Study & Analysis of Construction Project Management with Earn Value Management System

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Abstract— As India is one of the fastest developing countries in the world, remarkable achievements have been made in the construction field. Construction companies in India are now facing new opportunities and challenges. In last few decades concept of project management has gained increasing demand among big construction industries. Now a day's customer and client are demanding higher level of performance with respect to schedule, cost from construction organization, at the same time available to fulfill the client's requirements are becoming crucial to complete project within agreed schedule and cost. In this research / thesis mentioned, knowledge about concept of construction project management with the application of Earned Value Management System. It also includes schedule monitoring, controlling, cost monitoring, controlling with respect to established baseline standards, and various elements of project management. The observations and knowledge from literature review are applied to analyze the construction project management using earned values analysis and management in Indian construction industry. General information regarding project - a management in Indian construction industry including challenges for schedule and cost control management will be presented in this research to give some idea regarding difference between Indian construction industry and western countries. The mentioned objectives are to be tested through the experimental and field methods like case study. By using the knowledge from literature review and results from case study analysis some measures to improve project management with earned value management in Indian construction industry are recommended

Key words- Construction management, Earned Value, Earned Schedule, Project Management

I. INTRODUCTION

This paper describes how to effectively implement Earned Value Management System (EVMS) on construction projects in India. EVMS is a valuable technique to determine real gains and losses on projects and provides a means to balance gains/losses and maximize the gains. EVMS is a powerful tool to control simultaneously physical and cost performance. It provides integrated schedule (time), progress and cost management information related to scope and procurement, quality and risks.

Construction Project Management (CPM) and Earned Value Management System (EVMS) are both very important disciplines for advanced study by building professionals.

Both disciplines attempt to meet/ resolve built-asset stakeholder's need for an effective means to meet their objectives short or long term. In the context of Corporate Real Estate (CRE) or Project Management (PM) both are of vital importance.

Earned Value Management System, on the other hand, attempts to encompass a much wider spectrum of competencies that some time may be regarded as outside the normal training of building Professionals. A popular definition for "Earned Value Management System" (EVMS) is: "Earned Value analysis is a method of performance measurement. Earned Value is a program management technique that uses "work in progress" to indicate what will happen to work in the future. Earned Value is an enhancement over traditional accounting progress measures. Traditional methods focus on planned accomplishment (expenditure) and actual costs. Earned Value goes one step further and examines actual accomplishment. This gives managers greater insight into potential risk areas. With clearer picture, managers can create risk mitigation plans based on actual cost, schedule and technical progress of the work. 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. Earned Value Management System is not a specific system or tool set, but rather, a set of guidelines that guide a company's management control system"

Earned value analysis is a method of performance measurement. Many project managers manage their project performance by comparing planned to actual results. With this method, one could easily be on time but overspend according to the plan. A better method is earned value because it integrates cost, schedule and scope and can be used to forecast future performance and project completion dates. The objectives of this article are study how effectively we can perform / bring the construction project on schedule by using EVMS technique. These include various factors, difficulties and benefits, problems and solutions and criteria and results based on the experience of a real case study in India.

EVMS is applied on a project construction of 1 No Natural draught Cooling Tower at Raipur in Chhattisgarh state in India. The construction is to be done in 22 Months.

The case study is documented with reports, graphs, analyses and comments. A critical review of the application of EVMS for the NDCT is provided in this paper. It shows that EVMS had a relevant role in the integrated management of the project scope, time, progress, cost and risks and the procurement of the main project supplies and services.

EVA contributed to the success of the case study project.

Retrieval Number: D1195093413/13©BEIESP
Journal Website: www.ijitee.org

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Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
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II. METHODOLOGY

The methodology for the study involved the descriptive analysis of a real study case, the Construction of NDCT project.

Case studies can be exploratory, explanatory or descriptive. The research methodology, in this case, comprises a simple descriptive real case study by the authors. The reports from the NDCT Project were used to get data for the study. Some tables are reproduced in this article.

