Why Does VE Discover Design Solutions that the Traditional Design Process Often Does Not?

The Answer in Six Illustrative Examples

Outline

Introduction

Example VE proposals

Answers to the title question

Traditional design & VE study relationship

Conclusions

Introduction

Ever hear these statements?

"We don't need a value engineering (VE) study. We already do VE in our regular design process." – Project Manager

Introduction

Ever hear these statements?

"We don't need a value engineering (VE) study. We already do VE in our regular design process." – Project Manager

"We don't need a value engineering study. The design team should already be doing value engineering in our regular design process." – Owner

Introduction

VE practitioners don't agree.

Why?

Typical answer:

"Because the regular/traditional design process doesn't include a systematic process by a multidisciplinary team to improve the value of a project through the analysis of its functions" *(value methodology).*

Introduction

Can't disagree.

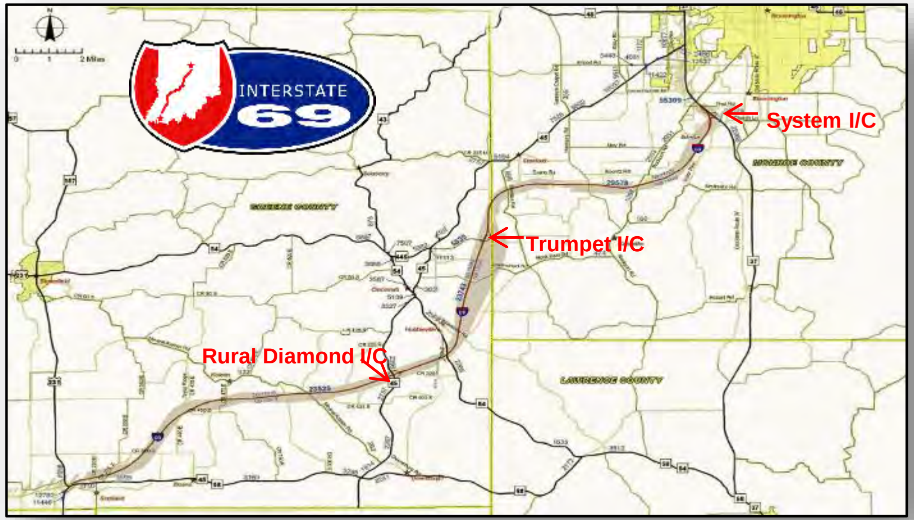
But *examples* often inform (and persuade) better than theory.

Let's look at *six examples* from actual VE studies of designs that would likely not have been possible without VE.

Example No. 1

Project: I-69 Section 4

- **Owner**: INDOT
- **Description**: New 27-mile interstate freeway
- **Key components**: 3 interchanges; 47 bridges; extreme ridge/valley rock terrain
- **Construction cost**: $567 million



Example No. 1

Project: I-69 Section 4

- **VE target**: 12 waterway bridges
- **Applicable functions**:
  - Basic: reduce impacts
  - Secondary: limit head/backwater
- **Baseline concept**: set bridge lengths/waterway openings for Q_{100} = 0.14 ft. backwater (INDOT design standard); 0.86' less than 1.0 ft. legal maximum

Example No. 1

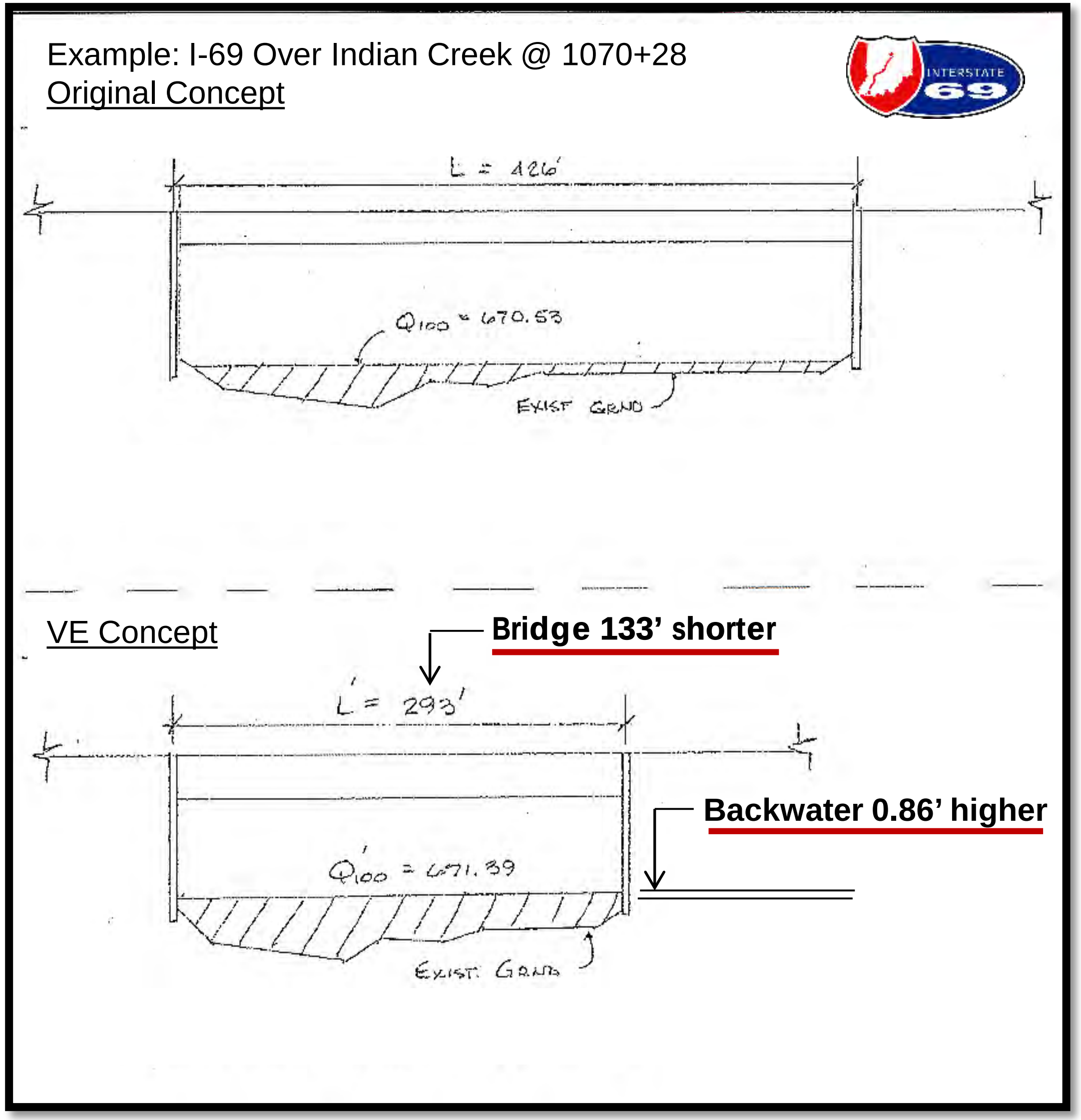
- **Key VE questions**:
  - *Do we need that much secondary function to reduce impacts?*
  - *What is the cost of reducing impacts that much?*
  - *Is the cost of reducing impacts that much (0.86’) worth the benefit?*
  - *Is “compensate impacts” with a shorter bridge a better value than “reduce impacts” with a longer bridge?*

