

A REVIEW ON EARNED VALUE MANAGEMENT TECHNIQUES ASSURING QUALITY AND SAFETY PAST COVID-19

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Abstract – Construction managers monitor projects on a frequent basis to verify that they are performing as expected. The construction industry invests revelatory time and resources to improve quality and safety while lowering costs and schedule implications. The construction business has a genuine goal to improve construction design operating procedures in order to improve efficiency. Quality and safety underperformances have historically been caused by poorly managed quality control and safety exercises. Poor quality work has always had an influence on construction operations in terms of cost and time. COVID-19's unexpected issues and concerns highlighted the need to modernize the construction industry's Earned Value Management (EVM) system to reflect these quality and safety requirements. The purpose of this topic is to show the Earned Value Construction Operation (EVCM) system, which is a sophisticated EVM system. To capture costs, EVCM incorporates quality and safety as mentioned variables. EVCM has a new indication that is linked to quality control conditioning and increases the delicacy of design reporting in normal or epidemic building environments. Detailing engineering and executive safety practices during COVID-19, analyzing effective PPE during an epidemic, and statistically assaying design data to demonstrate EVCM are all part of the technique employed in this debate. This discussion's gift is a piece of field-validated data on the cost and schedule consequences of artificial construction during a COVID-19 terrain EVCM was also created to forecast cost and scheduling consequences while maintaining quality and safety. The knowledge gained during this debate will eventually improve the construction industry's ability to respond to an epidemic and incorporate quality and safety requirements into a schedule that will allow them to track and manage progress more efficiently.

1. INTRODUCTION

Construction Directors have a profound desire to develop advanced cost and schedule processes to more inform the operation of construction systems. The unknown challenges and misgivings of COVID-19 stressed the need to ameliorate the Earned Value. Operation (EVM) system within construction to reflect these quality and safety conditioning. This exploration addresses the fresh safety protocols and particular defensive outfits needed during an epidemic. By enforcing protocols described in this study, social distancing,

wearing proper PPE, sanitizing practices, and medical pre-screening infection can be reduced and suitable to stop the coming surge. The case study will demonstrate how quality control of failed examinations and safety mishaps adds time and cost to a design.

2. LITERATURE REVIEW

[2.1] Ricardo Viana Vargas, MSc, IPMA-B, PMP (2003), "Earned Value Analysis in The Control of Systems Success or Failure?"

The ideal of this paper is to present and agitate the main obstacles and benefits of the use of the Earned Value Analysis in designs, including factors to be enhanced and executed during the design plan and conduct to be taken while the design is fulfilled and controlled. Also, through a real case study in civil construction field, the connection of the system is faced with a theoretical reference, in order to identify aspects of the connection of the tool tested in case study. The results to be presented and argued are subdivided in two zone The first one is about the different features of each business and its philanthropy for the success or failure in the prosecution of the Earned Value Analysis, and the second is about the characteristics of similarity inaugurate in all businesses that together favor or not the use of the tool.

[2.2] Jose Angelo Valle, Carlos Alberto Pereira Soares (2004) The Use Of Earned Value Analysis (Eva) In The Cost Operation Of Construction Projects

The main content in the paper is to present and agitate the main factors involved in the use of Earned Value Analysis (EVA) in the cost operation of civil construction systems. These factors include advantages and disadvantages, difficulties and benefits, problems and results and criteria and results rested on the experience of a real case study in Brazil.

[2.3] M.MOFID (2011), "Perfecting Construction Management of an Educational Center by Applying Earned Value Fashion"

This paper aims to explore the generalities of earned value system, its styles and criteria, performance measures and auguring design progress. In order to compare between

EVPM system and traditional styles, the effectiveness of applying EVPM in a real design, construction of an educational center in one of the petrochemical refineries as a case study is explained. Reports deduced from using earned value system in the design indicated that the director was suitable to have exact information about the design details and also eased the pitfalls in his opinions in critical conditions of the design. Accordingly, the design was finished after a short period of time.

