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Road Geometric Design in Terms of Value Engineering

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ABSTRACT

Value Engineering, "VE" is one tool that can counteract the growing of highway problems in both design and construction phases by providing: cost reduction, process improvement and alternative means and materials for highway construction and maintenance. The main purpose of VE is to deliver the necessary function of a certain facility at its lowest cost.

For better understanding the VE application, one should first identify the main terms which named, function, cost, worth and value. The systematic approach of VE is the job plan. It helps to identify high-cost areas of the project as well as determining the most economical combination of functions to achieve the target either highway geometric design or construction or both.

The function analysis approach leads to more innovative solutions than item oriented traditional cost reduction approaches. Another approach used for identifying/classifying the functional relationships of a study project known as Functional Analysis System Technique, "FAST". Using a FAST, a good understanding of the overall problem and its solution can be obtained. Results clarifies that the value engineering, FAST technique can be applied in the road design process in Egypt.

Keywords: *Value Engineering – Cost – Function – Worth – Job Plan*

1 INTRODUCTION

In the current biennium where many governments are faced with declining revenues and budget short falls. Today, Value Engineering is an important or perhaps more important than at any other juncture of time in recent history. Highway needs are growing which the flow of financial resources is still standing, if not falling back. Energy crisis has brought recognition to the finites of our resources and realization that we must conserve current resources, both financial and natural, and search for new techniques and materials responding to highway requirements. Value Engineering, VE is one tool that can counteract these growing problems by:

a) Cost reduction;
b) Process improvement; and
c) Alternative means and materials for highway construction/maintenance /3 /.

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VE may be applied at any point in highway operation, development and maintenance. To attain the highest effectiveness, however, VE should be undertaken as early as possible when impact of decisions on life-cycle costs is highest. Figure 1 represents the distribution of total costs as expended over the life-cycle of a typical construction project /12/.

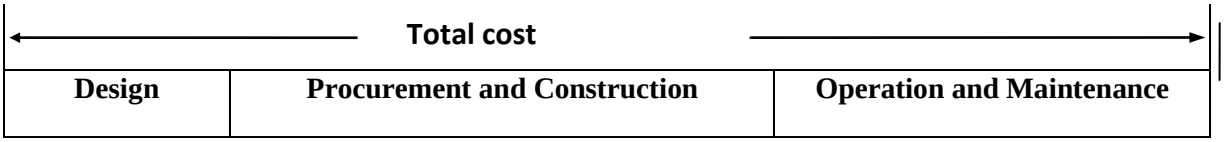

Figure 1: Cost Distribution along Different Life Stages

Usually, all of the initial cost of a construction project adds up to less than 50% of the total life cycle cost. At the outset of any project, when criteria are being established, any effort is directed to identify functions; eliminate unnecessary functions, speculate on alternatives, adopt the most-effective alternative, and provide a plan for implementing the chosen alternative. Ways are found to assure that the suggested solutions implemented to plan and schedule. Awareness of opportunities to employ VE, should before most at all times. This awareness should be demonstrated from the project conception to completion of construction and into the maintenance operation. Location, embankments, structures and pavements, alternate designs and materials, construction and maintenance, these items should be considered in VE of any highway project.

2 VALUE ENGINEERING, VE DEFINITION

There have been many attempts to define VE. Definitions mentioned hereinafter were reached by some of the lea-ding authorities in the application of VE. According to U.S. Department of Transportation, DOT, 1992: VE is an organized effort to analyze the functions of systems, equipment, facilities, services and suppliers for the purpose of achieving the essential function at the lowest life-cycle cost consistent with required performance, reliability, quality and safety.

According to Eric Adam /7/: “Value analysis, value engineering and/or value management: An organized approach to locate, identify and remove unnecessary resource.

Dell ‘Isola defined, VE, as simple as /1/:” A systematic approach for obtaining optimum value for every dollar spent.”

The Society of American Value Engineers, “SAVE” defined VE as: “The systematic application of recognized techniques which identify the function of a product or service, established a value for that function, and provide the necessary function reliably at the lowest overall cost.” In all instances, the required function should be achieved at the lowest possible life - cycle cost consistent with performance, maintainability, safety and quality requirements /3/.

VE is a creative, organized approach chose objective is to optimize cost and/or performance of a facility or system. Through a system of investigation, unnecessary expenditure is avoided, resulting in improved value and economy. The VE approach is directed toward analysis of functions and concerned with elimination or modification of anything that adds cost to an item without contributing to its required functions /10/. VE is not aimed at finding fault with current designs or ways to “cheapen” projects. Instead, VE is a process that looks at ways to:

- **Improve** the overall design;
- **Simplify** project construction;
- **Improve** project maintenance and
- **Lower** a project’s initial and/or life-cycle cost.