- **Answers**:
  - ***No***
  - ***$600K (two bridges)***
  - ***No (upstream land inaccessible, undevelopable rock outcrops)***
  - ***Yes (cost of flood easements to “compensate impacts” insignificant compared to longer bridges that “reduce impacts”)***

Example No. 1

Project: I-69 Section 4

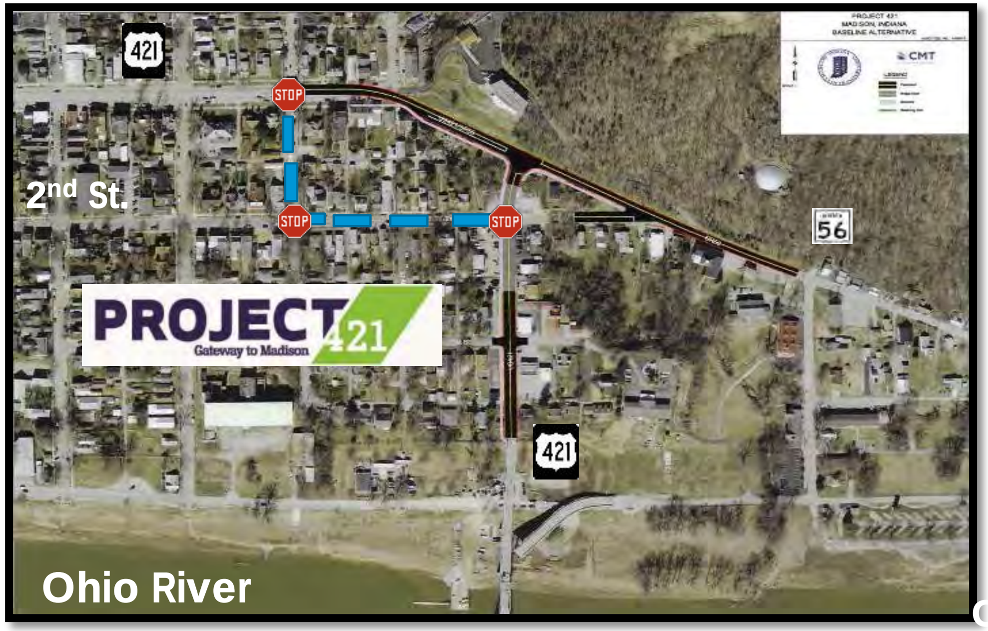
- **VE concept:**
  - **Shorten waterway bridge** by 133 ft. (30%)
  - Increase backwater by 0.86' to 1.0 ft. legal maximum
  - Purchase **flood easement** for increased backwater impacts
  - Total accepted VE cost savings (2 bridges): **$600,750**



Example No. 2

Project: Project 421 Urban Street Realignment

- **Owner**: INDOT
- **Description**: realignment of 0.32 miles of two-lane US 421 to eliminate three 90-degree, stop-controlled turns
- **Construction cost**: $11 million



Example No. 2

Project: Project 421 Urban Street Realignment

- **VE Target**: bridge over 2nd Street
- **Applicable functions**:
  - Basic: reduce grade
  - Secondary: eliminate conflicts; span R/W
- **Baseline concept**:
  - Extend US 421 north from 2nd St. to SR 56
  - Signalized at-grade intersection at SR 56
  - 360’ bridge over 2nd Street due to 23’ SR 56/2nd grade differential

Example No. 2

- **Key VE questions**:
  - *How else can we reduce grade?*
  - *How else can we address conflicts?*
  - *What is the cost of reducing grade & eliminating conflicts via a bridge?*
  - *Is the cost of a bridge worth the functions provided?*
- **Answers**:
  - ***Lengthen grade; curve horizontal alignment to west***
  - ***Manage vs. eliminate conflicts (E/W stop control; mainline free flow)***
  - ***$4.9 million (not including avoided signal life-cycle costs)***
  - ***No (VE concept a better value)***