[2.4] Gayatri Vyas (2012), "Cost Controlling Using Earned Value Analysis in Construction Industriousness"

This study is to present and club the main parameters involved in the computation of Earned Value Analysis (EVA) in the cost operation of civil construction systems. The purpose of this discussion is 3-fold. Originally, Earned Value Analysis software is developed in Visual Coming Comparison of named parameters between Project 2007, Primavera P6 and developed software is done. Thus, it can be concluded that the software could be used in a wide range of systems for Earned Value Analysis computation.

[2.5] Sunil Ganpat Mahadik, Pankaj P. Bhangale (2013) "Study & Analysis of Construction Project Management with Earn Value Management System"

In this exploration/ thesis mentioned, knowledge about generality of construction design operation with the operation of Earned Value Management System. It also includes schedule monitoring, controlling, cost monitoring, controlling with respect to established birth morals, and colorful rudiments of design operation. The observances and knowledge from literature review are applied to dissect the construction design operation using earned values analysis and operation in Indian construction assiduity. General information regarding design-a operation in Indian construction assiduity including challenges for schedule and cost control operation will be presented in this exploration to give some idea regarding difference between Indian construction assiduity and western countries.

[2.6] Jordy Batselier and Mario Vanhoucke (2015) "Empirical Evaluation of Earned Value Management Vaticinating Delicacy for Time and Cost"

Author aims capability to directly read a design's final duration and cost is essential to successful design operation. The fashion of earned value operation (EVM) is considered to give an effective methodology for carrying similar vaticinations; still, this has not yet been adequately tested on empirical data. Thus, the delicacy of the most generally used EVM time and cost foretelling styles is estimated on a different and qualitative database conforming of 51 real-life systems. As utmost systems appear from the construction assiduity, an unequivocal focus on these construction systems is handed. Also, the asked real foretelling issues rested on the

factual design progress data are also supported by a Monte Carlo simulation study.

[2.7] Suqrat Babar; Muhammad Jamaluddin Thaheem, Ph. D, Aff.M. ASCE; and Bilal Ayub, Aff.M. ASCE (2016), "Estimated Cost at Completion Integrating Trouble into Earned Value Management"

In this paper author presents an assiduity standard for covering the performance of ongoing systems. The performance birth is set up in the planning phase to measure any time and cost diversions during design prosecution. Rested on the current progress, an estimate at completion (EAC) is read. Traditionally, EVM only focuses on the design schedule (SPI) and cost (CPI), and doesn't address other important aspects of health and safety, stakeholder satisfaction, and quality. Despite its superior expression, EVM vaticinations are still told by design pitfalls and misgivings, leading to inconsistency between EAC results attained through standard formulae.

3. EVM: EARNED VALUES MANAGEMENT

A methodical approach to the integration and magnitude of cost, schedule, and specialized (compass) accomplishments on a design. Provides the capability to examine detailed schedule information, critical program and specialized landmarks, and cost data. Systems over budget and behind schedule 53 of systems finish over budget and behind schedule 52 finish at 189 of their original budgets, 18 are simply no way completed. Statistically proven performance protrusions. Performance at a design's 25 completion point will remain steady throughout the design's lifecycle. Harmonious performance measures allow comparison across the portfolio.

Earned Value operation is a system of performance dimension. Earned Value is a design operation approach that uses "work in progress" to indicate what will be to work in the future. Earned Value is an improvement over traditional account progress measure. Traditional styles concentrate on planned, accomplishment (expenditure) and factual costs. The earned value approach is superior to independent schedule and cost control for assessing work progress in order to identify implicit schedule slippage and areas of budget overruns. Earned Value goes one step further and examines factual accomplishment. This gives directors lesser sagacity into implicit threat areas. With clearer picture, directors can produce threat mitigation plans grounded on factual cost, schedule and specialized progress of the work. It's an "early warning" program/ design operation tool that enables directors to identify and control problems before they come impossible.

