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**CSVA/SAVE Paper**

**Title: "Cost Estimating and Value Management: Cost Avoidance and Best Value"**

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**Bio:**

Stuart Sokoloff, PE has more 40 years of experience on varied bridge and highway projects located throughout the US and Canada as contractor, construction engineer, program/project manager, value engineer, forensic engineer and prime consultant. Project types include highways, bridges (long span, suspension, cable stayed, network arch, segmental, etc.), foundations, marine structures, mass transit, buildings and design-build efforts. Public sector clients/project owners include: Ministry of Transportation Ontario, Indiana DOT, New York City DOT, Mass Highway Dept., New York State Thruway Authority, Illinois Tollway Authority, Wisconsin DOT, Tri-borough Bridge and Tunnel Auth., Michigan DOT, New York State DOT and New Jersey DOT.

Mr. Sokoloff's constructability clients include many of the largest contractors including Skanska, Perini, Granite, Kiewit, Carillion, etc. His experience includes construction designs and cost estimating for multi-million construction projects while employed by Slattery/Skanska.

Mr. Sokoloff has participated in over 150 formal VE Studies for 35 different CVS over the past two decades. Formal Value Engineering and constructability assessments for bridge and highway projects include geotechnical, foundation, structural, and constructability issues with construction cost ranging to $2.0 billion.

## Introduction

There are often claims of cost "savings" achieved by a Value Engineering Study. This paper & presentation evaluates the significance and limitations of the cost estimates prepared during the VE study. Topics discussed related to Cost Estimating and the VE Study include:

1.0 Cost Estimating and Best Value
2.0 The cost of any construction project
3.0 Contractor Bid Estimates
4.0 Design Engineer Estimator's in-progress estimates: basis; accuracy; contingency; historical costs
5.0 VE Estimates & Time Limitations: Value targets: Liability
6.0 Life Cycle Cost
7.0 Cost Avoidance
8.0 Cost & Risk
9.0 Conclusions

## 1.0 Cost Estimating & Best Value

The name we use to designate the future cost of a construction project speaks volumes: "Construction Estimate". It is an in- progress design evaluation of the items of work anticipated, the quantity of the item, and the unit cost of each item. The Design Engineer and Value Engineer base their estimates on in-progress documents while the Contractor bases its bid estimate on final contract documents.

The term 'Best Value' is defined as Performance (Function) divided by Cost:

V=P(F)/$ (resources)

Therefore, cost is one of two inherent elements to identify Best Value as the goal of the Value Engineering Study. In effect, the VE Study is bifurcated into a technical evaluation of the performance (function) of various elements and the cost associated with each of these elements.

Editorial Note: The writer has a bias for the more universally understood term 'Performance' rather than the technical, parochial and proprietary term 'Function' used by CVS practitioners.

**2.0 The cost of any construction Project**

Real costs are actual expenditures whether current or future. Estimated costs are anticipated future expenditures which may or may not become actual. The most significant contribution of an in-progress design estimate by the Design Engineer or the Value Engineer is to indicate the required budget allotment associated with a scope of work/project.

The real cost of any project is **The Lowest Responsive Bid Submitted by A Viable Contractor.** Construction costs associated with unforeseen conditions, delays and contract extras are future issues and cannot be known during the design, estimating and bidding efforts.

The Contractor is not concerned with Life Cycle/Future Costs beyond the relatively short post construction guarantee/warranty period, but only with initial installation/construction costs for most types of procurement such as Design-Bid-Build & Design-Build, except for Design-Build-Operate & Maintain. Life Cycle Costing is of major concern to the Owner, Design Engineer and Value Engineer.

There is a distinction between projects whose costs are under estimated and projects that exceed their estimated budgets (cost ever-run). There are many potential reasons for such an occurrence most of which are beyond the control of the Design and Value Estimators:

-Estimate is too low (inaccurate quantities or unit costs)
-Difficult to construct designs
-Owner control of the design
-Poor construction management
-Scope creep
-Aggressive/unrealistic schedules
-Increase in the cost of money
-Unforeseen conditions

Examples of projects whose construction costs have significantly exceeded their budgets include:

-Boston Central Artery
-MBTA Green Line (Boston)
-East Side Access (New York City)
-Silver Line Dulles Extension (Washington DC/Virginia)
-Eglinton Line Extension (Toronto)
-California High Speed Rail
-Department of Veterans Affairs Hospitals (Nationwide)

