Economical Design / Case Studies

Alabama Technology Transfer Center Workshop

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*University of Wyoming & SSSBA Bridge Technology Center*
Outline of Today’s Presentation

• Competitiveness of Steel Bridges
• Bridges Built Using eSPAN140
• County Built Steel Bridges
Economics Case Study

Steel vs. Concrete Costs
Audrain County, MO
Steel and Concrete Bridges in Missouri Counties
Case Study Bridges: Side-by-Side Comparison

Steel

Audrain County, MO Bridge 411
Built 2012
Steel 4 Girders
47.5 ft. Span
24 ft. Roadway Width
2 ft. Structural Depth
No Skew

Concrete

Audrain County, MO Bridge 336
Built 2012
Precast 6 Hollowcore Slab Girders
50.5 ft. Span
24 ft. Roadway Width
2 ft. Structural Depth
20° Skew
Case Study Bridges: Side-by-Side Comparison Total Cost of Structure

Steel

- Material = $41,764
- Labor = $24,125
- Equipment = $21,521
- Guard Rail = $7,895
- Rock = $8,302
- Engineering = $8,246
- TOTAL = $111,853 ($97.48 / sq. ft.)

Concrete

- Material = $67,450
- Labor = $26,110
- Equipment = $24,966
- Guard Rail = $6,603
- Rock = $7,571
- Engineering = $21,335
- TOTAL = $154,035 ($120.83 / sq. ft.)

19.3% Total Bridge Cost Savings with Steel
Case Study Bridges: Side-by-Side Comparison

**Steel**

<table>
<thead>
<tr>
<th></th>
<th>Total Bridge Costs per ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Cost</strong></td>
<td>$97.48 / sq. ft.</td>
</tr>
<tr>
<td><strong>Total Construction Cost</strong></td>
<td>$90.29 / sq. ft. (no Engineering)</td>
</tr>
<tr>
<td><strong>Adjusted Construction Cost</strong></td>
<td>$83.05 / sq. ft. (no Engineering or Rock)</td>
</tr>
</tbody>
</table>

**Concrete**

<table>
<thead>
<tr>
<th></th>
<th>Total Bridge Costs per ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Cost</strong></td>
<td>$120.83 / sq. ft.</td>
</tr>
<tr>
<td><strong>Total Construction Cost</strong></td>
<td>$104.08 / sq. ft. (no Engineering)</td>
</tr>
<tr>
<td><strong>Adjusted Construction Cost</strong></td>
<td>$98.14 / sq. ft. (no Engineering or Rock)</td>
</tr>
</tbody>
</table>
### Steel

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girders</td>
<td>$21,463</td>
</tr>
<tr>
<td>Deck Panels</td>
<td>$7,999</td>
</tr>
<tr>
<td>Reinf Steel</td>
<td>$3,135</td>
</tr>
<tr>
<td>Concrete</td>
<td>$4,180</td>
</tr>
<tr>
<td>Labor</td>
<td>$5,522</td>
</tr>
<tr>
<td>Equipment*</td>
<td>$500</td>
</tr>
<tr>
<td><strong>SUPER TOTAL</strong></td>
<td><strong>$42,799</strong></td>
</tr>
</tbody>
</table>

**SUPER TOTAL = $37.54 / sq. ft.**

*Added cost to use galvanized steel = $5,453.80 or $0.22 / lb. (includes est. 10% fabrication fee)
**Cost to use weathering steel is approximately $0.04 / lb. (already included in cost in example)*

*County Crane (30 Ton) used for Steel, Larger Rented Crane (100 Ton) Required for Concrete (Equivalent County Crane Cost is $1520, would result in Steel Cost of $38.88 / sq. ft.)

### Concrete

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slab Girders</td>
<td>$50,765</td>
</tr>
<tr>
<td>Deck Panels</td>
<td>$0</td>
</tr>
<tr>
<td>Reinf Steel</td>
<td>$724</td>
</tr>
<tr>
<td>Concrete</td>
<td>$965</td>
</tr>
<tr>
<td>Labor</td>
<td>$4,884</td>
</tr>
<tr>
<td>Equipment*</td>
<td>$4,000</td>
</tr>
<tr>
<td><strong>SUPER TOTAL</strong></td>
<td><strong>$61,338</strong></td>
</tr>
</tbody>
</table>

**SUPER TOTAL = $50.61 / sq. ft.**
Case Study Bridges: Audrain County, MO

Steel: Superstructure $37.54 per sq. ft.
Concrete: Superstructure Cost $50.61 per sq. ft.

