Online Design Tools: eSPAN140 Demonstration & Design Example
Steel Bridge Economy & Case Studies

Michigan Bridge Conference: Tuesday, March 20 (Ann Arbor, MI)

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The Short Span Steel Bridge Alliance

- Program officially started September 2007
  - Objective – make steel the material of choice for short span steel bridges.
  - Short span steel bridges have spans up to 140 ft
  - First North American industry-wide effort to provide education and design support for short span steel bridges.
SSSBA Website

- eSPAN140 Web-based Design Tool
- Bridge Technology Center
- Technical Design Resources
- Project Case Studies
- News Updates & Social Media (Twitter / LinkedIn / Facebook)
- Email Newsletter (sign-up to receive it)

Join Today!

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http://www.shortspansteelbridges.org/
The Problem...

- Bridge engineers are well trained on the use of short span concrete bridges.
  - In fact, over than 80% of the short span bridges in the United States are made of concrete.

- Many County and (DOT) engineers are simply not educated/familiar with the design, construction, and economics of short span steel bridges.
  - Concrete provides simple, standardized, cost-effective, “tinker toy” solutions to construct short span steel bridges.
  - Steel bridges are “perceived to be too” complex, “Swiss watch”-like, and too expensive.
Case Study Bridges: Audrain County, MO

- Project Location:
Case Study Bridges: Audrain County, MO (cont’d)

- **MO Bridge 411**
  - Built 2012
  - 4 Steel Girders
  - 47.5 ft Span
  - 24 ft Roadway Width
  - 2 ft Structural Depth + Slab

- **MO Bridge 336**
  - Built 2012
  - 6 Precast Hollowcore Slabs
  - 50.5 ft Span
  - 24 ft Roadway Width
  - 2 ft Structural Depth + Slab
Case Study Bridges: Audrain County, MO (cont’d)

- **Steel:**
  - Total Bridge Costs:
    - Material = $41,764
    - Labor = $24,125
    - Equipment = $21,521
    - Guardrail = $7,895
    - Rock = $8,302
    - Engineering = $8,246
    - TOTAL = $111,853 ($97.48/ft²)

- **Concrete:**
  - Total Bridge Costs:
    - Material = $67,450
    - Labor = $26,110
    - Equipment = $24,966
    - Guardrail = $6,603
    - Rock = $7,571
    - Engineering = $21,335
    - TOTAL = $154,035

  19.3% Total Cost Savings w/ Steel
Case Study Bridges: Audrain County, MO (cont’d)

- Steel:
  - Total Cost per ft²:
    - Total Cost = $97.48/ft²
    - Construction = $90.29/ft²
      - No Engineering
    - Adjusted = $83.05/ft²
      - No Engineering or Rock

- Concrete:
  - Total Cost per ft²:
    - Total Cost = $120.83/ft²
    - Construction = $104.08/ft²
      - No Engineering
    - Adjusted = $98.14/ft²
      - No Engineering or Rock
Case Study Bridges: Audrain County, MO (cont’d)

- **Steel:**
  - **Superstructure Only:**
    - Start to finish = 10 days
    - Girders = $21,463
    - Deck Panels = $7999
    - Reinf. Steel = $3135
    - Concrete = $4180
    - Labor = $5522
    - Equipment* = $500
    - **TOTAL =** $42,799

  *Material Considerations:*
  - Added cost to use galvanized steel $\approx$ $0.22/\text{lb}$ (includes est. 10% fabrication fee)
  - Added cost to use weathering steel $\approx$ $0.04/\text{lb}$ (already included in cost in example)

  *Equipment Considerations:*
  - County crane (30-ton) used for steel; Larger rented crane required for concrete
    - Equivalent county crane cost is $1520 (would result in steel cost of $38.88/\text{ft}^2$)

- **Concrete:**
  - **Superstructure Only:**
    - Start to finish = 13 days
    - Slab Girders = $50,765
    - Deck Panels = $0
    - Reinf. Steel = $724
    - Concrete = $965
    - Labor = $4884
    - Equipment* = $4000
    - **TOTAL =** $61,338

  =$50.61/\text{ft}^2$
Case Study Bridges: Audrain County, MO (cont’d)

- **Steel:**
  - Superstructure total cost of $37.54 per ft$^2$

- **Concrete:**
  - Superstructure total cost of $50.61 per ft$^2$

*Same bridge conditions:*
- Structural Depth = 2 ft + Slab (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
Advantages of MO Bridge 411

- Lighter cranes required:
  - Owner cranes can save costs.
Advantages of MO Bridge 411 (cont’d)

- Lighter abutments possible for steel bridges.
Advantages of MO Bridge 411 (cont’d)

- Cast-in-place deck on prestressed concrete deck panels
Advantages of MO Bridge 411 (cont’d)

- Simple and practical details:
Advantages of MO Bridge 411 (cont’d)

- Elastomeric bearings and integral abutments:
Advantages of MO Bridge 411 (cont’d)

