

Project Performance Evaluation using EVA Technique: Kotay Bridge Construction Project on Kayto River in Afghanistan

Mehmet Nurettin UGURAL*, Halil Ibrahim BURGAN

Abstract: The objective of the study is the assessment of an operating bridge project in terms of its performance by the evaluate project performance (EVA) technique. To apply the EVA technique, cost and schedule baselines and an update record of performed work with spent money is prepared for the project. The data is taken directly from site office of the project. Kotay bridge construction project is selected for case study. Project tracking is achieved by taking EVA technique to assess the Kotay bridge construction project performance in the last five months, and to find out the cost and time overruns if they exist. The Estimation at Completion (EAC) and To-Complete Performance Index (TCPI) are found as well to know how efficiently are used the remaining financial resources. The study revealed that CPI and SPI are both less than 1.0, which means that the project could not be performed well. Cost & time overruns are clearly indicated as well.

Keywords: bridge project; Earned Value Analysis (EVA); kotay bridge; project performance evaluation; river

1 INTRODUCTION

Cost and time overruns are crucial problems that are frequently encountered by construction projects around the world [1]. Low cost and time performance are significant issues that arise in the construction industry nowadays [2]. In order to prevent time and cost overruns, it is therefore highly important to check and observe the progress at all levels of the project. Also, a suitable project management process can do this. [3]. Effective techniques and methods must be used to minimize cost and time overruns in construction projects [4]. There are various methods for measuring performance of construction projects; one of them is Earned Value Analysis (EVA) [5].

The EVA is an important project management tool, which helps project managers to control the progress of the project easily. EVA specifies not only the current situation of the project but also forecasts the future perspective of the project. It describes the variances of cost and time from the plan as well [6]. EVA is a powerful quantitative technique; it is used for observing and checking the project progress. Performance of the project, cost and time overruns can be measured through this technique easily. It enables forecasting final cost and project duration, which is vitally important for project managers, in order to minimize losses of time and cost in project [7].

EVA was first applied by the United States Department of Defense in 1960 for forecasting large scale projects. EVA was used in construction projects for the first time [8]. EVA is a significant method which is used for project control and monitoring across the world [9]. EVA is now used in many Industries: defense, IT, pharmaceuticals, oil and gas, and also in the construction industry, particularly infrastructure [10].

In Afghanistan, as an emerging undeveloped country, the number of construction projects was relatively low before 2002. After 2002, number and volume of construction projects rapidly increased. This change was due to the flood of foreign countries' funded projects, government's developmental projects and small private projects [11]. Starting that time, there was no any standard or regulation about project performance monitoring and controlling. "Many engineering projects are over the budget and backlog

so that the quantity of waste in our building work is increasing rapidly" stated Michael Thibautand Shays Christopher [12]. For a country with a weak economy like Afghanistan, which stands with foreign donations, it is crucial to monitor the projects accurately and to have control over projects to avoid time and cost overruns.

In order to control a project, first it should be measured and monitored and then a direction should be given. EVA includes two kinds of metrics; one for monitoring and others for directive control of the project. Schedule Performing Index (SPI), Cost Performing Index (CPI), Schedule Variance (SV) & Cost Variance (CV) are monitoring tools as mentioned before. To-Complete Performance Index (TCPI) & Estimation at Completion (EAC) are performance metrics and they are used to assess future project performance. They are helpful for management strategies of a project [13].

In this paper, Kotay Bridge Project which is located on the road of Gurbuz in eastern Khost province of Afghanistan is studied. The bridge is financed by the United State Army Corps of Engineers (USACE). The main purpose of this study is to apply the EVA technique in the mentioned project to evaluate the past accomplishment & current status of the project and predict the future appearance of the project.

2 LITERATURE REVIEW

Many researches are showing that there are time overruns & costs in construction management projects worldwide. A study which was conducted on 8000 construction projects showed that exclusively 16% of them could meet 3 major standards on performance of the project: concluding on time, within quality & cost standards [2]. So, Afghanistan construction industry is not an exception in this regard. A study which was conducted shows that cost overrun is a serious problem for construction projects in Afghanistan [14].

The advantages of EVA against other project inspection methods and the appropriateness of the EVA's implementation in building projects are investigated in Malaysia [4]. The results showed that, since the formulas of EVA are far stronger when measuring a project's

information, they are more versatile, robust, appropriate and accurate to be implemented in a complex project.