Confidentiality is assured in the results and reports provided. All the data, reports, databases, perceptions and concerns were obtained from the participants of the project. They were the primary source of information in this study case in addition to the reports. The data is partially reproduced in this paper.

The data collected by author includes the project management applied to the project since from the inception consists the base line schedule, method statement involved to achieve the schedule program, the budgeted vs actual schedule, the billing schedule, the schedule billing vs actual billing, the schedule cost vs actual cost for determining the EVMS parameters, indices.

III. EARNED VALUE MANAGEMENT SYSTEM (EVMS) BASICS AND CONCEPTS

According to Flemming (1996), EVMS originated in the USA Department of Defense from the former Cost/Schedule Control Systems Criteria (C/SCSC). The EVMS technique is used in several countries to get better cost and schedule control.

A variety of terminology is used as a descriptor for this approach. These include Earned Value Analysis (EVA), Earned Value Management (EVM), Earned Value Management System (EVMS) and Earned Value Technique (EVT).

The main EVMS variables (indicators) are:

BCWS (Budgeted Cost of Work Scheduled) - PV (Planned Value)

BCWP (Budgeted Cost of Work Performed) - EV (Earned Value)

ACWP (Actual Cost of Work Performed) - AC (Actual Cost)

Performance analysis parameters:-

SV (Schedule Variance) determines whether a project is ahead of or behind the schedule. It is calculated as given : $SV = EV - PV$; A positive value indicates a favorable condition and a negative value indicates unfavorable condition.

CV (Cost Variance) shows whether a project is under budget or over budget: $CV = EV - AC$;

Performance analysis Index:-

SPI (Schedule Performed Index) indicates how efficiently the project team is using its time: $SPI = EV / PV$; SPI = 1 (project on time); SPI <1 (performing less than planned); SPI > 1 (performing more than planned)

CPI (Cost Performed Index) gauges how efficiently the team is using its resources: $CPI = EV / AC$; CPI = 1 (project on budget); CPI < 1 (spending more than planned); CPI > 1 (spending less than planned)

These processes are related with the Project Management (PM) processes (planning, execution and control) according to the following table 1:

Table: I– EVMS processes related with PM processes

EVMS processes related with Project Management processes		
PLANNING	EXECUTION	CONTROL
Model Definition	Register of results for financial control	EVA Progress Report elaboration
Planning activities, resources and costs in an accounting plan	-	Monitoring and Control with actions

## IV. EVMS APPLIED TO CONSTRUCTION OF NDCT PROJECT

The Project is basically construction of Natural Draught Cooling Tower for a power plant of capacity 685 MW at village area in Chattisgarh state, India. The construction involved both design as well as construction. Both the design and construction is awarded to one contractor and proof consultant for checking of construction and design.

The success of EVMS requires the clear responsibility in a project. The Project had the following responsibility as shown in below Table.

Table II - Responsibility Matrix -The code R = Responsible, A = Approval

| Sr.	CONCEPTUAL AND DETAILED DESIGN	O	D	C
1	Design of RCC Structure	A	A	R
2	Design of Mechanical Equipment		A	R
3	Analysis and comments on detailed design		A	
4	Design review after comments from Designer		A	R
5	Distribution of the detailed design approved for construction		A	R
6	Technical specifications, memorials and supporting details	A		R
7	Maintenance of the Technical File and "as built" documentation	A		R

Typical Organization chart
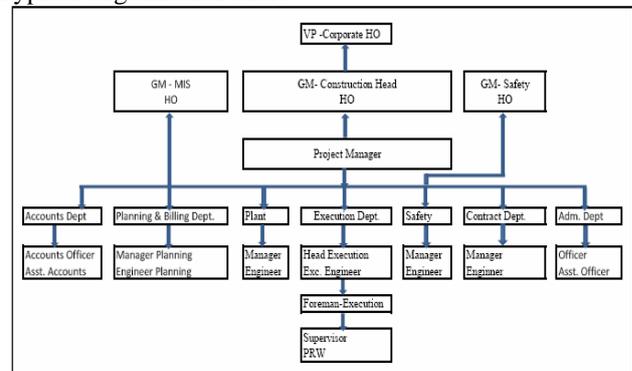
Further after defining the overall organization in the project now the responsibility can be fixed as per the project schedule requirement which can be clearly shown by "Work Break Down Structure" The WBS acts as a vehicle for integrating baseline cost and time plan, and, thus, is an aid in relating plans to objectives.