The earned value system (EVM) is frequently used as a design control approach to give a quantitative measure of schedule performance. In the EVM, the schedule and cost

performance indicators (C/ SPI) are used for constant monitoring of the design's cost and schedule grounded on an original critical path system (CPM) schedule. By using an earned value and Earned schedule system the following questions can be answered objectively

- Where have we been?
- Where are we now?
- Where are we going?

The Earned value basics are as follows

Calculated cost of work schedule (BCWS) Quite literally, it represents the budgets of the conditioning that are planned or schedule to be completed.

Actual cost of worked schedule (ACWP) It represents the actual cost charged against the conditioning that were completed.

Budgeted cost of worked performed (BCWP) This is the traditional earned value that we speak of. It represents the planned or schedule cost of the conditioning that are completed. The distinction between the BCWS and the BCWP is that the former represents the budget of the conditioning that were planned to be completed and subsequently the budget of the exercise that actually were completed.

Cost variance (CV) The CV is veritably important factor to measure design performance. CV indicates how important over or under budget the design is. CV can be calculated as using the following formula

$$CV = BCWP - ACWP$$

The formula cost variance gives the variance in terms of cost which will indicate how less or more cost has been to complete the as per of date. Positive cost variance indicates the design in under budget. Negative cost variance indicates is over budget.

Schedule friction (SV) Schedule friction indicates how much ahead or behind the design is. The formula of schedule friction is as follows

$$SV = BCWP - BCWS$$

The formula of schedule variance gives the variance in the terms of cost which will indicate how important cost of the work is yet to be completed as per schedule or how important cost of work has been completed over above the listed cost. Positive schedule variance indicates we're ahead of schedule. Negative schedule variance indicates we're behind of schedule.

Cost performance Index (CPI) This is an indicator showing the effectiveness of the application of the resources on the design. This can be calculated using following formula,

$$CPI = BCWP / ACWP$$

Schedule performance index (SPI) This is an indicator showing the effectiveness of the time employed on the design. SPI can be calculated by using following formula,

$$SPI = BCWP / BCWS$$

The formula mentioned above gives the effectiveness of the design crew in exercising the time allocated for the design. SPI value lower than 1 indicates that the design crew is less effective in exercising the time allocated to the design.

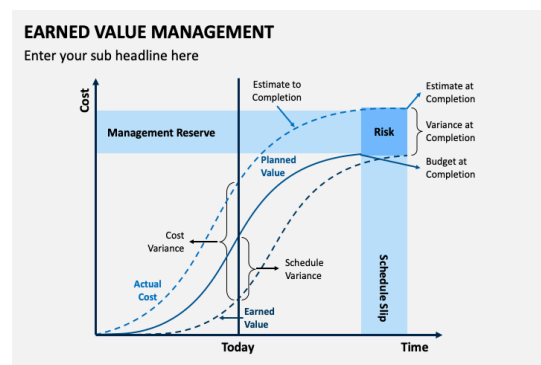


Fig. 1 Earned Value Management Graph

The new performance indicator system is:

Quality Schedule performance indicator Its formula is QSPI = BCWP/ BCWS, with SPI larger, lower than or equal to 1 indicating the progress being ahead of, behind or accompanying with programmed schedule. When QSPI I, we should also dissect the cause (14). Still, also we should take measures to hoist the quality, indeed if the schedule were to be delayed, If the progress runs ahead of schedule because the quality position diminishments.

Quality Cost performance indicator Its formula is QCPI = BCWP/ ACWP, with QCPI larger, lower than or equal to I indicating the cost dwindling, adding or coinciding with programmed cost. When QCPI 1, we should also dissect the cause for the drop of cost. However, we should make quality the precedence, If it concerns the quality.

Quality performance indicator Its formula is QPI = QACWP/ ACWP, with QPI larger, lower than or equal to I indicating the quality frugality dwindling, adding or coinciding with programmed value. When QPI> Qj, we should dissect the cause for the increase of quality cost. However, we can reduce the breakdown cost and increase forestallment cost to reduce

quality cost, If it's because of the increase of construction breakdown.

