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Possibility of Using Value Engineering in Highway Projects

Renata Schneiderova Heralova

Czech Technical University in Prague, Faculty of Civil Engineering, Thakurova 7, 166 29 Prague, Czech Republic

Abstract

The paper deals with the possibility of using value engineering in highway projects. The reasons for criticizing highway projects are usually three. Firstly, they do not achieve expected project goals, secondly, project delivery is not within a reasonable amount of time, and finally, costs are not in line with their budget limits. The author believes that value engineering methodology can help to find ways to improve solutions to these problems by balancing cost, schedule, and scope through the generation of innovative alternatives. It was found that a project can significantly save on costs and improve performance of project functioning by using the appropriate value engineering process at the right time. The paper summarizes the benefits and effectiveness of the value engineering methodology along with recommendations.

Keywords: cost, highway construction, public projects, value engineering (VE)

1. Introduction

Programs in the public works sector such as highway construction are being criticized for delivering projects that fail to hit the following targets:

- Expected project objectives
- Delivery within a reasonable amount of time
- Costs no more than their budgeted amounts

In order to avoid this, care must be taken to achieve a reasonable number of highway projects that meet the expected project goals, are completed in time, and do not exceed the planned costs. Performance-based value engineering, modified for public works applications, can help achieve this. There is the need for a project management tool that efficiently identifies and balances project scope with the schedule and costs. Furthermore, project managers need to identify and analyze a large quantity of project alternatives with an appreciable variation in scope, schedule and cost.

Escalating construction and maintenance costs, combined with reduced revenues, have led to an increased interest in value engineering by government transportation agencies [1]. All national agencies in Asia have national regulations mandating that certain projects have be value analyzed. In the USA, the Value Engineering Final Rule requires value engineering analyses of projects on the National Highway System (NHS) which receive Federal assistance reaching an estimated total cost of $50,000,000 or more, also bridge projects on the NHS receiving Federal assistance reaching an estimated total cost of $40,000,000 or more, and it provides for VE analysis guidance on projects [2]. There are no similar regulations in the Czech Republic.

Value Engineering helps a project to meet the customer's need for cost efficiency within a short timeframe. It is important to realize that VE tools focused on the construction sector, particularly public works construction projects, should have greater emphasis on project scope, as this aspect of public works is usually the challenging aspect of project development. VE study looks for ways to improve solutions to a problem. It is a function-oriented, systematic, team approach, used to analyze and improve value in a product, facility design, system, or service. It offers a powerful methodology for solving problems and reducing costs while improving performance and quality. Value engineering studies can provide measured balance in cost, schedule, and scope by generating multiple innovative alternatives. This requires a motivated team of professionals in cooperation with project stakeholders stimulated and guided by such an appropriate process.

The main goals of this paper are to suggest a performance measurement based on the VE method for public projects and to summarize the benefits of the proposed methodology.

2. Literature review

Value Engineering is a conscious and explicit set of disciplined procedures designed to seek out optimum value for both an initial and long-term investment. First utilized in manufacturing industry during World War II, it has been widely used in the construction industry for many years.

The Society of American Value Engineers (SAVE) was formed in 1959 as a professional society dedicated to the advancement of VE through a better understanding of the principles, methods, and concepts involved. The Society of American Value Engineers defines VE as the systematic application of recognized techniques that identifies the function of the product or service, establishes a monetary value for that function, and provides the necessary function reliably at the lowest possible cost. Therefore, the purpose of a systematic VE approach is well demonstrated when the user is able to define and segregate the necessary functions from the unnecessary functions and thereby develop alternative means of accomplishing the necessary functions at a lower total cost [3].

VE in the construction industry is mainly an organized effort to challenge the design and construction plans of projects to provide the required facility at the lowest overall cost consistent with requirements for performance, reliability, and maintainability [4].

Research [5] emphasizes the "VE Job Plan" as an organized and systematic approach tool and is the key to success in VE studies. The job plan is the road map for defining the required task in determining the most economical combination of functions to complete the task. It is through the job plan that the study identifies the key areas of unnecessary costs and seeks new and creative ways of performing the same function.

Other research [6] defines VE by what is true and what is not true about the VE concept. They state that VE is a systematic and multi-disciplined management technique. On the other hand, it is not a design reviewing, cost lowering, or quality control process. The Function Analysis System Technique (FAST) diagram is a powerful tool that helps to organize the random listing of functions by answering the questions: How? Why? What does it do? What must it do? This helps the VE team to develop many verb-noun functions' structure and their interrelationships. Also, FAST diagrams aid in the identification of basic function and scope [7].

However, little research has indicated the importance of a performance measurement-based VE methodology for public construction projects. One study [1] demonstrates how a performance-based value engineering methodology helps save time and money and increases that functional performance. The objective of this study was to upgrade and expand existing facilities and systems on an express highway linking Seoul to Pusan. The VE study generated several innovative alternatives capable of saving up to 50% of project costs and also increasing performance and value from the baseline project plan.

