Application of Value Engineering Methodology to Roads and Highway Projects

By Muhammad Ajmal Khan
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VE / VA / VM is the systematic method to improve the “value” of a product or service by using an examination of function.

\[ V \text{ (value)} = \frac{F \text{ (function)}}{C \text{ (cost)}} \]

VE uses a combination of creative and analytical techniques to identify alternative ways to achieve objectives. The use of Function Analysis differentiates VE from other problem solving approaches.

VE never compromises on basic function but reduces the cost or increases the function at same cost. “Basic Functions” mean the functions that users require for products or services.

For any Civil Engineering project:

VE is the systematic application of recognized techniques by a multi-disciplinary team for generating alternatives through the use of creative thinking that accomplishes the original purpose (basic function) of the project at the lowest life-cycle cost without sacrificing

- safety,
- necessary quality
- and environmental attributes

Application of Value Engineering mainly:

- Solves problems
- Decreases costs
- Improves value, quality & performance
- Uses resources more effectively
- reduces the time of project completion
Value Engineering Definition:

Value Engineering is not:

✗ A **Design Review**
   It is not planned to correct omissions in the design, nor to review drawings, BOQ, Estimates etc. made by designers.

✗ A **Cost Cutting Process**
   It does not cut cost by sacrificing needed quality, reliability or performance.

✗ **Routinely Done by all Design Engineers**
   It is not a part of the normal design process, but a formal cost and function analysis.
What Value Engineering Can Do?

- Focus on the “big picture”
- Improve decision making
- Develop realistic budgets
- Ensure required functions / project scope
- Enhance understanding of total project
- Challenge paradigms
- Accelerate the design process
- Encourage cross-discipline communication
- Identify and remove unnecessary costs
Value Engineering Process

How Does the Value Methodology Work?

The value methodology works through a VE / VA / VM study that brings together a multidisciplinary team of people who own the problem and have the expertise to identify and solve it. A VM study team works under the direction of a facilitator who follows an established set of procedures - the VM job plan - to review the project, making sure the team understands customer requirements and develops a cost-effective solution.

-- SAVE International

**VE Process → Team Leader + Multidisciplinary Team + VE Job Plan**

- **Information Phase**
  - Project Initiation, Requirement, Existing Condition, Budget, Project Stage etc.

- **Function Analysis Phase**
  - Project Scope, TOR, Policy, Design Criteria, Standards, Specifications etc.

- **Creative Phase**
  - Creative Brainstorming to identify other ways to perform the project’s function(s)

- **Evaluation Phase**
  - Critical judgment of VE application for value improvement while delivering the project’s scope/function(s) and considering performance requirements and resource limits

- **Development Phase**
  - The VE Team develops the selected alternatives/proposals with sufficient documentation to allow decision makers to determine if the alternative should be implemented

- **Presentation Phase**
  - The team leader develops a report and/or presentation that documents VE

- **Implementation & Monitoring Phase**

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**VM / VE / VA Job Plan**
When should a Value Engineering Study should be undertaken?

The cost of making changes to a project depends on when VE is introduced. Early changes are naturally *practical* and *cost effective* than later ones, as shown in the diagram below:

**Savings and Costs of Value Engineering**

<table>
<thead>
<tr>
<th>Time</th>
<th>Concept</th>
<th>Preliminary Design</th>
<th>Final Design</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructive VE Opportunity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destructive Intervention</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Best VE cost-saving opportunities occur early in project.
Value Engineering – Who Manages the Costs

Mainly Policy Makers and Designers are responsible for savings in life cycle cost of a project.
Value Engineering – through Flexibility in Design

Application of Value Engineering Methodology to Roads and Highway Projects at Project Initiation and Design Stages

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Achieving Flexibility in Design

“Green Book” (AASHTO)


This book bridges Design Standards with “Flexibility in Highway Design”
Main Message - No Save without Flexibility

Designers have flexibility!