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Stylianopoulos, L.C. /6/ mentioned that, the purpose of VE is to deliver the necessary function of a certain facility at the lowest cost.

3 FUNDAMENTALS OF VALUE ENGINEERING

In order to better understand the application of VE, one should first identify the following main terms:

3.1 Function

There are 2-distinguishable types of functions, and the following definitions may help in differentiating between them:

3.1.1 Basic Function:

The needed performance characteristic (s) of item, which is required to make it perform and/or sell, the item may be a facility, service, method, building system.

3.1.2 Secondary Function:

It is the function which supports basic function but generally exists only because of the particular design approach that has been taken to perform the basic function, hence it may or may not be essential to neither the product, nor the user.

Function analysis is the key element in VE, because the purpose of VE is to obtain the required function(s) of an item at the lowest total cost.

3.2 Cost:

It is the total amount of money required to obtain and use the function that have been specified. Costs play a major role in the methodology because they form the basis for all savings and a guide toward selecting areas for applications.

3.3 Worth:

It refers to the least cost required to provide function(s) that are needed by the user of the accomplished project. The U.S. Department of Defense defined the worth as "the least cost of providing the needed function and the required performance and is found by means of comparison of costs and units which are functionally equivalent".

3.4 Value:

VE is concerned with both the economical and use values. Function is closely related to use value or the properties and qualities, which satisfactorily and reliably accomplish a use. In general, the relationship of worth to cost is the principal measure of value, which is a dimensionless expression.

$$\textit{Value Index} = \textit{worth} / \textit{cost} = \textit{utility} / \textit{cost} = \textit{function} / \textit{cost}$$

$$V_{max} = F / C_{min}$$

Where: V_{max} : is the maximum value,
F : is the function and
C_{min} : is the minimum cost.

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The value may be increased by doing any of the following:

1. Improve the project utility with no change in cost;
2. Retain the same utility for the less cost;
3. Combine utility improve with less cost.

VE should generally be undertaken when there is an assumed potential a significant ratio of cost saving of the VE. This VE use can also be applied to design standards, construction procedures, and VE incentive clauses in construction contracts as deemed and appropriate by the operating administrations /11/.

The Japanese introduced VE in 1970 through the auspices of the Institute of Business and management of Tokyo. Venkataraman S.S. /13/ began his VE studies in Japan in 1967. Table (1) presents summary of VE project studies during 1975-1991.

Ron F. /9/ presented report details about the V.E. program within Virginia Department of Transportation, VDOT, and displayed the positive aspects and likewise the negatives that have been encountered.

Table [1] Summary of V.E project studies in Japan /13/.

Total projects	Successful	Partially Successful	Failed	Inadequate Data
275	142	29	67	29

4 VALUE ENGINEERING FOR OPTIMIZING COST

A number of factors inherent to the construction process must be considered in application of the VE concept such as:

i. *Who affects costs?*
ii. *Where does the agency money go during the time period of design, construction, maintenance and operating a facility?*
iii. *Determination of points during the life-cycle period where the use of VE will have the greatest payoff,*
iv. *Determination of a system element that contains the bulk of costs to direct VE effort, to get high-cost saving;*
v. *The validity of cost estimates;*
vi. *The ever-increasing energy cost.*

A reasonable expectation from a formal value engineering program in construction cost reduction from 5-20% when applied to any agency construction program and cost of the VE effort is usually less than 10 % of the implemented saving.

VE is applied in the design and construction of public roads, bridges and other structural works, specifications and standards as well as maintenance management systems (MMS), as related to operation and maintenance procedures. The proven performance of value engineering in highway design and construction has prompted the U.S. Federal highway Administration (FHWA), AASHTO has issued their first "Guidelines for Value Engineering" in 1987 /3/. Value Engineering in road building applications are numerous and diversified, and cover its full spectrum from conceptual planning to actual construction & pavement management systems.

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5 VALUE ENGINEERING METHODOLOGY

The systematic approach of value engineering is job plan. It helps identify high-cost areas of the project as well as determine the most economical combination of functions to achieve the task. The job plan procedural steps are called phases because there are many tasks in each phase /3/. The job plan is normally followed in sequence; phase by phase, the phases are as follows:

The 1-st phase ***(Selection Phase)****:*

Projects are selected to achieve maximum monetary savings, or other benefits, such as shorter construction schedule.

The 2-nd phase ***(Investigation Phase):***

The investigation phase is divided into 2 stages namely investigation project and analysis of both its function and cost.