Benefits of Earned value system (EVMs)

Following are some of the benefits of EVM described the heritage of using the criteria of government contracts for three decades (1996). Note that don't separate benefits of earned

value data from the benefits of criteria, maybe the trustability data depends on the chastened operation of the operation practices described by criteria.

- It's a single operation control system that provides dependable data
- The associated database of the completed systems is useful for relative analysis
- The accumulative cost performance indicator (CPI) provides an early warning signal.
- The schedule performance indicator (SPI) provides an early warning signal.
- The CPI is the predictor for the final cost of the design.
- It uses an indicator- grounded system to read the final cost of the design.
- The periodic (e.g. Weekly or yearly) CPI is a standard.

4. Estimation of BOCW in India, Best Practices, and Associated Cost and Schedule Impacts in a Pandemic

Construction workers constitute one of the largest classes of workers in the unorganized sector. Grounded on the sample check conducted by National Sample Survey Organization (NSSO) in 2011-12, about 5 crore workers are engaged in the construction conditioning in the country. In order to protect the interest of the workers of this sector, popularly referred to as Structure and Other Construction Workers (BOCW), the govt has legislated exclusive and comprehensive labor legislation, viz.,

a. The Structure and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996

b. The Structure and Other Construction Workers 'Welfare Cess Act, 1996

Further, the BOCW Central Rules, 1998 and Structure, and Other Construction Workers Welfare Cess Rules, were also notified vide announcement dated 19.11.1998 & 26.3.1998 independently. The Act enlists the Structure and Other Construction work on Section 2 (d) and also defines the meaning of Structure and other hard hat in Section 2 (e). These legislations regulate the employment and conditions of

service, safety, and health measures for the construction workers through State Welfare Boards constituted at the State Level. Welfare measures are financed by a tax of Cess on all construction works at rates between 1 to 2 of the construction cost of the structure/ design (presently Government has notified Cess to be levied @ 1). The finances so collected are to be used for furnishing fiscal backing to the families of registered workers in case of an accident, old age pension, casing loans, payment of insurance decoration, children's education, medical and motherliness benefits. as imaged at Section 22 of the 1996 Act. Further, the State Governments are also empowered to make necessary rules in regard to the preface and perpetration of the weal schemes in agreement with the provision under Section 62.

Generally available estimates of the population of BOCW indicate a figure of 4.5 to 5.5 crore similar workers in the entire country who are engaged in construction conditioning in the public as well as the private sector. Taking a cue from the NSSO check, a figure of a minimum of 5 crore BOCW within the country are often considered a largely genuine and usually accepted estimate. Out of an estimated total pool of 50 crores in the country, it can be seen that 10 of the total pool is engaged in construction conditioning. Thus, BOCW is considered a big knob of the pool. Not only that, it's also the most important pool, a major player in nation- structure, and yet the most neglected lot.

It's material to mention that this pool needs Social Protection the most and thus should be registered with the State Welfare Boards as per the Act, in order to mileage of the benefits of Social Security. Unfortunately, it's noticed that out of the 5 crore estimated construction workers, only 3.48 crore workers have been registered as of date. This means that about 30% of workers are still left- avoidance of the border of the Registration process in the countries.

More importantly, only 2.57 crore BOCW are plant to be 'live' registered workers as of date. It indicates that only half the estimated BOCW are 'live', whose enrollment has been renewed up so far. This actually means that only five in ten workers in the field are live-listed and eligible for benefits under the cess fund. A state-wise figure of estimated, registered, and live workers is added in the form of Table A. This situation needs correction and hence necessitates drastic measures.

A critical reading of the numbers for cash backing to BOCW in Table A drives home the point that only 1.8 crore heirs could mileage of fiscal backing through Direct Benefit Transfer (DBT) during the COVID-19 epidemic. It was substantially due to the non-availability of Aadhaar and Bank Details of individual workers. A sprinkle of countries couldn't expend a single rupee due to the absence of any similar records of bank details and non-digitization of data.