Experience counts
Designers have flexibility!

Without flexibility, we cannot go for **Value Engineering**.

**Now, What is Flexibility in Design?**

It is the use of sound engineering judgment rather than strict adherence to design standards and criteria.

It addresses safety, mobility and preserves natural and historic resources and community values.

It provides joint use for motor vehicles, public transit, cyclists and pedestrians.

It is a reasoned, well thought out, justifiable design that balances goals, project needs and community/stakeholder interests.
Flexibility in Using Design Criteria

Flexibility decreases as we advance through the design process.
Flexibility in Design Elements

Roadway Cross Section - For Local Urban Streets
as per AASHTO Green Book & Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT≤400)

Widths: 3.3 m in Residential and 3.6 m in Industrial areas
Lanes 3.0 m wide are acceptable on low speed facilities
Lanes 2.7 m wide are appropriate on low volume roads in rural and residential areas

Parking lanes:
in Residential areas, parallel parking 2.1 m – 2.4 m on one or both sides

Buffer for parking:
not required – rarely used in any country, contributes a lot of cost
Flexibility in Design Elements

Make urban junctions as compact as possible

Corner Radius: 3m and 4.5m
As per AASHTO Green Book “Guidelines for right-turning radii into minor side streets in urban areas usually range from 1.5 to 9 m [5 to 30 ft] and most are between 3 and 4.5 m”
An Example of flexibility in Design

How many different ways can we design a 4-lane road by applying Design Standards:

<table>
<thead>
<tr>
<th>Description</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane Width</td>
<td>3.00m to 3.65m</td>
</tr>
<tr>
<td>Shoulder width</td>
<td>0.60m to 3.00m</td>
</tr>
<tr>
<td>Side Walk / Cycle path</td>
<td>1.20m to 3.50m</td>
</tr>
<tr>
<td>Median</td>
<td>0.60m to 12.00m</td>
</tr>
<tr>
<td></td>
<td>Raised or flush</td>
</tr>
<tr>
<td>Others</td>
<td>Street Lighting, Landscape, Service Road, Parking Lanes etc.</td>
</tr>
</tbody>
</table>

- Highway designers have choices (not mandates)
- Designers should understand the functional basis of design criteria and standards
- AASHTO Green Book is flexible
### Cost consuming “Design Elements”:

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wider lane width</td>
<td>2.7 to 3.3 m is sufficient for local streets</td>
</tr>
<tr>
<td>Wider shoulder width</td>
<td>For low volume two lane roads, not required</td>
</tr>
<tr>
<td>Too wide side walk / footpath</td>
<td>1.8 m is wide enough for two persons to walk side by side and 1.20 for one person</td>
</tr>
<tr>
<td>Roadside development</td>
<td>Use of curb, barriers, fences etc.</td>
</tr>
<tr>
<td>Too big corner radii</td>
<td>As per Green Book minimum 4.5 m but in Dubai it is 15m</td>
</tr>
<tr>
<td>Too much parking</td>
<td>Constructing more than required parking in residential areas</td>
</tr>
<tr>
<td>Extra buffer for parking</td>
<td>This is the most cost consuming element, used in Dubai</td>
</tr>
<tr>
<td>Excessive traffic signs, markings etc.</td>
<td>Use of excessive traffic signs are also dangerous for safety</td>
</tr>
<tr>
<td>Pavement thickness</td>
<td>Passenger cars do not contribute any load effect on road, else providing higher pavement thickness</td>
</tr>
</tbody>
</table>
Reduce Kerb Return Radius

Corner Radius: 3m and 4.5m
As per AASHTO Green Book “Guidelines for right-turning radii into minor side streets in urban areas usually range from 1.5 to 9 m [5 to 30 ft] and most are between 3 and 4.5 m”
Eliminate Unnecessary Design Elements

Eliminate Buffer for Parking
Cost consuming, Not required
Drivers park behind the parked cars and create congestion

Ultimately an increase in project cost
Eliminate Unnecessary Design Elements

Eliminate Unjustified Traffic Signs and advertising signs

Stop, go, yield, right of way, school ahead, slow down and toll ahead can cause confusion to most any driver. Too many traffic signs can be conflicting and dangerous, and may lead to fender benders or more serious crashes, argues Duke University psychology professor John Staddon in a 2008 Atlantic article "Distracting Miss Daisy."