The design stage is the key stage of investment control in highway engineering. The advantages and disadvantages of design scheme quality directly influence the whole effect of project investment and application. Another study [8] verifies the reliability of applying value engineering in optimizing a design scheme of highway engineering using an actual engineering example. How to apply the theories and methods of value engineering in construction project is shown in [9]. In the construction of the road during the design process, the construction costs were reduced and the construction period was shortened by using value engineering methods. This paper analyzes loss of control in a highway investment at the design stage and puts forward some methods to control the cost of a highway for consideration in a Design Department, such as promoting quota-designs, optimizing a design project, enhancing design management and so on.

According to the Federal Aid Highway Program (USA) [2], value engineering is defined as the systematic process of review and analysis of a project, during the concept and design phases, by a multidisciplinary team of people not involved in the project, and that is conducted to put forward recommendations for providing a) the needed functions safely, reliably, efficiently, and at the lowest overall cost; b) improving the value and quality of the project; and c) reducing the time to complete the project. The successful application of the VE process can contribute measurable benefits to the quality of surface transportation improvement projects and to the effective delivery of the overall Federal Aid Highway Program. The Value Engineering Final Rule was published in 2014, and this Final Rule removes the VE analysis requirement for projects delivered using the design/build method of construction, provides VE analysis guidance for projects delivered using the construction manager/general contractor (CM/GC) method of project delivery, and increases the project thresholds for required VE analyses to:

- Projects on the National Highway System (NHS) receiving Federal assistance with an estimated total cost of $50,000,000 or more
- Bridge projects on the NHS receiving Federal assistance with an estimated total cost of $40,000,000 or more.

Their web site describes the FHWA's VE program, discusses many subjects crucial to the administration of a successful VE program, and attests to the program's benefits through the compilation of annual accomplishment reports and descriptions of successful practices and VE analyses. The FHWA's VE program applies to the Federal Aid Program under which the funds authorized for Federal aid highway acts are distributed to States for projects developed and administered by State Departments of Transportation (DOT). The FHWA annually collects information on VE accomplishments within the Federal Aid and Federal Lands Highway Programs. The following Table 1 summarizes recent savings realized by conducting VE.

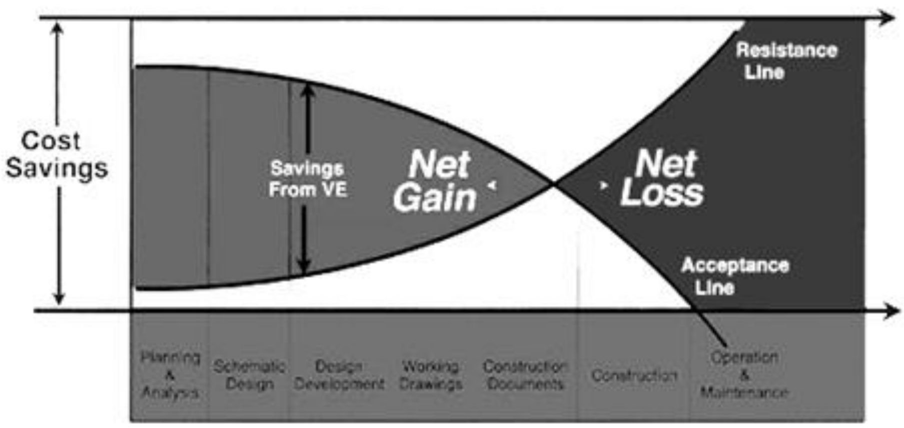
Table 1. Summary of past VE savings

Year	2014	2013	2012	2011	2010
Number of VE Studies	215	281	352	378	402
Cost to Conduct VE Studies and Program Administration	$8.7 M	$9.8 M	$12.0 M	$12.5 M	$13.6 M
Estimated Construction Cost of Projects Studied	$20.9 B	$23.0 B	$30.3 B	$32.3 B	$34.2 B
Percent of Project Cost Saved	8.32%	5.01%	3.78%	3.12%	5.79%
Return on Investment	200:1	118:1	96:1	80:1	146:1

3. Value engineering in construction projects

Value Engineering is not a design/peer review or a cost-cutting exercise. Value engineering is a creative, organized effort, which analyzes the requirements of a project for the purpose of achieving the essential functions at the lowest life cycle cost (LCC). Through a group investigation, using experienced, multi-disciplinary teams, value and economy are improved through the study of alternative design concepts, materials, and methods without compromising the functional and value objectives of the client. VE can be applied at any point in a project, even in construction. However, typically the earlier it is applied the higher the return on the time and effort invested – see Fig. 1 [4]. The three main stages of a project and a VE application are described below.

Fig. 1. Potential savings from value engineering application.



3.1. *Planning*

At the planning stage of development, there are additional benefits to be derived from a Value Engineering Workshop. An independent team can review the program, perform a functional analysis of the project, obtain the owners and users definition of value, define the key criteria and objectives for the project, verify the proposed program, review master plan utility options, offer alternative solutions, and verify the budget.