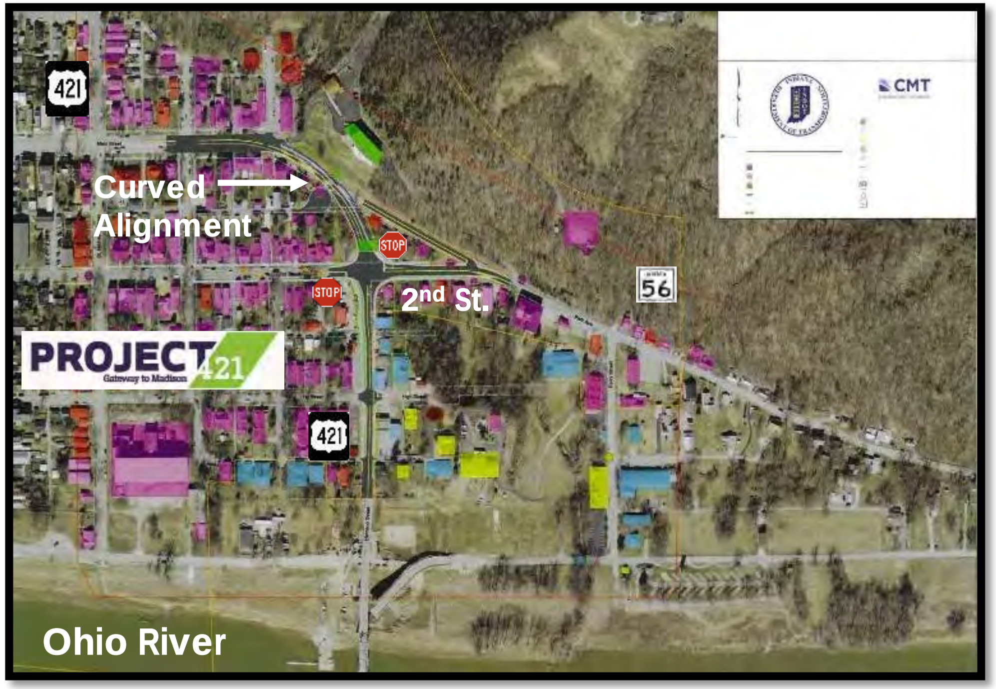
Example No. 2

Project: Project 421 Urban Street Realignment

- **VE concept:**
  - Curve US 421 to west; **eliminate signalized intersection** at SR 56
  - **Eliminate grade separation** at 2nd St.; use at-grade intersection
  - Total accepted VE cost savings: **$4.9 million** (46.2%)

Baseline Concept

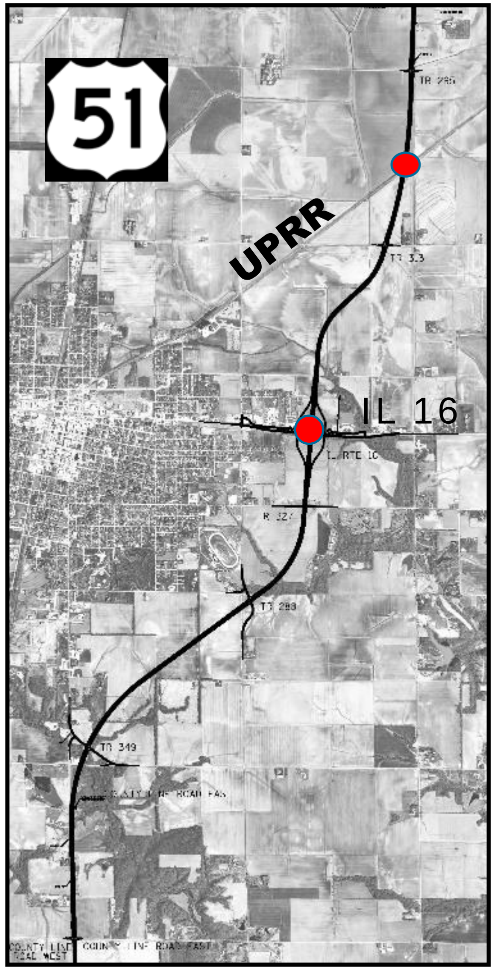
VE Concept



Example No.3

Project: US 51 Expressway (Pana Bypass)

- **Owner**: IDOT
- **Description**: 7.04 miles of rural, limited-access 4–lane expressway
- **Key components**:
  - UPRR mainline overpass
  - IL 16 interchange overpass
- **Construction cost**: $50 million



Example No. 3

Project: US 51 Expressway (Pana Bypass)

- **VE target**: earth fill
- **Applicable functions**:
  - Basic: elevate roadway
  - Secondary: limit deceleration
- **Baseline concept**:
  - Utilize 2% (desirable) maximum grade at UPRR overpass
  - Utilize 2% (desirable) maximum grade at IL Rte. 16 interchange overpass
  - Borrow required for fill