**3.0 Contractor Bid Cost Estimates**

**3.**1The contractor's estimate is based upon a fully developed design as presented by the contract documents (drawings, specifications, general and special conditions). The contractor then evaluates anticipated quantities (take-offs); the cost to purchase, deliver and install the item; the equipment needed;

and any other issues that impact upon intended operations. An example of a Contractor's estimate is as follows:

| Item | Unit | Quantity | Unit Cost | Item Cost |
|---|---|---|---|---|
| Structural Fill | CY | 1,000 | $25 | $25,000 |

The above simple presentation is the outcome/end result of a cost analysis but does not indicate how the $25/CY is determined. The Item Cost engenders consideration of a number of elements such as labor, equipment, and materials installed. It also must account for labor costs, the time to perform an operation, equipment required, the cost of consumables such as gasoline or electricity to power equipment, site logistics that impact upon the time to perform each operation, the number of operations required, the possible need for re-handling materials, the cost to deliver materials to the site, cost to bring equipment to the site, etc. The table below presents the logic to determine an accurate estimate for the Structural Fill example.

**Quantity**- Based on a "take-off" of materials required from the Engineers drawings.
(Note: an incomplete drawing will most likely result in an incorrect/inaccurate quantity)

**Unit Cost**

**Material**

-cost of material
-cost of delivery to the job site (source location)

**Labor**

-how many workers in what labor categories & burdened hourly rate are required
-how long will it take to place and compact the structural fill

**Equipment**

- type of equipment required
- equipment power (gasoline, electricity) costs are required for the anticipated duration of work

### 3.2 Duration/Manpower of a Contractor's Estimate Preparation

The contractor performs the above analysis for each item (permanent or temporary) to complete the work. For a $100 million project a contractor would typically have 2 or 3 take-off engineers determining quantities and 2 construction estimators analyzing the project over 3-4 weeks to prepare the bid estimate. Alternatively, a particular Contractor maintains its own historical database of similar projects and can use these values.

## 4.0 Design Engineer Estimates

### 4.1 Engineer in-progress estimates: basis; historical costs; accuracy; contingency

Most VE Studies take place between 10% (scoping) and 50% design completion with the majority midway between the two at 30% or so. At this early stage in design, major design concepts have been developed but are not complete. Many item quantities are not yet determined and uncertainty remains in the quantities and other future design related issues. The Design Engineer's estimate is an in-progress design evaluation of the items of work anticipated; the quantities of the various item; and the unit cost of each item.

### 4.2 Accuracy/Contingency

From a cost perspective, the incompleteness/uncertainty of the in-progress design is addressed by applying a contingency factor to the in- progress estimate. The contingency factor is typically as high as 25% at an early stage of design and is eventually decreased or even abandoned at 100% design completion. As an example, a $100 million estimate is increased to $125 million because the Design Engineer can only work off the incomplete drawings to prepare the estimate.

**4.3 Basis of Cost/Historical Database Costs**
How is a $100 million project based on a 30% complete design estimated by the Design Engineer? Unlike the Contractor's estimator who performs specific estimating calculations or uses its own cost database based on a 100% complete design, the Design Engineer will typically not perform specific cost calculations. Even if so attempted, the Engineer would not know what specific equipment will be used, whether the contractor owns or will rent equipment, or the time to perform each task.

The Design Engineer will probably use a historical database of costs kept by the owner, an internal database kept by the Design Engineer, or other general costs references such as RS Means, etc. Generic/nationwide cost references are modified by cost factor adjustments for specific geographic locations and do not apply to any special conditions for a particular project.

The unit prices provided by Owner's data-bases are unit bid prices submitted by contractors on previous projects which may or may not have relevance to the specific project at hand. In addition, these submitted item bid prices often do NOT reflect the actual cost to a contractor as all contractors "Unbalance/Front Load" their bids. Items completed early in a construction project are bid at a higher than actual unit price to get an early payback and items that are completed near the end of a project have their prices decreased. Contractors will additionally unbalance the unit cost bid amount for items whose quantities will either over-run or under run. Items whose quantities are envisioned to over-run will be bid at a higher than actual unit price. Unbalancing unit bid prices as above further obfuscates the accuracy of any database unit costs used by the Design Engineer and thus the VE Estimator.

**5.0 VE Cost Estimate s**
**5.1 VE Estimating**
The VE Estimator uses the information provided by the Design Engineer and is likewise constrained to use historical costs and prepare the VE Estimate based upon 30% complete drawings. However, the VE Estimator need not be concerned with all items but only concentrate on those items that constitute the majority of a project's cost according to the Value Targets (items with the highest costs) identified during the VE Study.