3.2. *Design*

Design is the stage that most VE participants usually become involved, the point at least when the design has made it to the schematic stage. The primary tool available to the VE team is the Workshop. The Workshop is an opportunity to bring the design team and client together to review the proposed design solutions, the cost estimate, and the intended implementation schedule and approach, with a view to implementing the best value for the money. The definition of what is good value on any particular project will change from client to client and project to project. The five-step “VE Job Plan” is followed, as prescribed by SAVE International:

- Information Phase (understanding the background, analysis of the key functional issues – the cost and impacts associated with function)
- Creative Phase (ways to provide the necessary function at a lesser LCC - improved value for client)
- Analysis Phase (criteria definition for evaluation, ideas analysis, weighted evaluation)
- Development Phase (ideas are expanded into workable solutions – design change, evaluation of advantages and disadvantages, cost comparison, LCC calculation, comparison to original design)
- Presentation Phase (recommendations, key cost impacts).

3.3. *Construction*

During construction value engineering is still possible. Contractors can be provided with monetary incentives to propose solutions that offer enhanced value to the owner, and a share in the financial benefits realized. Clearly the owner must consider contractor-generated proposals very carefully, from both a life-cycle perspective [10], and a liability perspective. The team must be brought in to the decision-making process to agree to the proposed change in order not having any negative impact on the overall design and project function.

Value Engineering is not only beneficial, but essential because:

- The functionality of the project is often improved as well as producing impressive savings, both on initial and Life Cycle Cost
- A "second look" at the design produced by engineers gives the assurance that all reasonable alternatives have been explored
- Cost estimates and scope statements are checked thoroughly assuring that nothing has been omitted or underestimated
- It assures that best value will be obtained over the life of the project

4. Performance measurement- based value engineering

One of the problems with studies on public highway projects is the tendency for them to become a “cost-cutting” tool instead of a value-enhancing tool [11], [12]. Since costs are reported only at the conclusion of each study, there is no mechanism for weighting the value of the project costs that were cut against the project scope and project delivery components that accompanied these costs. Using value engineering and the performance measurement application in VE can help to optimize a project plan by minimizing cost and maximizing function performance. Project stakeholders quantify what and how well the project delivers project scope, schedule, and costs by measuring the impact and rating the effectiveness of the alternatives along with the performance measurement criteria. The reasons why we need to measure project performance for public works can be given. It brings transparency to all project issues for the project stakeholders, it handles “conflicting” project criteria, it addresses technical issues using quantitative or qualitative parameters, and it improves the probability of delivering a project that serves the community with optimal project value. Below, the formula shows the relationships between value, performance and life cycle cost.

$$V_i = \frac{P_i}{LCC_i} \quad (1)$$

Where:
V_i … Value of improved alternative *i*
P_i … Performance of improved alternative *i*
LCC_i … Life cycle cost of improved alternative *i*

In the VE process, project stakeholders identify the performance criteria, establish their relative weights, and then rate the current project. The VE team establishes the performance of the new alternatives as compared to the current project's performance, and project stakeholders verify the performance ratings for the VE alternatives. Determining the project performance criteria is an important process for measuring the project functions. Qualitative and quantitative parameters should be used to increase the objectivity of the application. Proposed criteria for highway construction are quality and safety, constructability, public-friendliness, environmental-friendliness, socioeconomic factors, operational efficiency and maintainability, and project management considerations. After the project performance criteria and relative importance (weightings) are determined, stakeholders define the performance criteria parameters by identifying the units of measurement for each of the performance criteria and by establishing a range of acceptable values for these criteria. The selected sets of alternatives are compared against the original design concepts. The total performance rating is divided by the total project life cycle cost to produce a value index (1), and the difference between the value indices of the original design and the alternatives is expressed as a Value Improvement.

5. Conclusion and Recommendation

The quality and cost of highways and other projects in the public works sector can benefit by the application of value engineering methodologies. Specifically, the VE methodology provides for analyzing the project objectives and attributes, which, in turn, focuses the development of alternatives in the value study. Government agencies that apply value engineering to their construction programs can achieve the following benefits: resolve technical problems on complex projects, gain additional technical expertise, give emphasis to efficient use of resources, improve project performance and achieve cost savings. Project performance measurements quantify the quality of project objectives and the timeframe in which they are delivered, which in turn allows the project value to be determined. Through VE program use in the public sector, significant improvement in project performance and cost savings has been experienced. Improving the relationship between the project performance and project life cycle costs has been a major benefit to public project managers. These savings have been extended into other public projects, a real value for the taxpayer. Most importantly, using VE could accelerate construction because it creates a consensus-building foundation. VE studies carried out in the public sector have allowed for the development of consensus on what the project scope, budget, and delivery should be. This consensus has been formed with project stakeholders, such as local governments, transportation and regulatory agencies and the communities involved or affected.

Acknowledgements

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