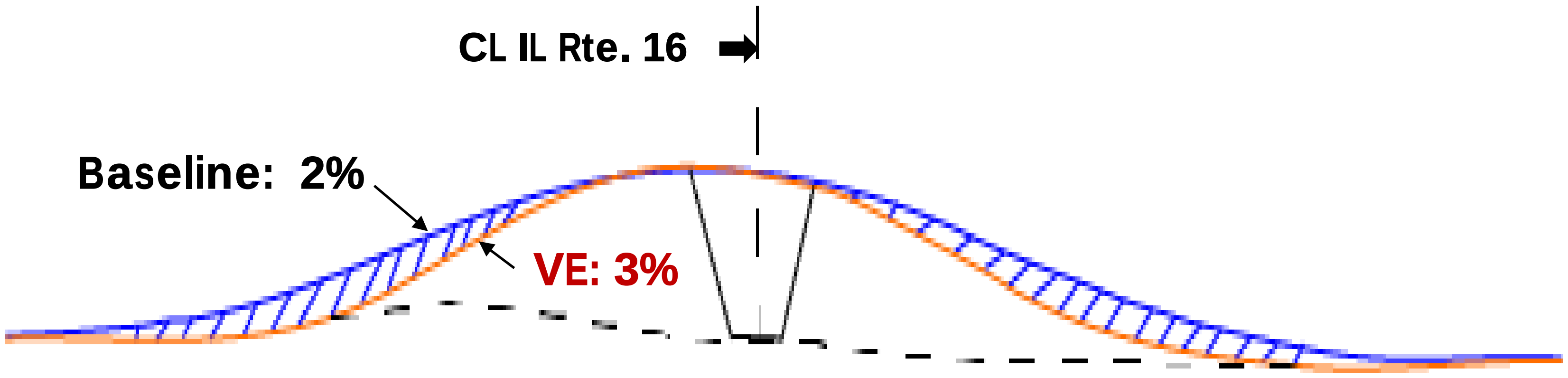
Example No. 3

- **Key VE questions**:
  - *Why use desirable 2% grade vs. 3% maximum?*
  - *How much truck deceleration?*
  - *What is cost of borrow to limit (reduce) truck deceleration?*
  - *Is cost of borrow worth reducing that much deceleration?*
- **Answers**:
  - ***Limit truck deceleration***
  - **Minimal (*low truck volumes; max. grade at PRVC*)**
  - ***$1.2 million***
  - ***No (negligible performance Δ; significant cost)***

Example No. 3

Project: US 51 Expressway (Pana Bypass)

- **VE concept**:
  - **Utilize 3% max. grade** vs. 2% at UPRR overpass & IL Rte. 16 interchange overpass
  - Low truck ADT; short max. grade length; less borrow required
  - Total accepted VE cost savings: **$1.2 million**



US 51 Profile Grade

Example No. 4

Project: IL 104 Bridge over Illinois River

- **Owner**: IDOT
- **Description**: replace existing truss bridge with 2740 ft.-long 10-span bridge with tied-arch navigation span
- **Construction cost**: $45 million

Example No. 4

Project: IL 104 Bridge over Illinois River

- **Value targets**: substructure; earth borrow
- **Applicable functions**:
  - Basic: elevate profile
  - Secondary: limit speed-change
- **Baseline concept**:
  - Utilize 4% maximum grade on both sides of river
  - Span levee on west side of river; provide standard local road clearance of 13.42’

Example No. 4

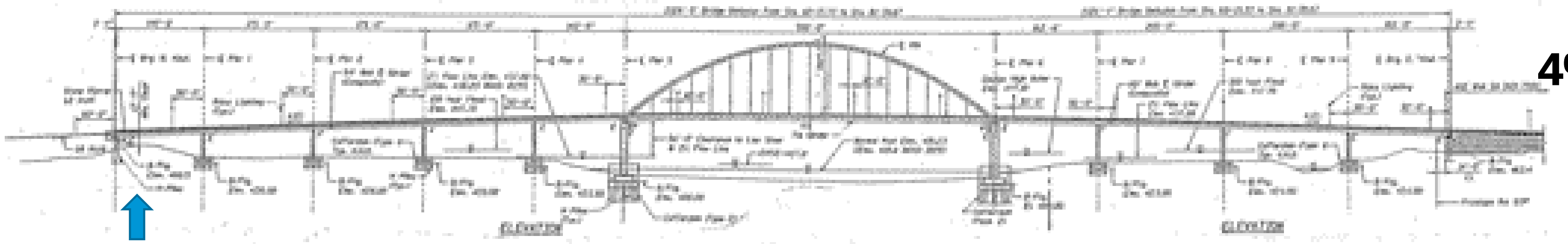
- **Key VE questions**:
  - *Is 4% needed on west side of river?*
  - *Does bridge need to clear levee? By how much?*
  - *What is cost of substructure & borrow to limit (reduce) speed-change and clear levee on west side or river?*
  - *Is cost worth limiting speed-change; clearing levee by that much?*

- **Answers**:
  - ***No (only on east side in city limits)***
  - ***No (Only enough for maintenance pickup truck)***
  - ***$764,000***
  - ***No (increasing decel inbound/increasing accel outbound is better; pickup-truck clearance meets operational need)***

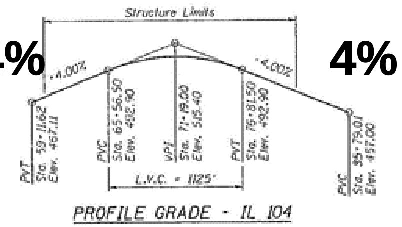
Example No. 4

Project: IL 104 Bridge over Illinois River

- **VE concept**:
  - Use **5%** grade **west side** of river; 4% east side (unsymmetrical)
  - **Reduce levee clearance** to 8.62 ft.
  - Total accepted VE cost savings: **$764,000** (1.6%)



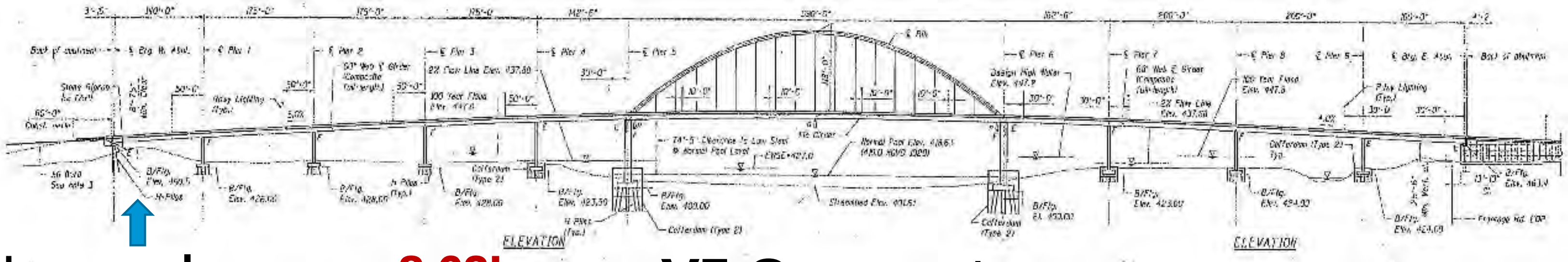
4%



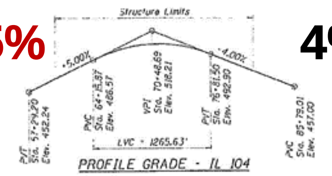
4%

Levee clearance 13.42'