The separate States Welfare Boards (SWB) have been collecting the weal Cess from the employers/ builders in

agreement with the provision of BOCW Welfare Cess Rules since 1988. The details are as follows

- Accumulative Cess Collected (till 31.05.2020) –Rs. crores
- Accumulative Expenditure (till 31.03.2020) –Rs. crores
- Expenditure during Covid-19 (till 15.06.2020) –Rs. 4905 crores
- Cess Fund Balance Available with all SWBs as of date – Rs. crores (approx.)

Supreme Court Directives It's apparent that the weal fund constituted for the purpose of promoting weal measures for the benefit of the construction workers isn't optimally employed to the asked extent. The functioning and effectiveness of the Structure and Other Construction Workers Welfare Cess Act 1996 and Rules 1998 came under the close scrutiny of the Hon'ble Supreme Court in Writ Petition (Civil) No. 318 of 2006 in which the Hon'ble Court gave veritably important directions. Following which, the advisory was issued by the Central Ministry to all or any SWBs to border schemes within the lines of Model Welfare Schemes for the development workers. Further, an action plan was also given to the States/ SWBs for strengthening perpetration ministry. The separate Governments and its Boards have been trying to overcome several constraints in relating, registering, and icing the inflow of benefits of the fund to the construction workers and their wards. The challenges similar as low position of education among the workers, lack of mindfulness about the weal schemes, temporary nature of their employment and hazy hand-employer relationship, and indefinite ages of employment, among others are encountered while perpetration.

The plight of construction workers during Covid-19 The problems of the migratory construction workers during the COVID-19 epidemic brought to the fore, the attention of all concerned authorities, especially about the pathetic conditions in which the construction workers have lived and impelled to come onto the thoroughfares as the needed backing weren't forthcoming timely. The crunches and the failings in the delivery medium and setbacks on the part of the agencies

5. RESEARCH METHODOLOGY

The improved methodology has two contributions to enhancing the value of a more accurate total performance index incorporating quality control. The first part uses standard EVM formulas but with improved formulas by incorporating the QSPI to calculate a more defined and realistic total construction performance index. The second part is conducting analysis utilizing descriptive statistics Excel. The analysis reviews the mean, standard deviation, and upper and lower confidence intervals. The descriptive

statistics compare EVM metrics of furnaces without a quality control index.

The Earned Value Construction Method (EVCM) uses prescriptive formulas to calculate indices and variances. In construction, most managers are familiar with the basic concepts of EVM. The construction project manager uses two indices and the variances for evaluating project performance. The first index is the Cost Performance Index (CPI), which is needed to monitor the project's cost. The second index is the Schedule Performance Index (SPI) which monitors the schedule's health. The use of cost and schedule variances to determine if trends are occurring.

The project must have project data inputs to calculate the performance indices. The data inputs are the project deliverables converted into a value. The values are numeric in representing time, quantities, or actual measurements. This value is known as the planned value (PV).

The indices have two known outputs, CPI and SPI, which are interpreted in equal to, greater than, and less than 1.0. If the result is greater than or equal to 1.0, the project executes as planned or better. When the result is less than 1.0, there is a reason to believe that the project's health is impacted. The project construction manager assumes the risk and accepts responsibility for its adverse performance.

6. CONCLUSIONS

Compared to the traditional earned value system, the quality earned value system not only indicates the accomplishment of the program but also indicates that the increase or decline in cost caused in part by the increase of quality cost and the schedule overdue may be caused by the increase of breakdown cost in quality cost.

Quality earned value operation enables the establishment of a scientific program operation system, including work breakdown structure, tracking and reporting system, program cost account system, complete system support, integrated examiner system of schedule, cost, and quality, and largely effective information operation system, richen administration system and scientific mortal resource operation system.

Quality earned value operation is an effective operation tool in program prosecution. It realizes real-time monitoring and integrated operation of the three targets of schedule, cost, and quality. The position of its operation will be extremely important to the accomplishment of the program's target.

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