- Use of weathering steel:
## Case Study Bridges: Additional Bridges in MO

<table>
<thead>
<tr>
<th>Superstructure</th>
<th>Steel</th>
<th>Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge Number</td>
<td>061 140 149 152 710</td>
<td>AVG 028 057 069 520 AVG</td>
</tr>
<tr>
<td>Span Length</td>
<td>50 50 40 62 64</td>
<td>53.2 36 36 38 40</td>
</tr>
<tr>
<td>Skew</td>
<td>0 0 0 30 35</td>
<td>13 0 15 20 30</td>
</tr>
<tr>
<td>Cost Summary</td>
<td>- Labor $14,568 $21,705 $15,853 $24,765 $31,949</td>
<td>$21,768 $12,065 $15,379 $14,674 $19,044</td>
</tr>
<tr>
<td></td>
<td>- Material $56,676 $53,593 $46,28$2 $92,821 $69,357</td>
<td>$63,746 $51,589 $54,450 $50,576 $46,850</td>
</tr>
<tr>
<td></td>
<td>- Rock $6,170 $6,216 $3,694 $8,235 $6,501</td>
<td>$6,163 $5,135 $7,549 $5,378 $3,621</td>
</tr>
<tr>
<td></td>
<td>- Equipment $7,487 $12,026 $7,017 $19,579 $15,266</td>
<td>$12,275 $5,568 $10,952 $11,093 $14,742</td>
</tr>
<tr>
<td></td>
<td>- Guardrail $4,715 $7,146 $3,961 $7,003 $7,003</td>
<td>$5,966 $4,737 $4,663 $5,356 $3,323</td>
</tr>
<tr>
<td>Construction Cost</td>
<td>$89,616 $100,686 $76,807 $152,403 $130,076</td>
<td>$109,918 $79,094 $92,993 $87,077 $87,580</td>
</tr>
<tr>
<td>CONST. COST PER FT²</td>
<td>$74.68 $83.91 $80.01 $102.42 $84.68</td>
<td>$86.09 $91.54 $107.63 $95.48 $91.23</td>
</tr>
</tbody>
</table>
The Solution

- **Standardized designs for short span steel bridges**
  - BTC led a 3-year industry-wide effort (owners, fabricators, designers, associations, service centers, etc. involved)
    - Over 3,000 designs evaluated
  - Result = simple standardized designs for short span bridges
    - Rolled beam, plate, & buried soil steel structures
  - Standards used to develop eSPAN140
    - 650 total preliminary bridges designed
    - Adding abutments, substructure, CSP enhancements, metric, and Canadian designs in next 12 months.
  - BTC working with Mexico & Canada to develop MEX/CAN version
  - BTC working with AASHTO for designs to become a national guideline
http://www.espan140.com/
Free Online Design Tool for Short Span Steel Bridges
Utilizes Standard Short Span Steel Bridge Designs

SHORT SPAN STEEL BRIDGE DESIGN STANDARDS
Standards for Short Span Steel Bridge Designs

• Goals:
  – Economically competitive
  – Expedite & economize the design process
  – Simple repetitive details & member sizes.

• Bridge Design Parameters:
  – Span lengths: 40 feet to 140 feet (5-foot increments)
  – Girder spacing: 6 feet, 7.5 feet, 9 feet and 10.5 feet
  – For each of these increments, the following were designed:
    • Steel girders
    • Shear stud & stiffener layouts
    • Welding and fabrication details
    • Elastomeric bearings
    • Concrete deck design

Primary value is use as an estimating tool!

• Now have the ability to produce a valid steel bridge design in minutes
• Obtain a cost estimate from a fabricator within a day
• Can directly compete with concrete alternate
• Design can then be further optimized
Standard Short Span Steel Bridge Designs (cont’d)

- Four types of girder types:
  - Homogeneous plate girders (50 ksi steel)
  - Hybrid plate girders
    - 50 ksi top flanges and webs, 70 ksi bottom flanges
  - Lightest weight rolled beams (50 ksi steel)
    - Utilizing the lightest weight girder necessary
  - Limited depth rolled beams (50 ksi steel)
    - Designed to meet a target L/D of 25

- In addition, girders were designed to accommodate commonly stockpiled plate thicknesses and rolled beam sizes.
Standard Short Span Steel Bridge Designs (cont’d)

- Bridges were designed according to AASHTO LRFD Specs:
  - Strength I, Service II, Fatigue, Constructability, L/800 Deflection
  - HL-93 Vehicular Live Loading
- Additional Design Loads:
  - SIP unit weight: 15 psf
  - FWS: 25 psf
  - Concrete barriers = 520 lb/ft
  - Misc. steel wt. increase = 5%
  - Concrete unit weight = 150 pcf
  - Steel unit weight = 490 pcf
  - Concrete haunch = 2 in
  - Constant flange width
  - Constant web height
Standard Short Span Steel Bridge Designs (cont’d)

• Weight comparisons (9’-0” girder spacing):

![Graph showing weight comparisons for different bridge designs]
One-stop shop for customized steel bridge and culvert solutions!