Baseline Concept



5%



4%

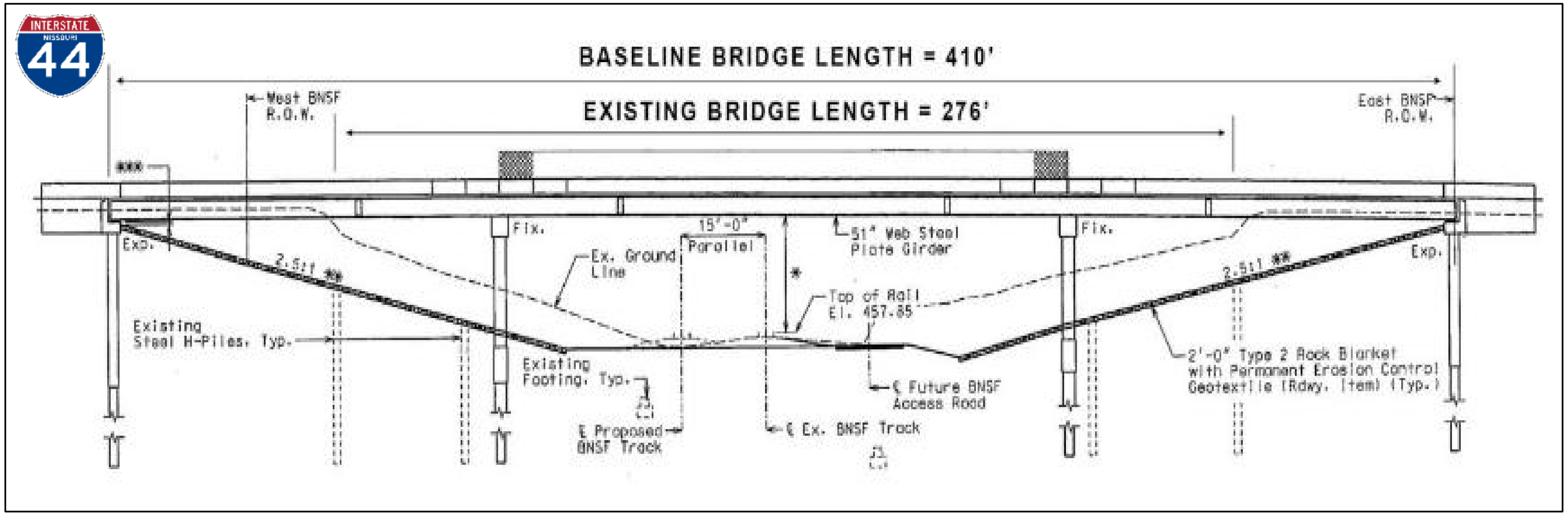
Levee clearance 8.62'

VE Concept

Example No. 5

Project: Replace I-44 Bridges over BNSF RR

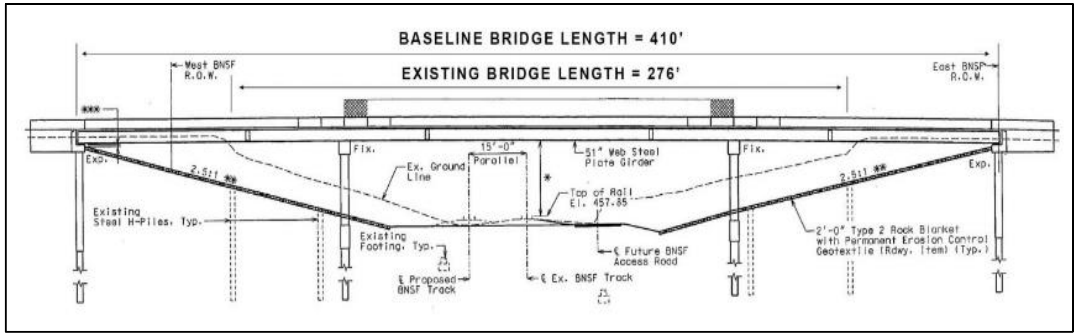
- **Owner**: MoDOT
- **Description**: replace existing 3-span bridge over BNSF Railroad with 3-span, continuous steel-plate girder bridge
- **Construction cost**: $16 million



Example No. 5

Project: Replace I-44 Bridges over BNSF RR

- **Applicable basic function**: span/clear RR requirements
- **Baseline concept**:
  - 3-span, cont. steel-plate curved girders with integral bents
  - Length = 410 ft. ; 134 ft. longer (48%) than existing bridge
  - Spans newly cut fill slopes (not a RR requirement)
  - Four splices per girder line (18); erection in limited rail-traffic gaps
  - EB bridge provides 5’-2” excess track clearance due to super
  - Two expansion joints (one on each end)



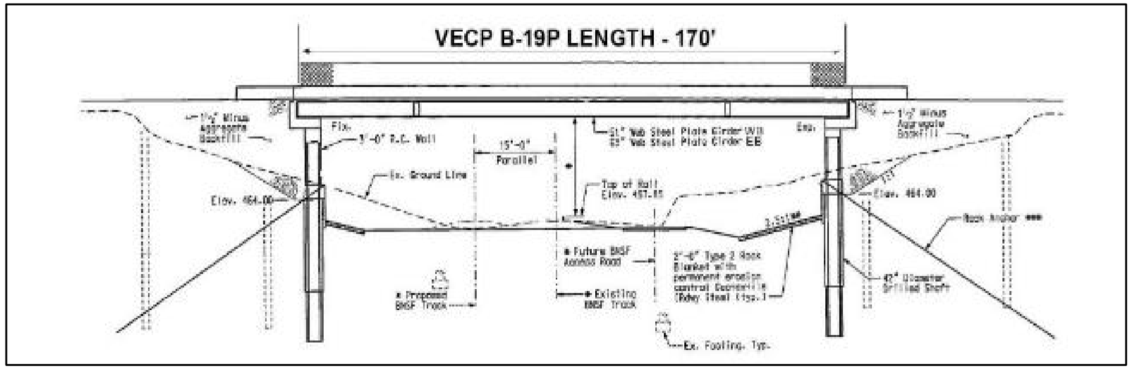
Example No. 5

- **Key VE questions**:
  - *Why is baseline bridge 58% longer than existing bridge?*
  - *Does the bridge need to span the approach fills?*
  - *How many working days does it take to erect 18 curved, 4-splice girders in limited windows of stopped rail traffic?*
  - *Is the optimized **material-cost** design the lowest **total cost**?*