Some studies are conducted to address the application of EVA technique in real case studies in construction projects. EVA technique in construction of a commercial complex building is used in order to evaluate performance of the project [13]. In Brazil, a study is carried out about this subject [15]. EVA is used for the civil construction in Rio de Janeiro, Brazil, in a case study of an indoor amusement park, called Monica Park, inside the Citta America Shopping Centre. The case study includes a critical examination of EVA's operation in Amusement Park. It is shown that EVA plays a vital role in integral management of the projects' key supplies and resources, distance, time, development, expense, risk and provision.

In India, a study is conducted in order to use the EVA technique in a typical housing construction project in Kerala, India [10]. Objectives of the study are: a) to study the use of EVA as a tool for the effective management of cost & other critical variables like time, b) to suggest strategies for the effective use of EVA tool for cost management in housing construction projects. The study reveals that EVA helps to minimize overruns in cost and time.

The report explores how EVA can be applied in infrastructure projects as an infrastructure control tool and how EVA impacts day by day project work in South Africa. EVA is used as a project control tools in infrastructure construction in South African projects [5]. The project performance of EVA is found to have a positive effect. The scenario revealed that after EVA was applied, the project worked well.

An additional study is carried out as a case study in India, the Sangapura Bridge project [3]. The EVA technique for the tracking of costs and time overruns is taken into account. Construction of the mentioned bridge started in January 2016 and total duration of the project was 867 days. In the study, EVA is applied only over a period of five months. The earned value results have been obtained for 15 days based on the progress update done for every 15 days. The Schedule Variance, Cost Variance, CPI and SPI are clearly indicated through EVA.

In view of the foregoing discussion, it is noted that there are a number of case studies using EVA technique in construction projects worldwide. However, case studies in Afghanistan that analyze the utility of project management tools like EVA for evaluating project performance do not exist.

3 THEORETICAL BACKGROUND

The EVA evaluates performance of the project in three key dimensions: time, cost and scope. These three dimensions are known by the PMI as the "iron triangle" and their importance is recognized for their efficiency in project control [16].

3.1 Earned Value Analysis (EVA) Parameters

3.1.1 Data

The steps of the evaluation variables as used data in the project are described below (Fig. 1):

- a) Budget at Completion (BAC), total budgeted cost of project.

- b) Actual Cost of Work Performed (ACWP) or Actual Cost (AC).
- c) Budgeted Cost of Work Performed (BCWP) or Earned value (EV).
- d) Budgeted Cost of Work Scheduled (BCWS) or Planned Value (PV).

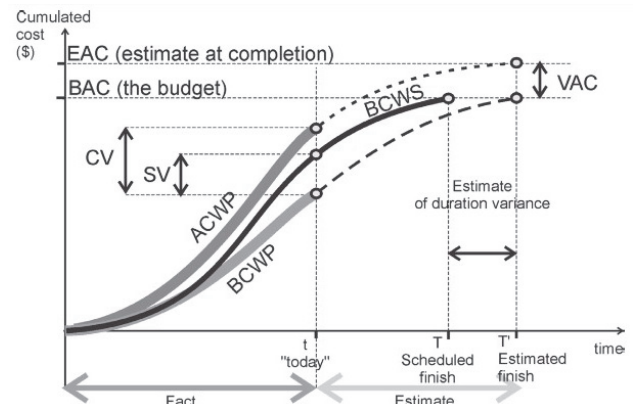


Figure 1 Earned value curves [6]

3.1.2 The indicators of project status

- a) Schedule Variance (SV) shows how much you are ahead or behind schedule:

$$SV = BCWP - BCWS$$

- b) Cost Variance (CV) explains the variation between future and actual works cost:

$$CV = BCWP - ACWP$$

- c) Schedule performance index (SPI) is an indicator of schedule efficiency explained as the proportion of earned value to future value:

$$SPI = BCWS/BCWP$$

- d) Cost performance index (CPI) is an indicator of the budgeted resources' cost efficiency, explained as a ratio of earned value to actual cost:

$$CPI = BCWP/ACWP$$

When CPI and $SPI = 1$, it means that the project is on budget and on the schedule.

When CPI and $SPI < 1$, it means that the project is behind the schedule and over budget.

When CPI and $SPI > 1$, it means that the project is ahead of schedule and under budget.

- e) Percentage Complete (PC): It shows project completion up to date by percentage:

$$PC = BCWP/BAC$$

3.1.3 Earned Value "Forecasting" Parameters

- a) Estimation at Completion (EAC) estimates final project cost at the end if CPI remains the same:

$$EAC = BAC/CPI$$

b) To-Complete Performance Index (*TCPI*) is a proportion between the left over study and the money left from the budget:

$$TCPI = \frac{BAC - BCWP}{BAC - ACWP}$$

4 METHODOLOGY

The methodology for this study is that of a real case study of a prestressed concrete post tensioned bridge project using Earned Value Management (EVA) technique. EVA is one of the most accurate methods for monitoring and controlling project performance. EVA is used widely in big projects, mainly government activity projects. The EVA methodology is strongly recommended by Project Management Institute (PMI) because of its ability to monitor time and cost variations effectively for complex projects. While complex, EVA can be tailored to fit any project of any scale [17].