Ultimately an increase in project cost
Eliminate Unnecessary Design Elements

Eliminate Local Street Landscaping

No international practice for providing Landscaping in Local Streets. Authorities only make legislation and provide guidance to the residents for making landscape in front of their houses.

Ultimately an increase in project cost
Now we analyze VE for R853 – Roads in Al Barsha 1, 2 & 3
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By Reducing Local Street Road width 7.0m to 6.6m
We saved AED 6 million,
if we go for 6.0m road width we will save about AED 5 million

Project R853 has 180 T-Junctions
If we use radius 7m, we will save about AED 1.5 million
It will also promote calming measures on all over Al Barsha

1.8 m is wide enough for two persons to walk side by side
Introducing 1.8m Sidewalk in all residential area, we can save about AED 5 million, if we go for 1.2 m sidewalk, we will save additional AED 5 million.

Asphalt Paving on Sidewalk
We can further reduce the cost by asphalt paving on sidewalk instead of block paving, if authority approves.

Buffer for Parking
By eliminating buffer for parking, we already saved AED 16 million

Local Street Landscape
By eliminating Local Street Landscape, we already saved AED 14 million
### By Cost Cut for R853 – Roads in Al Barsha 1, 2 & 3

<table>
<thead>
<tr>
<th>Work Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off Street Parking</td>
<td>AED 10 million</td>
</tr>
<tr>
<td>Kerb &amp; Side walks</td>
<td>AED 75 million</td>
</tr>
<tr>
<td>Paving of Sikka</td>
<td>AED 20 million</td>
</tr>
<tr>
<td>Drainage Work</td>
<td>AED 10 million</td>
</tr>
<tr>
<td>Irrigation Works</td>
<td>AED 23 million</td>
</tr>
</tbody>
</table>
Saving through Construction Materials

Analyze High Cost / High Volume Items of a Project.

Remember:

80% of a project’s cost can be found in 20% of the items

Pareto Principle (80-20 rule)
Value Engineering – Analyzing Construction Materials:

High Cost / High Volume Items of any Road Project:

**Earthworks (Two items generates 80% Cost)**

1. Excavation
2. Filling of Embankments by imported material
Value Engineering – Analyzing Construction Materials:

High Cost / High Volume Items of any Road Project:

ROADS AND PAVINGS
(7 items generates 90% Cost)

- Granular sub base
- Wet mix macadam road base
- AC Wearing course
- AC Base Course
- Block paving (60mm & 80mm)
- Up stand kerb / heel kerb
- Concrete barrier
Value Engineering – Analyzing Construction Materials:

High Cost / High Volume Items of any Road Project:

BRIDGE WORKS

(6 items generates 80% Cost)

Concrete all Class
Bridge Deck
Reinforcement – steel bars
Main web cables – Pre-stressed Concrete
Fences - Reinforced Concrete Barrier
Value Engineering – Analyzing Construction Materials:

High Cost / High Volume Items of any Road Project:

- **Structural Metalwork** (2 items generate 80% Costs)
  - Overhead Gantries (including piling, foundation, steel works etc.)
  - Overhead Traffic Signals
Value Engineering – Pavement Design