This Project WBS has the following levels:

Level 1 : Construction of Raft foundation
Level 2 : Construction of Pond Wall Pedestal / Construction of Pond floor
Level 3: Construction of Racker column
Level 4 : Construction of RC Shell upto top
Level 5: Construction of Grillage column, bracing, HW Duct
Level 6 : Erection of All Beams
Level 7: Erection of Mechanical items

BARCHART –
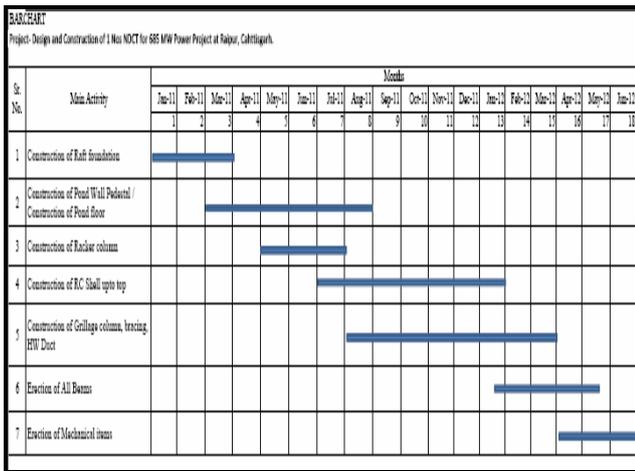
The reports such as Project Estimate which were showing the budgeted billing, the actual billing, the actual cost collected from project site which were implemented by the Project Manager.

Project Estimate:-

Based on above data the EVMS variables are taken and made a Table as follows

Table III – EVMS Variables

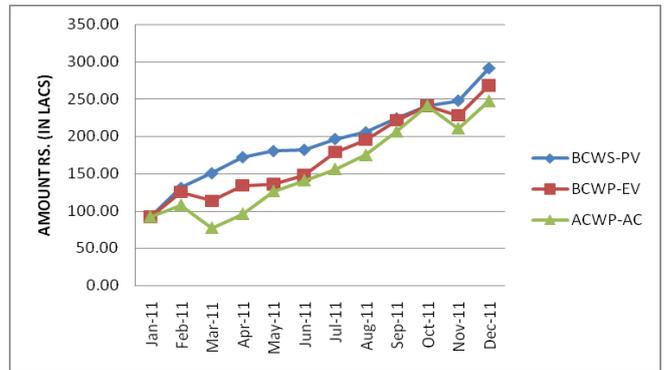| Month	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
BCWS - PV	92.05	130.98	150.68	172.20	180.45	182.13
BCWP - EV	92.05	125.36	113.58	134.08	135.60	147.70
ACWP -AC	92.05	107.65	77.02	95.85	126.28	140.76
Month	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11
BCWS -PV	196.56	205.63	224.25	240.85	248.06	291.50
BCWP -EV	178.91	195.27	221.50	240.85	228.14	268.09
ACWP -AC	155.88	174.64	206.23	240.85	210.27	247.09

Figure 4.14 – Earned Value Analysis – BCWS-PV, BCWP-EV and ACWP- AC (Amount Rs. In Lacs)