The methodology comprised the direct involvement by the author in managing and controlling of the bridge project and the day to day construction work. Regular visits to the construction site and collections of the data were integral to the study.

4.1 Application of Kotay Bridge Project on Kayto River

The bridge project is a prestressed concrete post tensioned one lane bridge located on the road of Gorbuz in Khost (Matun) District, Khost Province, Afghanistan [18]. The bridge is constructed on the Kayto River at the town of Kotay with a 4 m carriage way in 1.5 m shoulders/walkways. The bridge has 4 spans 30.65 m long; the total length is 123.35 m. Approach-PCC surface 7m wide with 1.5 HMA shoulders, for a total width of 10m. The PCC shall be a minimum of 30 cm THK and 10 m long. The bridges on the rivers can be affected by natural disasters and extreme events as floods, landslides & soil erosion [19]. Reconstruction procedures should be applied to old bridges in this case.



Figure 2 Map of the Gulam Khan road project [18]



Figure 3 Stones stacked around bridge foundations [18]

Table 1 Work schedule and cost estimate of the project

S. N	Activity ID	Activity Description	BAC / \$	Duration / day	Start Date	End date
1	A	Geotechnical Investigation and design works	80000	24	1-Feb-16	25-Feb-16
2	B	Security and Protection	18000	23	25-Feb-16	19-Mar-16
3	C	Mobilization and site preparation	65000	15	19-Mar-16	3-Apr-16
4	D	Boring and Pile Foundations	106000	39	3-Apr-16	12-May-16
5	E	Pile Caps works	44000	36	12-May-16	17-Jun-16
6	F	Piers Construction	82000	44	17-Jun-16	31-Jul-16
7	G	Pier Caps	38000	29	31-Jul-16	29-Aug-16
8	H	Abutments	34000	22	17-Jun-16	9-Jul-16
9	I	Girders Concrete	170000	60	3-Apr-16	2-Jun-16
10	J	Cables Stressing & Grouting	32000	20	2-Jun-16	22-Jun-16
11	K	Girders Launching	55000	17	29-Aug-16	15-Sep-16
12	L	Diaphragms	48000	28	15-Sep-16	13-Oct-16
13	M	Deck Slab	82000	30	13-Oct-16	12-Nov-16
14	N	Back walls	18000	9	13-Oct-16	22-Oct-16
15	O	Wing Walls	23000	21	13-Oct-16	3-Nov-16
16	P	Embankments	14000	15	3-Nov-16	18-Nov-16
17	Q	Approach Slabs	18000	13	18-Nov-16	1-Nov-16
18	R	Handrails	8000	10	12-Nov-16	22-Nov-16
19	S	Pavement	36000	8	1-Dec-16	9-Dec-16
20	T	Demobilization	40000	6	9-Dec-16	15-Dec-16

A work program and a cost estimate of the project were produced for the purpose of this research and were saved as a basis (Tab. 1). The calculation of each operation requires the amount of material costs, labour costs, equipment costs, and overhead costs to reduce the distortion of the overhead costs of the project. (Fig. 2 to 4).



Figure 4 Bridge abutment with exposed foundation due to soil erosion [18]

Total duration of the project is 317 calendar days. Gantt chart (Schedule) of the project is shown below; it shows the cross section at the 5th month as well (Fig. 5).

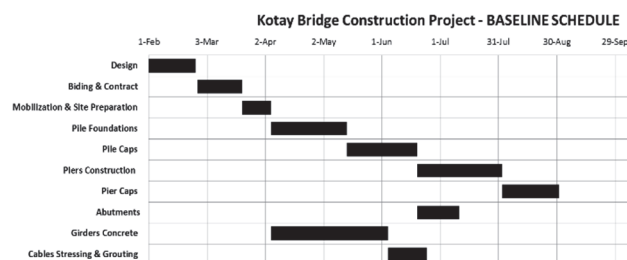


Figure 5 Project Schedule (Gantt chart)

4.2 Data Analysis

In order to check the performance of the project after 5 months (at 1st July) an update schedule and expenditures list are needed to display completion percentage of the activities and used budget for each activity. Then, the EVA technique is applied (Tab. 2).

