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Value Engineering Application in Highway Projects

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Abstract: Problem statement: Each year, a major part of revenues spent on Investing in sector development plans and State infrastructures filled with clear reduce costs and done on time Projects leading to high savings budget plans executive and will be return on Investment. **Approach:** On transportation projects, Value Engineering (VE) teamwork by involving construction, design and maintenance staff review the construction project features and look for ways to improve quality, control costs and time. Also this study briefly described VE and quality, cost schedule planning, application of VE, cost parameters, relationship of value, function, cost and worth. **Results:** VE, highway construction was survived and opportunities for better, less expensive means of completing the construction projects were analyzed. The intention is to progress project quality and productivity, foster innovation, optimize design elements, also ensure overall economical costs. **Conclusion:** This study achieved to the model Value Engineering in Highway Construction (VEHC) which cause decrease time, decrease cost and increase quality in highway it has been.

Key words: Value engineering, improve construction, highway construction

INTRODUCTION

Value engineering (VE) is a management tool to achieve essential functions of a product, service or project with the lowest cost. VE has become a standard practice for many government agencies and private engineering firms and contractors since its first adoption in the 1950s. It has been widely practiced in the construction industry and become an integral part in the development of many civil infrastructure projects.VE has been practiced for half a century in the construction industry with an aim to produce innovative ideas and solutions for enhanced project value(Zhang *et al*., 2009). Value Engineering (VE) or Value Management (VM) is one of the important project management tool, it can be defined as the systematic effort directed at analyzing the functional requirements of systems, equipment, facilities, procedures and supplies for the purpose of achieving the essential function at the lowest total cost, consistent with meeting needed performance, reliability, quality, maintainability, aesthetics, safety and fire resistance. VM as a management style focuses on value system evolution and resolution within projects, or organizational systems for that matter, by bringing the right team of stakeholders together at the right time. Through a structured, challenging, analytical and mediated process it permits value systems to coalesce to the benefit of the commissioning organization, regardless of whether the VM service is offered internally within an organization or is commissioned externally. VM also can be defined as a structured and analytical process, the purpose of which is to seek to achieve value for money by providing all of the necessary functions at the lowest cost consistent with required levels of quality and performance.

VE may be performed in two ways; proactively or reactively. A proactive approach uses VE to collect ideas starting at the beginning of design. Thus, multiple design alternative are considered and the most cost effective selected on a continual basis throughout .the design phase a reactive approach gathers cost effective alternatives through design reviews by other project personnel such as constructors and other designer engineers. This is performed after the entire design or specific component of design is complete. One of the best filed to apply VE concepts is the productivity. In construction projects; the productivity is the most critical factor to determine the project cost, duration and as a result; the benefit for all parties (Abd *et al*., 2008).

The goal of the study is to verify the effect of VE as a valid approach for highway improvement construction and to develop the VE technique in this procedure.

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Improving the value engineering process: VE is a structured problem solving process based on function analysis to improve the value of a system. Value is defined by a ratio of function to cost and consequently it can be increased by either improving the function or reducing the cost. The VE study is normally conducted by team of members of multi-disciplinary experience and expertise. First, the VE team establishes the functional relationships in a system through a "how-why" questioning technique. Then, the VE team develops a matrix of the various functions of the system against their associated costs. The value of the system is maximized by an optimal tradeoff between the functions and their associated costs. In the context of construction, the objective of the VE study is to achieve the necessary functions with the lowest project life cycle cost. This may be done through the use of new material, creative design, simplified construction process, innovative construction method, reduced construction cost and time, improved construction quality and safety, and minimal environmental impacts. A VE study includes three sessions, pre-workshop, workshop and Post-workshop. Each session in turn has some phases. For example, the workshop session includes three phases: information and function analysis phase, creativity phase and evaluation phase. It is generally recognized that the creative phase of the workshop is the most critical phase that determines the success or failure of a VE study because it is in this phase that creativity techniques are applied to generate innovative ideas for enhanced project functions and reduced project costs (Zhang *et al*., 2009).

Not all studies required a quantification of construction highway. The authors of some studies did not intend to establish the relationship between the explanatory variables and the dependent variable (cost, time and quality) (Yung and Yip, 2010).