Table IV – EVMS Performance analysis Index SPI and CPI – Month

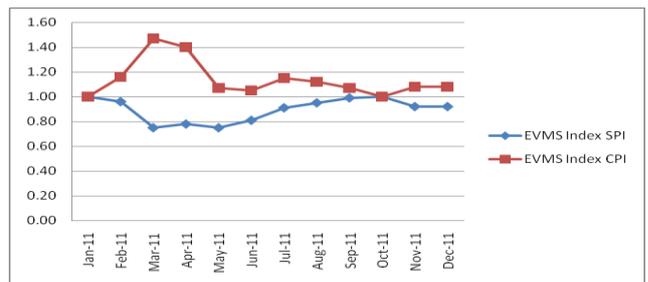| Month	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
SPI	1.00	0.96	0.75	0.78	0.75	0.81
CPI	1.00	1.16	1.47	1.40	1.07	1.05
Month	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11
SPI	0.91	0.95	0.99	1.00	0.92	0.92
CPI	1.15	1.12	1.07	1.00	1.08	1.08

Figure 2 – EVMS Performance analysis indexes SPI and CPI

V. CRITICAL ANALYSIS OF EVMS IN NDCT PROJECT AND SUGGESTIONS

The main objective of this case study on this project is to study and analyze the EVMS variable and performance indexes, from the data provided by site i have calculated the EVMS variables and performance indexes.

After in depth study I have shown the site about the project is through a critical stage as in most of the moth they could not able to achieve the Budgeted cost of Work Schedule.

Table V- EVMS SV and CV values

Month	Jan-11	Feb- 11	Mar-11	Apr-11	May-11	Jun-11
SV	0.00	-5.62	-37.10	-38.12	-44.85	-34.43
CV	0.00	17.72	36.55	38.23	9.31	6.94
Month	Jul-11	Aug- 11	Sep-11	Oct-11	Nov-11	Dec-11
SV	-17.65	-10.36	-2.75	0.00	-19.92	-23.41
CV	23.03	20.63	15.28	0.00	17.87	21.00

The billing is less than the planned resulted in to negative schedule variance. I have gone through each month why such happened and enlisted below the reason of backlog.

1) Due to Non availability of Design Drawing for some of the activities site could not able to start activity as per schedule.
2) Non delivery of material on site as per the schedule hampered the execution of the work and the activity is differed from the schedule
3) Due to non availability / Shortage of Material such as fine Aggregate, coarse aggregate.
4) Due to hike in price of Reinforcement and structural steel in market than the actual quoted at the time of Tender
5) Non availability of Funds at site.
6) Due to bad weather condition.
7) Due to non availability of Skilled labours in the project vicinity.

On above finding i have the following suggestion to Project team to improve the performance.

1) The design schedule should be made such a way that the approved design and drawing will be available in advance. This can also be achieved by keeping the design software same and common access to all Contractor, consultant and owner which will minimize the time duration of approval.
2) Indenting of Material should well in advance.
3) Approval of alternate sources of material to minimize the dependency.
4) To overcome the hike in price the provision of Escalation should there. At same time to avoid the delay explore the possibility of availability of inventory material with Customer or other site.
5) The cycle of billing and payment to contractor to be revise as per the project requirement.
6) The topography and geographical survey has to be done before tendering and accordingly billing to be plan.
7) Keep a own gang of skilled workers also take out the work from the workers by incentive methods, make a payment on productive basis.

On the implementation of above the project performance will be improved.

VI. STEPS TO SUCESSFUL EVMS IMPLEMENTATION

The findings of the case study have led me to the following recommended steps for successful implementation of EVMS.

1. Obtain top level organization commitment with EVMS
2. Education and training of the people in the project in EVMS
3. Scope well defined, detailed and identified, with proper WBS and packages
4. Schedule and budget organized according to the WBS
5. Clear Project Responsibility Tables, with clear responsibility descriptions
6. Clear flowchart of activities and relationship with the main participants
7. Cost/Schedule Control System with database and data collection procedures
8. Suitable reports related to EVA, well planned, analyzed and distributed
9. Procedures to consistency analysis and validation of information
10. Lessons Learned - continuous improvement process

VII. CONCLUSION

The main conclusion is that EVMS can provide an important contribution to the cost management of construction project.

i) The EVMS is very sensitive for scope change.
ii) The database and reporting system provide easy consistency analysis of data. Wrong data was easily detected and corrected. Error detection allowed improved practices and provided support for decision-making processes, as well as, negotiations with suppliers and subcontractors.
iii) EVA allowed scope change management to keep the final budget of the project within check by providing alternatives to decide in what activities to reduce scope or reduce specifications /performance to save money in order to fit cost overruns in other activities.