**5.2 Time Limitations**
'Some clients allow the estimator significant time to perform a "verification/reconciliation" of the Design Engineer's estimate while others allow little or no time at all for this effort.

During the VE Study, whether a 3 or 4 or 5-day study, the VE Estimator is the last to provide his expertise since the technical experts generally do not provide their ideas and analyses for costing until very late in the process. The VE Estimator then has only a limited time to prepare comparative cost estimates for perhaps 20 to 40 or more Alternatives, leaving little time for rigor of evaluation.

**5.3 Liability**
The VE Estimator can elect to use the Design Engineer's estimate or perform an independent estimate. Should the VE Estimators cost not be accurate there can be a significant liability in the eventuality that a project over-runs or is not financially viable.

**6.0 Life Cycle Costing**
Life Cycle Costing evaluates the future cost to maintain a structure or piece of equipment (repair, consumables, etc.) over its anticipated operational life and compare to the cost of future replacement at life's end. Life Cycle Costing is an important and sometimes determining evaluation for a VE Study outcome. Therefore, the Best Value equation can be refined as:

$$V=P(F)/(\$ \text{ construct} + \$ \text{ life cycle})$$

As an example, a Life Cycle evaluation can be the determining factor in deciding whether to rehabilitate or replace a structure, or decide what type of mechanical equipment is most appropriate to provide Best Value.

**7.0 Cost Avoidance**

There are indeed VE Alternatives that offer verifiable cost avoidance while maintaining project Performance. The writer prefers the term 'cost avoidance' as opposed to 'cost savings' or 'cost reduction' since the actual cost associated with most items during the VE Study are guesstimated.

Examples of cost avoidance Alternatives in achieving Best Value include:

- -Highway realignments to avoid right of way acquisition or other obstacles
- -Alternative super structure type (example: simple multiple span bridge versus a cable stay bridge)
- -Alternative foundation types (example: structure on grade versus piling)
- -Eliminating scope (if Performance is improved or not compromised)
- -Reduce the thickness of over-designed structural elements, etc.

**8.0 Risk in Regard to Cost**

**8.1 Cost and Risk**

A Risk evaluation during the VE Study, formal or otherwise, can identify the chance/probability and severity of a negative event occurring during the life of a project that will most likely involve cost impacts. Risks are ideally mitigated by design Alternatives, but this is not always the case. Almost every risk has an associated cost whose impact can be disastrous in light of a severe cost over-run.

Examples of Risk Issues with Cost implications include:

- -Right of Way acquisitions & project delays
- -Environmental Issues & Mitigations
- -Unavailability of Materials
- -Project type over-runs its estimated duration, etc.

**8.2 Contractor Risk versus Design Engineer/VE Risk**

Contractor risk is limited to the actual construction and as might be extended by warrantees/guarantees for some short period after construction. Design Engineer/VE Risk includes construction and maintenance/operations issues for the life of a project which can be up to 50 or 75 years. As an example, selection of inappropriate equipment could result in under performance, reduced production rates, and added yearly maintenance and power consumption costs

**9.0 Conclusions**

**9.1 Design Engineer & VE Study Estimates**

All quantities and therefore cost differentials offered as an outcome of the VE Study are based on the Design Engineer's 30% incomplete design and subject to perhaps a 25% contingency. VE Alternatives are therefore based on a comparison to incomplete early stage in-progress drawings. The cost estimates prepared during the VE Study for each of the many Alternatives reflect the uncertainties of an incomplete design.

**9.2 Accuracy of Design Engineer & VE Study Estimates**

The Engineer's estimates are based upon an incomplete design and general cost data which may or may not be relevant to the specific project. Inaccurate unit prices and quantities result in a problematic and questionable cost estimate.

**9.3 Cost "savings" as a claimed outcome of the VE Study**

Claims of outright cost savings as an outcome of a VE Study are premature and tenuous. **The VE estimate is only a relativistic comparative snapshot in time of VE technical Alternatives to the Engineer's in-progress base case.**

### 9.4 Clients/Life Cycle

**9.4** Clients should be made aware that Life Cycle Costing as a VE tool is a valuable and even necessary effort to guide Owners in their decision making pertaining to project scope, budgeting and expenditures.

### 9.5 Cost Risks

A Risk analysis, informal or otherwise, should be incorporated into the Standard VE Methodology as a necessary step in determining Best Value since almost every Risk has a cost implication that impacts upon scope, project approach, budgeting & expenditures.

**END**