25.8% superstructure cost savings

Same bridge conditions:
- Structural Depth = 2 ft. (No Difference in Approaches)
- Roadway Width = 24 ft.
- Same Abutments for Both Can be Used (Steel Could Use Lighter)
- Same Guard Rail System
- Same Work Crew
Steel Bridge - Advantages

Lighter Cranes Required (Owner Cranes Can Save Costs)
Steel Bridge - Advantages

Lighter Abutments Possible for Steel Bridges
Steel Bridge - Economy

Cast-in-Place Deck on Prestressed Concrete Deck Panels
Steel Bridge - Economy

Simple and Practical Details
Steel Bridge - Economy

Elastomeric Bearings & Integral Abutments
Steel Bridge - Economy

Weathering Steel
<table>
<thead>
<tr>
<th>Superstructure</th>
<th>Steel</th>
<th>Concrete</th>
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</thead>
<tbody>
<tr>
<td>Bridge Number</td>
<td>061 140 149 152 710 AVG</td>
<td>028 057 069 520 AVG</td>
</tr>
<tr>
<td>Span Length</td>
<td>50 50 40 62 64</td>
<td>53.2</td>
</tr>
<tr>
<td>Skew</td>
<td>0 0 0 30 35</td>
<td>13</td>
</tr>
<tr>
<td>Cost Summary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Labor</td>
<td>$14,568 $21,705 $15,853 $24,765 $31,949</td>
<td>$21,768</td>
</tr>
<tr>
<td>- Material</td>
<td>$56,676 $53,593 $46,282 $92,821 $69,357</td>
<td>$63,746</td>
</tr>
<tr>
<td>- Rock</td>
<td>$6,170 $6,216 $3,694 $8,235 $6,501</td>
<td>$6,163</td>
</tr>
<tr>
<td>- Equipment</td>
<td>$7,487 $12,026 $7,017 $19,579 $15,266</td>
<td>$12,275</td>
</tr>
<tr>
<td>- Guardrail</td>
<td>$4,715 $7,146 $3,961 $7,003 $7,003</td>
<td>$5,966</td>
</tr>
<tr>
<td>Construction Cost</td>
<td>$89,616 $100,686 $76,807 $152,403 $130,076</td>
<td>$109,918</td>
</tr>
<tr>
<td>CONST. COST PER FT²</td>
<td>$74.68 $83.91 $80.01 $102.42 $84.68</td>
<td>$86.09</td>
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The Bottom Line…

• Short span steel bridges compete and win!
eSPAN140 Designed Bridges
1st Direct Application of eSPAN140 – start to finish

Jesup South Bridge, Buchanan County, Iowa

- Buchanan County Iowa
- Count Crew Built Bridge
- Replacement using W36x135 rolled beams
- 65 feet length, 40 width
- Better Roads (February 2014)
County Crew Accomplishments:

- Longest Bridge Built
- First Steel Bridge Built
- First Concrete Deck
- First Integral Abutment
- Galvanized Steel
- Galvanized Rebar
- County Equipment
The New Jesup South Bridge
• Recently awarded 2 jobs with eSPAN140 preliminary designs (Gary Wisch, VP of Engineering)

• Boone County, Missouri
  • High Point Lane Bridge
  • 102 feet (2 lane rural road plate girder bridge)
  • 44” weathering steel plate girders (4 lines)
  • County was not going to consider steel
  • Competitive Bid Process (steel vs. concrete)
  • Used eSPAN140 for preliminary designs
  • Constructed in summer 2013

• Kansas Department of Transportation
  • Shawnee County
  • 112 feet (5 plate girder bridge)
  • Competitive bid process (steel vs. concrete)
  • DOT used eSPAN140 for preliminary design
  • Constructed in summer 2014
Another County Built Bridge

Muskingum County, OH
Muskingum County, Ohio
Boggs Road Bridge Replacement

Open to traffic in 21- working days

Before:
33-foot Span
22’-7” Wide

After:
44 - Foot Span Composite Design:
5 - W24 x 76 GR 50, Galvanized Steel Beams on 5-Foot spacing w/ 2-FT Overhang
Why 21 Days?