The Schedule Performance Index (SPI) is NOT a "time" performance index - it is really a "progress" performance index related only to physical progress. The SPI index deals with the variables planned values (PV) and earned values (EV) expressed in costs, in the vertical axis, but the time is the horizontal axis. Project managers can measure delays on the horizontal axis. We suggest to change the name from the Schedule Performance Index to the Progress Performance Index. It is related to progress, not time.

The Work Break Down Structure (WBS) is called the "soul" of the management process. It is very important to define a suitable structure for control and the accounting. The work packages must have clear responsibilities and criteria for measurements. It is important to balance greater or smaller packages in order to get better results in the process.

The main contribution of the EVMS process was the motivation of the project manager and his staff concerning the cost management and the goal to finish the project on budget. The EVMS process provided more perception about the costs and their related elements of scope, contracts, performance, suppliers, risks, procurement, communications, quality, people and negotiations.

EVMS inspires the participants to pay more attention to costs and progress, motivates the participants to discuss the cost elements with more intensity and optimize the costs resulting in a project that was finished on time and on budget.

REFERENCES

1. Humphreys, Kenneth; Bent, James A., Effective Project Management Through Applied Cost and Schedule Control, Marcel Dekker , Inc, New York, USA, 1996.
2. Humphreys, Kenneth; Wellman, Paul, Basic Cost Engineering., 3rd Ed.,Marcel Dekker Inc, New York, USA, 1996.
3. Humphreys, Kenneth; English, Lloyd M., Project and Cost Engineers HandBook, 3rd Ed.,Marcel Dekker Inc, New York, USA, 1993.
4. Humphreys, Kenneth ; Jelen's Cost and optimization Engineering", 3rd. Edition, MacGraw-Hill Inc., New Yourk, USA, 1991
5. Flemming, Quentin W.; Koppelmann, Joel M., Earned Value Project Management, Project Management Institute – PMI, 2nd. Ed., 1999.
6. Flemming, Q. W. Cost / Schedule Control Systems Criteria. The Management Guide to C/SCSC.England: Probus Publishing Company, 1988.
7. Smith, Nigel J., Project Cost Estimating, Ed. Thomas Telford, London, UK, 1995
8. Kerzner, Harold, Project Management, A Systems Approach to Planning, Scheduling and Controlling, Harold Kerzner, 6ª Edição, Van Nostrand Reinhold, 1998.

9. American National Standards Institute/Electronic Industries Alliance (1998). ANSI-EIA-748-98, Earned Value Management Systems. Arlington, VA: Electronic Industries Alliance; USA, 1998

10. PMI - Project Management Institute - Practice Standard for Earned Value Management http://www.pmi.org, access in November 15th, 2004.

11. YIN, Robert.; Case Study Research and Design, SAGE Publications, Thousand Oaks, California, USA,1994

12. YOUNG, S. David; O'BYRNE, Stephen F. Eva and value-based management. United States of America: McGraw-Hill Book, New York, USA,2001.

13. DOD/500-2R Department of Defense - Earned Value Management http://www.acq.osd.mil/pm –access in November 15th, 2004.

14. CHECKLAND Peter e HOLWELL Sue. "Action Research: Its Nature and Validity", Systemic Practice and Action Research, 11, 1, 1998, pp.13-16.

15. DICK Robert. What is Action Research, 1999, disponível em http://www.scu.edu.au/schools/gcm/ar/whatisar.html, access in July, 29th, 2002.

16. EINSENHARDT Karen M. "Building Theories from Case Study Research", Academy of Management Review, vol. 14, No. 4, pp. 532-550, 1989.