Provide Well Performing, Durable, Safe and Cost Effective Pavements

<table>
<thead>
<tr>
<th>Primary Factors</th>
<th>Secondary Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic</td>
<td>Performance of similar pavement materials</td>
</tr>
<tr>
<td>Soil Characteristics</td>
<td>Adjacent existing pavements</td>
</tr>
<tr>
<td>Weather</td>
<td>Availability of local materials/contractors</td>
</tr>
<tr>
<td>Construction considerations</td>
<td>Traffic safety</td>
</tr>
<tr>
<td>Recycling</td>
<td>Experimental features</td>
</tr>
<tr>
<td>Cost comparison</td>
<td>Stimulation of competition</td>
</tr>
<tr>
<td>✓Initial</td>
<td>RTA preference</td>
</tr>
<tr>
<td>✓Life Cycle</td>
<td></td>
</tr>
</tbody>
</table>

- RTA: Roads & Transport Authority
Use of Alternative pavement material and Recycled Material

<table>
<thead>
<tr>
<th>Aggregate Base Course</th>
<th>Wet Mix Macadam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure No. 0.14</td>
<td>Structure No. 0.14</td>
</tr>
<tr>
<td>Less Cost (about 50% of WMM)</td>
<td>High Cost</td>
</tr>
<tr>
<td>Construction methodology – Time consuming</td>
<td>Construction methodology – Quicker</td>
</tr>
<tr>
<td>Product and contractor available</td>
<td>and faster</td>
</tr>
<tr>
<td></td>
<td>Product and contractor available</td>
</tr>
</tbody>
</table>

Recycling — RTA to “Go Green”

Promote the Use of Recycled Materials in Roads Construction:

Main recycled materials are:
- Reclaimed road pavements
- Recycled concrete materials
- Shredded Tires
- Glass etc.
Why do Projects have “Unnecessary” Costs?

→ Habitual thinking: rigid application of standards, customs, and tradition without consideration of changing function, technology and value.

→ Over specifying – whole or any specific project component.

→ Lack of information, usually caused by a shortage of time – i.e. survey data, traffic data, parking requirements etc.

→ Too many decisions - too many alternatives designs.

→ Wrong beliefs, insensitivity to public needs or unfortunate experience with past projects.

→ Reluctance to seek advice, failure to admit ignorance of certain specialized aspects of project development.

→ Negative attitudes, failure to recognize creativity or innovativeness.

→ Poor human relations, lack of good communication, misunderstanding, jealousy and normal friction between people are usually source of unnecessary cost.
Value Engineering – Unnecessary Cost

CONSULTANTS are mainly responsible for increasing project cost:

WHY … … ?

Because of our payment procedure.

We pay on % basis of Established Tender Sum (ETS)

The higher ETS, the greater is the payment for CONSULTANT.

Therefore, consultants are increasing the cost of a project by smartly exaggerating design elements, adding unnecessary materials, traffic signs etc.

Be Careful ! ! !

Keep a tight check on Consultants….
Recommendation: Value Engineering Team

RTA have to make a VE team consisting of experts having VE expertise in respective field.

We start with a small group of experts in the required disciplines:

- Roads Planning & Design,
- Traffic engineering
- Traffic Safety,
- Bridge and Structure,
- PMS
- Landscape
- Street lighting
- Environmental,
- Construction ,
- Maintenance etc.
Recommendation – Mandatory Value Engineering

Value Engineering was first introduced in 1947 in USA and widely used by USA Department of Defence since 1959. SAVE (Society of American Value Engineers) was established in 1959, since then most of the US Departments are practicing Value Engineering.

- RTA has to make it mandatory for each department “to carry out Value Engineering (VE) analysis for each project with an estimated total cost of AED-------- million or more.”

- In this context, a project is defined as a portion of the highway, metro, railway, water way etc. that RTA proposes to construct, reconstruct, or improve.

- A project may consist of several contracts or phases over several years.

- Note, if total phases of the project is estimated to cost over AED------ -- million, then a VE study or analysis is required on either (1) the whole project, (2) a segment of the project or (3) on an element of the project.
Recommendation – Mandatory Value Engineering

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MORE CREDIT FOR OUR DEPARTMENT!
THANK YOU

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