- **Answers**:
  - ***Balance continuous steel plate-girder spans***
  - ***No, only RR tracks, future RR access road, and clearance offset***
  - ***Probably many more" (approximately three-four times as many)***
  - ***No (+ $1.325 million)***

Example No. 5

- **Project: Replace I-44 Bridges over BNSF RR**
  - **VECP concept**:
    - **Single-span bridge** with **straight girders**; aggregate **fill** on approaches; concrete wall abutments & wingwalls; 1 less exp. joint
    - Length = 170,' a **240' length reduction** from baseline (58%)
    - **One splice** per girder; (18 vs. 72 total splices)
    - **EB bridge**: (–)1 girder line, utilized excess clearance allowing **deeper** girder; **WB bridge**: (+)1 girder line/**shallower** girder
    - Gross savings: $1.325M; net savings to be shared: **$715,556** (4.4%)



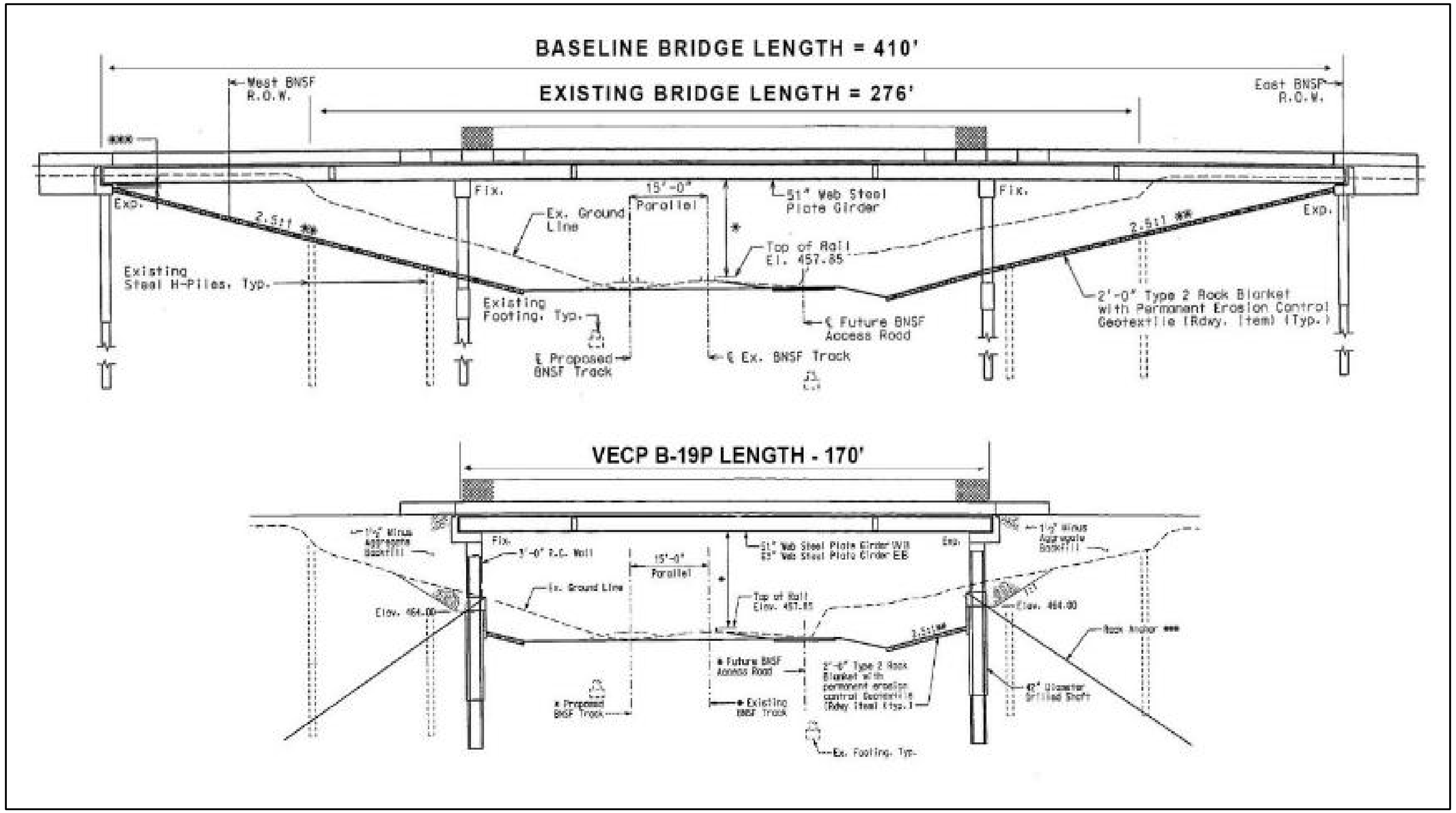
Example No. 5

Project: Replace I-44 Bridges over BNSF RR

Baseline Design

VECP Design

"Fraternal twin" bridges



Example No. 5

Project: Replace I-44 Bridges over BNSF RR

Lifting long segment

Placing short segment

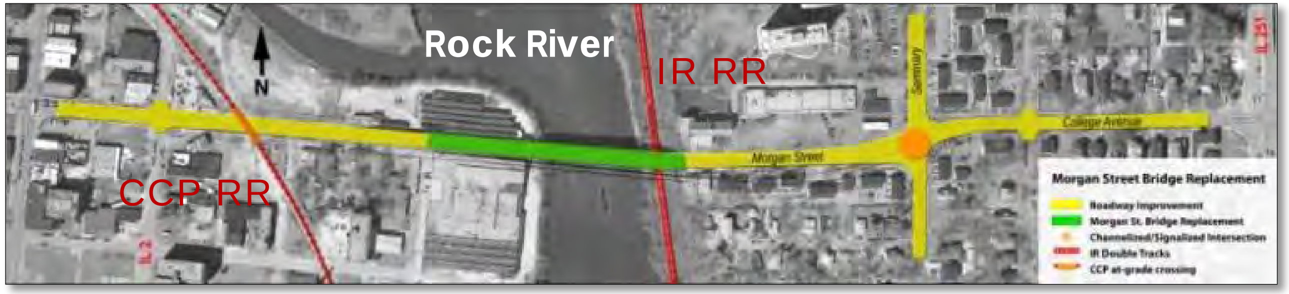
Placing long segment

Pinning & Bolt-torqueing splice