Principle of value engineering: Value engineering focuses on function analysis of research objects and strives to achieve the required function reliably at the lowest life cycle cost to gain the best integrated benefits. The basic formula for it is:

$$V_i = F_i / C_i \quad (1)$$

Where:

V_i = Value or value index of the i scheme
F_i = The function or function coefficient of the i scheme
C_i = Cost or cost coefficient of the i scheme

A higher value or value coefficient illuminates the required function is achieved at a lower life cycle cost. The scheme with the highest value or value index should be selected as the optimal scheme. The general programs applying value engineering to evaluate the schemes include identifying research object, object functions analysis, object cost analysis, scheme evaluation and analysis (Jiayou and Yanxin, 2009).

Relating quality and value: Relating qualities to value judgments the industry needs clear definitions of qualities, quality, value and values. It has been suggested here that values should follow Kohler's definition, i.e., they are the beliefs of the project team, whilst qualities should represent physical or functional product attributes.

Quality should be treated as an objective assessment of the qualities in relation to the project's values. Value, if treated subjectively, is a judgment by an individual about a product or a service, framed by their values. An objective assessment requires the evaluation and comparison of benefits and sacrifices, with appropriate units of measurement. The specific content of the assessment expression depends in the circumstances of the value assessment.

Defining value: Four fields were reviewed to develop an understanding of value that would be useful in construction:

- Theory and philosophy of value
- Manufacturing and product design practices such as value analysis, value engineering and lean manufacturing
- The recently emerged field of customer value management
- Construction management theory

The manufacturing sector has adopted an objective view of value for many years. Value analysis, for example, involves the testing of functions required by customers as design objectives. This approach substitutes for the direct engagement of customers (to identify their values to which the design must respond) recognizing that its success in doing so will be judged subjectively by these customers (Thomson *et al*., 2003).

MATERIALS AND METHODS

Multiple Regression model (MR): Regression estimation models are well established and widely used in cost estimation. They are effective due to a well-defined mathematical, as well as being able to explain the significance of each variable and relationship between independent variables.

Table 1: Use of value engineering techniques with method brain storming in construct highways

Year	Total offers	Total admission	Acceptance (%)	Saving ($)	Offer quality (savings unit^{-1})
1997	-	333	-	31,069,777	93,303
1998	376	329	87.50	38,400,000	116,717
1999	335	286	85.37	35,020,000	122,448
2000	354	269	75.99	40,655,000	151,134
2001	359	299	83.29	66,305,000	221,756
2002	416	347	83.41	61,101,000	176,084
2003	330	288	87.27	54,140,000	187,986
2004	310	255	82.26	40,129,000	157,369
Sum	2408	2406	-	366,819,777	-
Average	354	296	83.59	45,852,472	153,349

Source: FHWA, 2002

Basically, regression models are intended to find the linear combination of independent variables which best correlates with independent variables. The regression equation is expressed as follows:

$$Y = C + b_1X_1 + b_2X_3 + \ldots + b_k X_k \quad (2)$$

Where:

C = Regression constant
$b_1,b_2,\ldots,b_k$ = Regression estimates
$X_1,\ldots,X_k$ = Independent variables
Y = Dependent variable

The variables descriptions are mentioned in Table 1 for Poland and Thailand. The goal was to estimate regression coefficients of Eq. 2. Software "R" statistical tool was employed to perform regression analysis. The adjusted R-square value (R^2) is equal 0.72. Which for test significance of model ANOVA (F test) was performed (Sodikov, 2005).

Data collection: The data for this research were gathered through highway which constructed in Iran country to number 40 projects from year 2003 until 2009 and base total project for length Kilometer (KM) and for time Month (M) optioned. Also the questionnaire includes Value Engineering and quality that by consultant and employer and contractor to them answered. All this data will be stored and analyzed by using software's". The main purpose of using "R" to analyze the data is to create a result for achieve to model VE. After fitting a multiple regression model on data which VE as a dependent (response) variable and the dependent (explanatory) variables includes time, cost, quality the regression model is significance at the level of 95% with the P-value = 4.671e-10. The multiple R-square for this model is = 0.72which means 72% of variance of value explained by this variable. The parameters which can be included in the model with the significance level of 95 and p-value = 4.671e-10<0.05. Therefore final model achieved in following shown.

Multiple linear regression method: The results of analysis are obtained as shown in following. Analysis, the value engineering prediction model for main road construction according following equation:

$$VEHC = 4.125 - 0.231T - 3.297e\text{-}06C + 0.2615\,Q \quad (2)$$

Time = T

C = Cost

Q = Quality

The model has an R-square of 0.72, which means that 72% of the variation in the number of VE has been explained the regression line. The T-test also indicates that the model is significant and can be used for the prediction of the number of VE in main road construction. This study developed model value engineering in highway construction which might bring about a decrease in construction cost and time and an increase in project quality. But the other variable cannot be included in the model.