The 3-rd phase ***(Speculation Phase):***

The third phase is directed to "brainstorm" the functions of the item and to develop a wide variety of alternatives to provide the basic functions and the required secondary functions of the item to which value improvements are being made.

The 4-th phase ***(Evaluation Phase):***

The main purpose of the evaluation phase is to analyze the generated alternatives during the speculation phase, develop lower-cost ideas and list feasible alternatives in order to decrease savings potential.

The 5-th phase ***(Development phase):***

The target of the development phase is directed to collect additional data about selected alternatives during the evaluation phase to prepare cost estimates and ultimate project implementation.

The 6-th phase ***(Presentation Phase):***

The purpose of the presentation phase is to put the recommended alternatives on hand of decision-maker.

The 7-th phase ***(Implementation Phase):***

The goal of the implementation phase is to assure that the approved proposals are rapidly translated into action, to achieve the savings that were proposed.

The 8-th phase ***(Audit Phase****):*

The purpose of the audit phase is to assure that desired results have been attained. To apply the VE job plan, an important factor must be recognized: an effective VE effort must include all the job plan. To make a complete analysis of any project, the total cost of the item, the cost of each component and a breakout of the cost of each design component are needed. To achieve best value, functions must be carefully defined so that their associated costs may be determined and properly assigned.

The function analysis approach leads to more creative solutions than item oriented traditional cost reduction approaches /13/. The approach used for identifying and classifying the functional relationships of a study projects known as Functional Analysis System Technique, FAST.

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6 CONSTRUCTABILITY FOR HIGHWAY PROJECTS

Constructability can be considered as a continuous improvement program within the Total Quality Management "TQM" program. Constructability optimizes the following major project elements from start to finish of the project /2/, /6/, /10/:

- *Overall project plan;*
- *Planning and design;*
- *Construction-driven schedule; and*
- *Construction and major construction methods.*

RELATIONSHIP BETWEEN CONSTRUCTABILITY, VE, AND PRODUCTIVITY

VE is the systematic effort directed in analyzing the functional requirements of systems, equipment, facilities, procedures, and supplies for achieving essential function at the lowest total cost, consistent with meeting needed performance, reliability, quality, maintainability, aesthetics and safety (Kavanagh et.al. 1978). Total cost in this case, takes into account the Owner 's cost of planning, design, construction, and maintenance over the life cycle of the service and may consider the user is cost during the project life cycle.

Constructability, on the other hand, is primarily concerned with optimal construction costs consistent with the function and quality requirements and boundaries set. Out at the beginning by the owner and the design team. Thus, Constructability should be considered as one of the several tools of VE. The effectiveness of both VE programs and Constructability programs is dependent upon participants who are willing to work together, contribute and work as members of a team. From a practical point of view, contracted construction costs are the largest item in the budget, and most significant improvements in productivity will come through Constructability enhancement. Productivity is equated with lower construction costs and / or improved quality, hence encompassing a broader spectrum than Constructability /5/.

VE - Value Analysis Overlaps Constructability; i.e., its purpose is similar, that is to achieve the essential functions at the lowest total cost (cost reduction). However, the scope and reach of Constructability and VE are quite different. Value Engineering and Constructability both consider the life-cycle cost of the project. The application of VE and Constructability are similar in many respects, in that both concepts are applicable throughout the planning, design and construction phases, and each is likely to have the most impact during the early stages of project development. The enhancement of Constructability must result in productivity improvement as well as design enhancement

7 CONCLUSIONS

The main purpose of VE is to deliver the necessary function of a certain facility at the lowest cost. The main terms of Value Engineering are Function, cost, worth and value. The systematic approach of Value Engineering is the job plan. The job plan procedural steps are called phases because there are many tasks in each phase. It helps identify high-cost areas of the project as well as determine the most economical combination of functions to achieve the task (design or construction).

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The approach used for identifying and classifying the functional relationships of a study projects known as Functional Analysis System Technique (FAST). In Highway projects, Value Engineering is one tool that can counteract these growing problems by:

a) Cost reduction;
b) Process improvement; and
c) Alternative means and materials for highway construction and maintenance.

Location, embankments, structures and pavements, alternate designs and materials, construction and maintenance, these items should be considered in Value Eng. of any highway project. Constructability optimizes the following major project elements from start to finish of the project:

- ✓ *Overall project plan;*
- ✓ *Planning and design;*
- ✓ *Construction-driven schedule; and*
- ✓ *Construction and major construction methods.*

Therefore, Value Engineering can be applied at any point in highway design, operation, and maintenance.

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