Table 2 Calculated parameters by EVA technique

S.N	Activity	BAC	Scheduled Work %	PC %	BCWS	BCWP	ACWP	CPI	CV	SPI	SV
1	A	80,000	100	100.00	80,000	80,000	82,000	0.98	-2000	1.00	0
2	B	18,000	100	100.00	18,000	18,000	21,000	0.86	-3,000	1.00	0
3	C	65,000	100	100.00	65,000	65,000	65,000	1.00	0	1.00	0
4	D	106,000	100	100.00	106,000	106,000	120,000	0.88	-14,000	1.00	0
5	E	44,000	100	80.00	44,000	35,200	38,000	0.93	-2,800	0.80	-8,800
6	F	82,000	27	0.00	22,140	0	0	-	0	-	-22,140
7	G	38,000	0	0.00	0	0	0	-	0	-	0
8	H	34,000	54	25.00	18,360	8,500	10,000	0.85	-1,500	0.46	-9,860
9	I	170,000	100	90.00	170,000	153,000	160,000	0.96	-7,000	0.90	-17,000
10	J	32,000	100	95.00	32,000	30,400	30,400	1.00	0	0.95	-1,600
11	K	55,000	0	0	0	0	0	-	0	-	0
12	L	48,000	0	0	0	0	0	-	0	-	0
13	M	82,000	0	0	0	0	0	-	0	-	0
14	N	18,000	0	0	0	0	0	-	0	-	0
15	O	23,000	0	0	0	0	0	-	0	-	0
16	P	14,000	0	0	0	0	0	-	0	-	0
17	Q	18,000	0	0	0	0	0	-	0	-	0
18	R	8,000	0	0	0	0	0	-	0	-	0
19	S	36,000	0	0	0	0	0	-	0	-	0
20	T	40,000	0	0.00	0	0	0	-	0	-	0
21	Total	1,011,000	55	49	555,500	496,100	526,400	0.94	-30,300	0.89	-59,400

5 RESULTS AND DISCUSSION

The evaluation results are demonstrated. As seen $SPI = 0.89$ and $CPI = 0.94$, both are less than one. So, it can be said that the project is over the budget & back of the time table. In other words, overall project performance is poor in the last 5 months.

Cost overrun at the end of the 5th month = 30300 \$

Schedule overrun at the end of the 5th month = 59400 \$

The expected cost at the project completion if CPI stays the same:

$$EAC = BAC/CPI = 1011000/0.94 = 1075532 \$$$

The cost variance at completion (VAC) of the project:

$$VAC_{\text{cost}} = BAC - EAC = 1011000 - 1075532 = -64532 \$$$

The To-Complete Performance Index ($TCPI$) for the project:

$$TCPI = \frac{BAC - BCWP}{BAC - ACWP} = \frac{1011000 - 496100}{1011000 - 526400} = 1.06$$

By evaluating the outcomes from the EAC and $TCPI$ that have been estimated based on past performance, the project would end late and at a higher cost than expected if past performance persists for the rest of the period. Late completion is expected if negative schedule variances in activities are on the crucial line. To prevent undesirable outcomes, the project management should consider the results and take action.

The EVA makes clear that project performance is not good at the last five months. It shows in a very good manner where the problems are. Hence, project management can take advantage of these results, and can provide a suitable plan for remaining works, to avoid the time and cost overruns or at least minimize the losses.

6 CONCLUSIONS

In this study, an application of the EVA technique in a bridge construction project is presented and data is extracted directly from the project site office. The construction was started in February 2016. Duration of the project as per baseline schedule is 317 calendar days. Tracking till 1st July 2016 reveals 49% completion of overall project. The study discloses that CPI and SPI both are less than 1.0, which means that the project is not performed well; time and cost overruns are clearly indicated as well. The $TCPI = 1.06 > 1$ shows that the amount of the remaining work of the project must be done more effectively and at a better cost performance level than the project's executed work.

In the current paper, EVA was applied over a period of five months. Analysis can be made for the entire project, so that actual performance status of the whole project can be taken.

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Contact information:

Dr. Mehmet Nurettin UGURAL, Asst. Prof.
(Corresponding author)
Istanbul Kultur University, Faculty of Engineering,
Department of Civil Engineering,
Atakoy Campus, 34158 Istanbul / Turkey
E-mail: m.ugural@iku.edu.tr

Dr. Halil Ibrahim BURGAN, Asst. Prof.
Akdeniz University, Faculty of Engineering,
Department of Civil Engineering,
07070 Konyaalti, Antalya, Turkey
E-mail: burgan@akdeniz.edu.tr