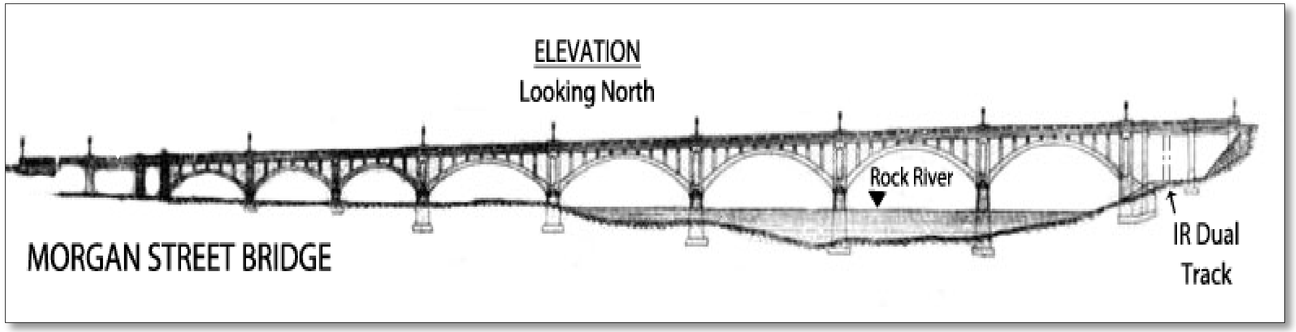
Example No. 6

Project: Morgan Street Bridge Replacement

- **Owner**: City of Rockford, IL
- **Description**: replace existing concrete, spandrel-arch bridge over Rock River & IR RR with 3-span tied-arch bridge
- **Construction cost**: $21.8 million



Project Map



Existing Bridge

Example No. 6

Project: Morgan Street Bridge Replacement

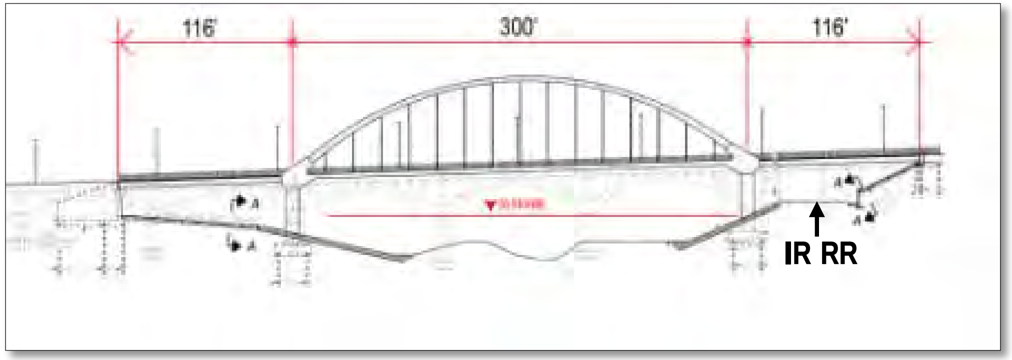
- **Value targets**: bridge main span; RR flagger
- **Applicable functions:**
  - Basic: span obstacles (Rock River & IR Railroad)
  - Secondary: accommodate RR operations
- **Baseline concept**:
  - 300 ft. main span; 116 ft. approach span over railroad ROW
  - Main span piers in river/cofferdams required
  - Vertical deck hangers
  - RR flagger to maintain IR RR operations & protect workers

Baseline Bridge Concept

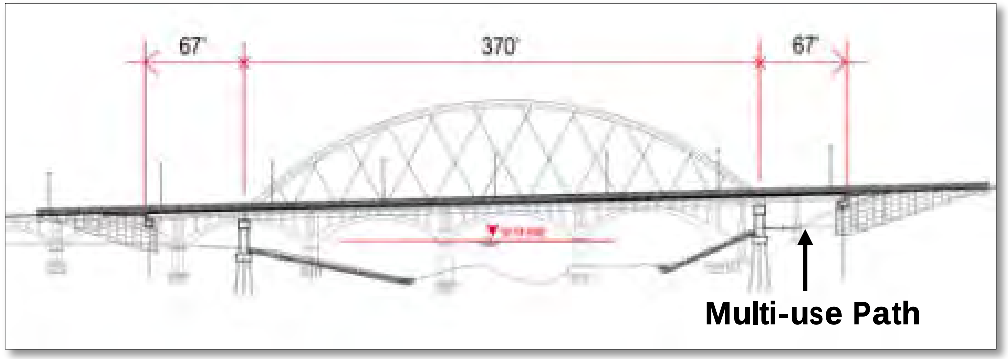
Example No. 6

Project: Morgan Street Bridge Replacement

- **VE concept**:
  - **Relocate IR Railroad** permanently to CCP Railroad
  - 370' main span vs. 300' baseline; main-span **piers out of river**
  - East **pier on former RR ROW**; X-Pattern ("network") Deck Hangers
  - **Multi-use path** under bridge on former RR ROW