RESULTS

Figure 1 the relationship between value engineering and cost shows that with reducing costs Value Engineering increased and Considering the linear equation Y = -0.000004X+4.892 shown that with reducing the costs value construction in projects linear form of increased and in Fig. 2 relationship between Value Engineering and time shows that with reducing time, Value Engineering increased also in Fig. 3 VE versus Time equal: Y= -1.2802X+6.8729 Shown that with Reducing the time value construction in projects increased. And in Fig. 2 shows that with increase quality, Value Engineering increased and this equation Y = 0.4482X+2.1806 Confirming. Meaning in per KM reduces cost and time in according previously research (Table 1) more than twenty studies studied.

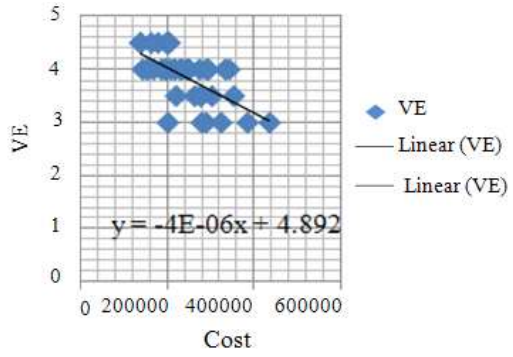

Fig. 1: The usage linearity between VE and cost

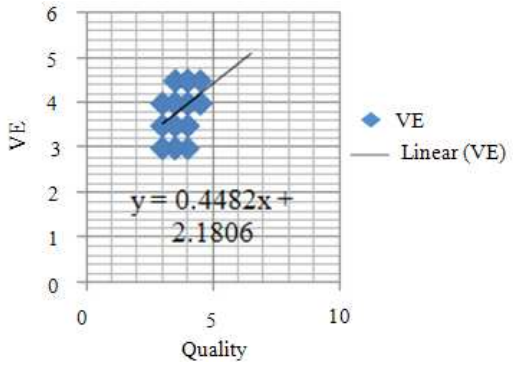

Fig. 2: The usage linearity between VE and quality

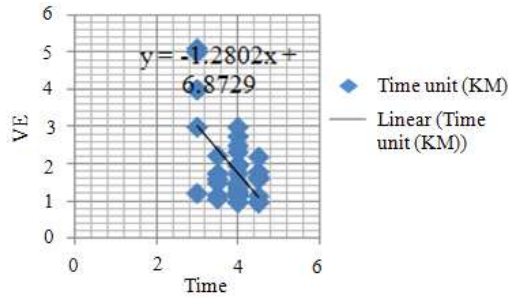

Fig. 3: The usage linearity between VE and time

In more them usage technique VE for reduce cost and time also increase quality according to recommendation engineering experiences and project manager to method brain storming presented but this model (VEHC) to accuracy control analyzed and this model for other project responses.

DISCUSSION

Usage of VE Project complexity is the most influential in construction Main road. Also strong influencing factors (cost, time and quality) affecting usage. The characteristics of the data collected for effect of VE in construction main road. The results show that the cost related process is the most important in the project then quality in finally time.The achieved high value in construction projects main reason usage VE is projects also with utilization and with use of this technique employers can more money save. This equally applies to reduce time, reduce cost and increase quality. This aspect of the technique VE is very useful for perform highways also for financial planning and performance timely projects.

CONCLUSION

The model in this study can in the evaluates the projects performance of VE study: By decrease cost, decrease time and increase quality which in this model for per KM using of technique VE that achieved: VEHC = 4.125-0.231T-3.297e-06C+0.2615Q also according to Fig. 1. The Usage Linearity between VE and Cost: Y= -0.000004X+4.892, Fig. 2: The Usage Linearity between VE and Quality is: Y = 0.4482X+2.1806 in finally Fig. 3: The Usage Linearity between VE and Time is Y = -1.2802 X+6.8729. So this model tested for another project and quality as separately calculated and shown. To assess the effects of a VE study needs to consider not only the final economy but also the reciprocation relationship between Value Engineering with time, relationship between VE with quality and then study reciprocation between the expeditor and the construction participants. However VE, highway projects are reviewed and opportunities for better, less expensive means of completing the projects are analyzed. The intention is to improve project quality and productivity, foster innovation, optimize design elements and ensure overall economical costs. The goal of a VE study is to achieve implement excellence. Its objectives are to improve quality, minimize total ownership costs and decrease time.

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