- eSPAN140 “related” design / used “in-house” engineering
  - “The team saved significant time and costs by planning and designing the structure in-house”

- Local crew installed the bridge

- “Light” crane / light weight and handling

- Stay-in-place forming / shear studs were installed through decking

- Traditional Abutments
Why 21 Days?

• “Our ability to handle, fabricate, repair and construct steel beam structures with equipment and tools we have on hand saves considerable time and money that we would ordinarily have to spend hiring a contractor” – Doug Davis, County Engineer for MCEO
Existing Boggs Road Bridge

Single Span Steel Beam Bridge, 33 - Foot Long; 22.7 - Feet Wide, With 6-inch Reinforced Concrete Deck
SUPERSTRUCTURE DESIGN

Design Criteria:
- 55 MPH Design Speed
- 55 MPH Legal Speed
- ADT = 285 (2014), Local Rural Road
- HL93 Loading

44 - Foot Span Composite Design:
5 - W24 x 76 GR 50, Galvanized Steel Beams on 5-Foot spacing w/ 2-FT Overhang
3 - ¾ IN-Diameter Shear Studs
DEMOLITION
MAY 20, 2014 (DAY 1)
FOOTING CONSTRUCTION
MAY 21-23 (DAYS 2-4)
ABUTMENT CONSTRUCTION
MAY 27- JUNE 2 (DAYS 5-9)
ABUTMENT CONSTRUCTION
INSTALLING BEAMS
JUNE 3 (DAY 10)
BACK WALL CONSTRUCTION
JUNE 3 - 4 (DAYS 10 & 11)
DECK FORMING
JUNE 5 & 6 (DAYS 12 - 13)
DECK FORM SYSTEM
DECK EDGE FORMING
JUNE 9 & 10 (DAYS 14 & 15)
SHEAR STUD INSTALLATION
JUNE 9 (Day 14)

3 - \( \frac{3}{4} \)-Inch x 5-inch Long Shear Studs Installed Through 18 Ga. 1.5c-decking
DECK REINFORCEMENT
JUNE 11-12 (DAYS 16 & 17)

2- Mats Of No.5 Rebar On 12-inch Centers
CONCRETE DECK POUR
JUNE 13 (DAY 18)

~42 CY of ODOT CL “S” (4,500 PSI) With IPANEX Water proofer, Wet Cured For Minimum Of 7 Days
BRIDGE RAILING INSTALLATION
JUNE 23-24 (DAYS 20-21)

Twin Steel Tubing With Nested Rail Transition Section And Turned Down (Type “A”) Anchor Assembly
BRIDGE OPEN TO TRAFFIC
JUNE 24 (WORK DAY 21)

Before:
33-foot Span
22’-7” Wide

After:
44-foot Span
24’-0” Wide
Boggs Road Bridge Video
## BOGGS ROAD BRIDGE REPLACEMENT
### STEEL VS. CONCRETE

#### Material Costs Steel:
1. Bolt Together Steel Structure $26,016
2. Decking (1.5C – 18 ga. Decking) $2,223
3. Shear Studs $1,680
4. Bridge Railing and Guard Rail $14,590
5. Reinforcing Steel $7,490
6. Concrete /Forms (180.5 CYs) $27,026
7. Asphalt Repair $11,500

Subtotal $90,524

#### Material Costs Concrete:
1. Concrete Box Beams (6 Beams) $59,400
2. Bridge Railing and Guard Rail $11,500
3. Reinforcing Steel $5,000
4. Concrete/Forms (160 CYs) $24,000
5. Asphalt Repair $11,500
6. Crane Rental $2,500

Subtotal $113,900

#### Labor and Equipment Costs:
1. Labor (21 days) $19,562
2. Equipment $21,679

Grand Total = $131,765 = $124.77 /ft²

#### Labor and Equipment Costs:
1. Labor (18 days) $14,757
2. Equipment $21,679

Grand Total = $150,336 = $142.36 /ft²

**Difference Between Steel Beams and Concrete Box Beams**

$18,571
The Bottom Line...

• Short span steel bridges compete and win!
Summary

- Steel Bridges are Competitive
- eSPAN140 puts a design on the Table
- Counties can build their own bridges and save Money