- eSPAN140 provides:
  - Standard designs and details for short span steel crossings
    - Rolled Beam and Plate Girders
    - Corrugated Steel Pipe and Structural Plate
  - Manufacturers' Steel Solutions (SSSBA Partners)
  - Coatings Solutions
  - Industry Contacts
    - Contacts can provide budget estimates and pricing information

Free and easy to use!!!
http://www.espan140.com/
eSPAN140 Example

- Start new project:

My Projects

Welcome to eSPAN140. If this is your first time here, please click on “Start New Project” to begin.

If you have already created a project, please use the table below to view past projects, complete partially existing inputs you provided, please click on “Duplicate”. This will allow you to create a new project (I have multiple bridges to design and have only a few input values to change).

Start New Project
eSPAN140 Example (cont’d)

- Step 1: Project Information

Project Name*
Sample Bridge

City/County*
Morgantown

State/Province* 📚
West Virginia

Roadway Name
Main Street

Bridge Span Length*
82 Feet 4 Inches

Next > Return to Projects
eSPAN140 Example (cont’d)

- Step 2: Project Details (general dimensions)
eSPAN140 Example (cont’d)

- Step 2: Project Details (pedestrian access option)
eSPAN140 Example (cont’d)

- Step 2: Project Details (remaining details)
eSPAN140 Example (cont’d)

- Example output (sample plate girder elevation):

**COMPOSITE PLATE GIRDER WITH PARTIALLY STIFFENED WEB - 4 GIRDERS AT 8’ 10” GIRDER SPACING, HOMOGENEOUS**

![Diagram of composite plate girder with partially stiffened web]

**Table: Plate Girder Size**

<table>
<thead>
<tr>
<th>Span (L) - ft</th>
<th>Top Flange (F)</th>
<th>Bottom Flange (G)</th>
<th>Web Plate (in)</th>
<th>Diaphragm (C) - ft</th>
<th>Shear Stiffeners</th>
<th>Shear Connector Max. Spacing</th>
<th>Individual Girder Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>14 x 3/4”</td>
<td>14 x 1”</td>
<td>17”</td>
<td>14 x 2”</td>
<td>61”</td>
<td>32 x 1/2”</td>
<td>21.25”</td>
</tr>
</tbody>
</table>
eSPAN140 Example (cont’d)

- Example output (typical fabrication details):
eSPAN140 Example (cont’d)

- Example output (typical fabrication details, cont’d):

```
- CONNECTION STIFFENER
- LEVEL OR SLOPING
- NOTE 1
- EQUAL
- MEMBER (SEE TABLE 1 THIS SHEET)
- CUT FLGS. FLUSH FOR W SECTION
- 3"

SEE STANDARD CLIPS & WELD TERMINATION DETAIL

TIGHT FIT

OPTION 1, OPTION 2

SHEAR STIFFENER (N.T.S.)

CONNECTION STIFFENER (N.T.S.)

E ½" x 5"
```
Design Example (cont’d)

- Typical section & deck details:
Design Example (cont’d)

- Typical bearing details:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>INTERNAL ELASTOMER LAYERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>16”</td>
<td>18”</td>
<td>4.375”</td>
<td>12”</td>
<td>5</td>
</tr>
</tbody>
</table>

BEARING ELEVATION
OPTION "A" (N.T.S.)

SEATED JOINT WI APPROVED SEALER (BOTH SIDES)

ABUTMENT STEM

ELASTOMERIC BEARING
EXISTING BEARING SEAT (IN GOOD CONDITION)
Design Example (cont’d)

- CSP & Structural Plate Standards:
Design Example (cont’d)

- Manufacturer’s Solutions:
Design Example (cont’d)

- Durability Solutions:
  - Weathering steel
  - Galvanized steel
  - Painted steel
Applications of eSPAN140

- **Jesup South Bridge, Buchanan County, Iowa** – 1st Direct Application
  - Buchanan County Iowa – **Constructed with County Crew**
  - Replacement using W36x135 rolled beams
  - 65 feet length, 40 width
  - Over $100,000 donations from members
  - Better Roads (February 2014)
Ohio Short Span Steel Bridge Design Standards

- In light of the success of eSPAN140, the Bridge Technology Center has been engaged in efforts to generate eSPAN140-based standards approved in a given state.
  
  - Recent efforts have been focused on in the State of Ohio.

- The Short Span Steel Bridge Alliance has begun the development of Ohio-specific short span steel bridge design standards.
  
  - We are eager to assist other agencies in the development of owner-specific short-span steel bridge standards!
Bridge Technology Center

- Free resource available to bridge owners and designers with questions related to:
  - Standard design and details of short span bridges (plate & rolled beam)
  - Standard design and details of corrugated steel pipe and structural plate.
Bridge Technology Center (cont’d)

- Training & Education Available!
  - Topics
    - Bridge Engineering-101
    - Steel bridge economy & cost-effective design
    - Standard designs (rolled beam, plate, CSP, structural plate)
    - Case studies/cost analysis
  - Format
    - Half-day workshops (county engineers/LTAPs)
    - Webinars (online training / presentations)
    - Steel Bridge Forums (DOTs)
    - Conferences/Trade show presentations
    - Technical Design Support (Bridge Technology Center)
    - SSSBA Website (Solutions Center, videos, etc.)

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Questions?

Thank You!