= Initial estimate of the Man-hours required to complete the project

$X^{(0)}{}_i$ = All Executable Scope Quantity of particular activity

$H^{(0)}{}_i$ = Estimated Man-hours to complete one unit quantity of the respective activity

Initial estimate of Progress or Percent of VoWD to the Total Value of the Project for i^{th} month

$$P^{(0)}{}_i= \Sigma\ (x_i\ /\ X^{(0)}{}_i)\ (H^{(0)}{}_i\ /\ Y^{(0)}{}_I \qquad (3)$$

Where,

$P^{(0)}{}_i$ = Initial calculation of Progress for i^{th} month

x_i = Executed Quantity in i^{th} month of a particular activity

$X^{(0)}$ = Scope Quantity of particular activity

$H^{(0)}$ = Estimated Man-hours to complete one unit quantity of the respective activity

$Y^{(0)}$ = Initial estimate of Total Man-hours required the complete the project

From the above estimate it is clear that in i^{th} period project reaches progress of $P^{(0)}$ by executing the quantity x_i in each of the breakable activities. This equation (3) is being conventionally used for all construction projects of process industries. Now we can proceed for the corrections required for progress derivation [11]. Construction product transportation is a physical activity involved in the flow of things between the point of origin and the point of consumption in order to meet requirements of customers or corporations [12].

If the employers fails to fulfil the salary structure company the performance level will not improve as expected by the higher authorities.[14] Functioning of a well-established organization need the hard work of employees. Recruitment and selection is a long-lasting one and a central aspect of HR Management. There was lot of problems needs to be handled by the HR department[15] Labor welfare facilities are an important tool to increase the productivity of the employees in any organization. Salary along will not motivate the employees, so in addition to the company must provide some welfare benefits to their employees[16].This paper investigates the impact of Internal Locus of Control on personal variables and job related factors. The primary research strategy employed was the survey strategy[17]. Researcher is very much interested on emission rates to know which mode of transport if more eco-friendly and remove logistical problems. SICAL Logistics has recently started a new project named Coastal RORO service as a part of their green logistics[18].

In the initial stage of the project, generally, the scope quantities will be estimated or pre matured quantities only being considered and upon growth, the actual scope quantities may be made available. There for it is important to update the scope quantities in the system once in a month or on some regular intervals. Like scope quantity updation, the considered unit man-hour also required to be revisited to calibrate with respect to the technology implemented and the construction methodologies adopted[10].

This Actual Percent VoWD to Total Estimate at Completion Value (Actual Progress) and the Planned Percent VoWD to Total Estimate at Completion Value (Planned Progress) are being used to monitor the Project.

IV. RESULTS AND DISCUSSION

To analyze these results, one simple project with some activities are considered for the calculation purpose.

The day was randomly selected and the some values were assumed for the calculation purpose.

Results are tabulated below

S No	Activity	Scope	UoM	Unit Man-hour	Total Man-hour	Weigtage	Quantity for the day		Quantity Cummulative		% VoWD for the Day		% VoWD Cummulative		Remark
							Planned	Actual	Planned	Actual	Planned	Actual	Planned	Actual	
1	Concreting	12000	CUM	75	900000	29.5%	100	80	9100	8580	0.25%	0.20%	22.39%	21.11%	
2	Structural Steel Fabrication	4000	MT	120	480000	15.7%	200	75	3200	2875	0.79%	0.30%	12.60%	11.32%	
3	Structureal Steel Erection	4000	MT	95	380000	12.5%	200	50	2700	2350	0.62%	0.16%	8.42%	7.32%	
4	Piping Fabrication	12000	ID	3.5	42000	1.4%	200	150	10700	10150	0.02%	0.02%	1.23%	1.17%	
5	Piping Erection	35000	IM	4.5	157500	5.2%	500	300	22500	20300	0.07%	0.04%	3.32%	3.00%	
6	Tankage Fabrication	2000	MT	200	400000	13.1%	50	40	1850	1740	0.33%	0.26%	12.14%	11.42%	
7	Tankage Erection	2000	MT	200	400000	13.1%	40	30	1040	930	0.26%	0.20%	6.82%	6.10%	
8	Equipment Erection	4500	Mt	50	225000	7.4%	50	30	3050	2830	0.08%	0.05%	5.00%	4.64%	
9	Electrical Equipment	150	MT	20	3000	0.1%	5	2	105	92	0.00%	0.00%	0.07%	0.06%	
10	Electrical Cable Laying	1500	MTR	1	1500	0.0%	200	50	1200	1050	0.01%	0.00%	0.04%	0.03%	
11	Instrument Installation	200	No	10	2000	0.1%	20	10	70	60	0.01%	0.00%	0.02%	0.02%	
12	Instrumentation Cable Laying	3000	MTR	1	3000	0.1%	200	100	400	200	0.01%	0.00%	0.01%	0.01%	
13	Insulation	3000	SQ.MTR	4	12000	0.4%	100		200	0	0.01%	0.00%	0.03%	0.00%	
14	Painting	14000	SQ.MTR	3	42000	1.4%					0.00%	0.00%	0.00%	0.00%	
Total					3048000	100.0%			0	0	2.46%	1.23%	72.09%	66.20%	

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Advantages of using this system

This system has more advantages like,

a. Single Progress figure status representation such as XX% actual out of YY % planned
b. Accurate calculation.
c. Simple calculation
d. Reduction of manual errors in process
e. Better Project management

IV. CONCLUSION

As this reduces lot of man-hour efforts and time this method can be encouraged for many of the construction projects.

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