Baseline Concept



VE Concept

Example No. 6

- **How did this happen? It began with a question by VE team:**
  - *How can we <u>eliminate RR flagger & cost</u> ($240,000)?*
  - Answer: *temporarily relocate IR RR traffic to CCP RR*
  - Both railroads accept idea but want the **IR relocation permanent** to eliminate at-grade "diamond" railroad crossing south of project

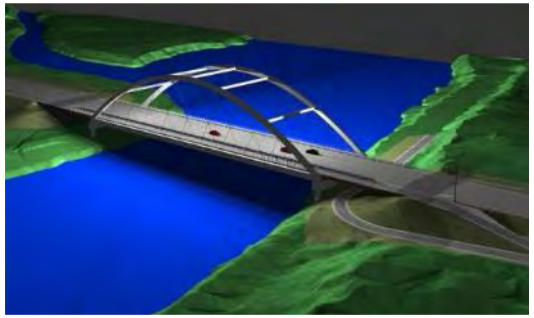
Diamond RR Crossing

  - Bridge no longer has to span a railroad; **span arrangement optimized**
  - Optimum span arrangement: 67'/370'/67'; piers out of river; use of former RR ROW; **no flagger needed**; **$815,00** cost savings
  - **Bonus**: four at-grade street/RR crossings eliminated south of project
  - **Bonus**: city takes possession of RR ROW; converts it to multi-use path

Example No. 6

- **Baseline design to VE design began with a simple question that was never asked during regular design:**

How can we eliminate the flagger?



VE Design Concept

Baseline Design

Completed VE Design

Example No. 6

- This final design would have never happened through the traditional design process.

Completed Project

Opening Day

Night Lighting

Six Examples - Summary

Project	Value Proposal	Savings
I-69 Sect. 4	**Shorter bridges** with flood easements	$4.9M
Project 421	**Eliminate bridge**/signalized intersection	$600K
US 51 Expressway	**3% max. grade** vs. 2% desirable	$1.2M
IL104 River Bridge	**Unsymmetrical vert. grade** (5% west of river)	$764K
I-44/BNSF RR Bridge	**“Fraternal twins”** mainline bridges	$715M
Morgan St. Bridge	**Relocate RR**; optimize bridge spans	$815K

Why Does VA/VE Discover Design Solutions that the Traditional Design Process Often Does Not?

- **Answer: VE *asks lots of questions* not asked in the traditional design process:**
  - What is the standard/past-practice design's function?
  - Is that function needed to meet purpose & need?
  - Is *all* of that function needed to meet purpose & need?
  - Is there another less costly way to accomplish that function?
  - Is there a less costly construction method than that required by the baseline design?

Why Does VA/VE Discover Design Solutions that the Traditional Design Process Often Does Not?

- **Why are VE questions *not asked* during traditional design (TD)? Answer:**
  - No need to know the function(s) of standard designs
  - Standard/past-practice designs are proven/comfortable
  - Surplus function(s) provide safety factor/contingency
  - No incentive to improve value of standard designs
  - Consultants: lower design liability; lower design fees
  - Consultants: concern with displeasing owners by questioning owner scope/standard designs

Why Does VA/VE Discover Design Solutions that the Traditional Design Process Often Does Not?

- **Answer: The VA/VE process discovers design solutions that the traditional design process often does not *because*:**
  - *It uses a systematic process by a multidisciplinary team to improve the value of a project through the analysis of its functions (**value methodology**).*
  - *It asks lots of **function-based questions**.*
  - *It has the **structure** and **team** to efficiently and effectively provide the answers, and also develop alternatives to meet project purpose & need at the lowest cost.*

Traditional Design/VE Relationship

- **Analogy: off-the-rack suit**
  - Fits the average person
  - No alterations or alteration costs required
  - Looks and fits great

Traditional Design/VE Relationship

- **Off-the-rack suit**
  - Doesn't fit persons smaller or larger than average
  - Without alterations, the suit exhibits poor value:
    - **Too tight** on larger-than-average person
    - **Too baggy** on smaller-than-average person

Traditional Design/VE Relationship

- **Standard designs are like an off-the-rack suit**
  - Fit the average project
  - No alterations to standards or alteration costs required
  - Often doesn't fit non-average project conditions
  - For non-average project conditions, alterations required to meet project purpose & need
  - Without alterations, the project can exhibit poor value
    - **Excess** function(s); **non-required** functions; **more costly** function(s)
    - **Excess cost** to meet project purpose & need

Traditional Design/VE Relationship

- **The most efficient and effective way to achieve the *optimum design* is to:**
  - Develop a **standards-based baseline design** using the traditional design process.
  - Conduct a **VE study** for the standards-based baseline design at key design stages:
    - planning/scope development
    - concept design *[most important]*
    - detailed design
    - post-award construction phase

Traditional Design/VE Relationship

- The traditional design process and VE are **complementary**
- VE should be a ***welcome partner***, not a threat or redundancy to traditional design

Conclusions

- **Traditional design "manufactures the suit"** (develops an acceptable baseline design), **but sometimes contains excess or more costly functions.**

- **VE makes the necessary "alterations"** (alternative VE concepts) **to precisely fit** (provide best value to) **the "wearer"** (the project purpose & need).

Traditional Design

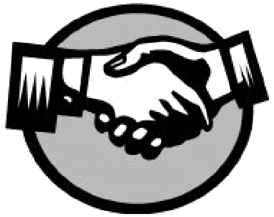
After VE Analysis

Conclusions

Traditional design + VE study = optimum design

TRADITIONAL DESIGN

Baseline
Design Report
PS&E



VE STUDY

Accepted
VE Proposals

OPTIMUM DESIGN

Best Value

Why Does VA/VE Discover Design Solutions that the Traditional Design Process Often Does Not?

QUESTIONS?

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