Simple Span Bridge Design with eSPAN140

Short Span Steel Bridge Alliance

NACE 2017 Short Span Steel Bridge Workshop
Cincinnati, OH
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Objective of Presentation:

- Provide bridge engineers & owners with resources to consider short span steel bridge solutions in design comparisons

Outline of Presentation

- Problem Statement
- Short Span Steel Bridge Alliance (SSSBA)
- Short Span Design Standards & eSPAN140
- eSPAN140 Bridges Constructed
Bridge Industry Statistics

- 310,000 (one-half) of the bridges in the U.S. are less than 140 feet in length – Considered Short Span Here
- Counties own 219,000 bridges of the approximate 610,000 bridges in the U.S. (most are short span)
- Short-span bridge replacement needs are great
Bridge Owner Needs for Today’s Bridges

- **Economical** in terms of design, fabrication, and construction practices

- **Standardized and Modular Bridges** for preliminary design comparisons and Accelerated Bridge Construction

- **Durability** over the life span and life cycle costs and performance

- **Sustainability** in use of recycled content and reusable material at end of service life
Additional Problem for Economy

There is a preconception that concrete bridges are less expensive than steel bridges for short spans.

Studies show that steel is competitive for county and state owners.

Next Presentation

*Short Span Shake-Up: Missouri Short Span Bridge Study Finds Steel Saved 25 Percent Over Concrete* (www.shortspansteelbridges.org bulletin & video)

*Historical Life Cycle Costs of Steel and Concrete Girder Bridges Concrete* (www.shortspansteelbridges.org bulletin & video)

Owners that only consider concrete bridges for short spans may be expending more funds than necessary.
Additional Problems for Convenience

Steel bridge design had not been standardized – each bridge was an original design that requires time and money, whereas concrete bridges are standardized designs.

The SSSBA developed standard simple-span and modular designs:

*eSPAN140 Short Span Steel Bridge Design*  
(www.eSPAN140.com & This Presentation)

*Press-Brake Tub Girder (PBTG) Modular & ABC Systems*  
(www.shortspansteelbridges.org report & video to come)

Owners can now compare preliminary steel and concrete alternatives immediately with standard steel and modular steel designs for competitive economy.
Short Span Steel Bridge Alliance

- Program started September 2007

- Initial Objective – provide standard designs for economical simple-span steel bridges up to 140 ft.

- First **North American** industry-wide effort to provide education and design support for short span steel bridges.
Producers

Coaters

Trade Organizations

Bridge Owners

Universities

Service Centers

Contractors

Fasteners

Fabricators

Design Firms

SHORT SPAN STEEL BRIDGE ALLIANCE

STEEL HAS THE SOLUTION

The New Steel
Providing Economical Steel Solutions to 140 Feet
Providing Economical Steel Solutions to 140 Feet

eSPAN140 Standard Girder Designs
Standard Short Span Steel Girder Bridge Designs

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

• Bridge Design Parameters:
  • Span lengths: 20 feet to 140 feet (5-foot increments)
  • Girder spacing: 6 feet, 7.5 feet, 9 feet and 10.5 feet
  • Limited Depth & Lightest Weight Rolled Beam Sections
  • Homogeneous & Hybrid plate girders with limited plate sizes
  • Selective cross-frame placement/design (AASHTO/NSBA)
  • Composite Deck & Shear Stud Design
  • Elastomeric Bearing Design
Standard Short Span Steel Girder Bridge Designs

- Four types of girder designs:
  - Lightest weight rolled beams (50 ksi steel)
  - Limited depth rolled beams (50 ksi steel)
  - Homogeneous plate girders (50 ksi steel)
  - Hybrid plate girders (HPS 70 ksi in critical flanges)

- In addition, girders were designed to accommodate commonly stockpiled plate thicknesses and rolled beam sizes
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 = 305 lb/ft
- Misc. steel wt. increase = 5%
- \( f_c' = 4,000 \text{ psi} \)
- Concrete unit weight = 150 pcf
- Steel unit weight = 490 pcf
- Concrete haunch = 2 in
- Constant flange width
- Constant web height
Free Online Design Tool for Short Span Steel Bridges

Developed by the Short Span Steel Bridge Alliance

http://www.espan140.com/
Providing Economical Steel Solutions to 140 Feet
eSPAN140 Overview

- eSPAN140 is an **easy-to-use** and **free** resource for bridge engineers & owners

In 3 easy steps, multiple steel solutions are recommended

1. Create a User's Account
2. Input Your Specific Project Details
3. View Your Instant Customized Solutions Books
eSPAN140 Overview (cont’d)

• 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 pe existing inputs you provided, please click on “Duplicate”. This will allow you to create a new project have multiple bridges to design and have only a few input values to change).

Start New Project
eSPAN140 Overview (cont’d)

- Range of available solutions:

<table>
<thead>
<tr>
<th>Solution Type**</th>
<th>Bridge Span Length</th>
<th>Skew Angle</th>
<th>Overhang Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolled Beam (40’ to 100’)**</td>
<td>![Bar Chart]</td>
<td>+/- 20 degrees</td>
<td>3’3” or less</td>
</tr>
<tr>
<td>Homogeneous Plate Girder (60’ to 140’)**</td>
<td>![Bar Chart]</td>
<td>+/- 20 degrees</td>
<td>3’3” or less</td>
</tr>
<tr>
<td>Hybrid Plate Girder (80’ to 140’)**</td>
<td>![Bar Chart]</td>
<td>+/- 20 degrees</td>
<td>3’3” or less</td>
</tr>
<tr>
<td>Corrugated Steel Pipe/Structural Shape (0’ to 85’)</td>
<td>![Bar Chart]</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td>Manufacturer’s Steel Solutions (all)</td>
<td>![Bar Chart]</td>
<td>All</td>
<td>All</td>
</tr>
</tbody>
</table>
Design Example

• Project Information

- **Project Name**: Sample Bridge
- **City/County**: Morgantown
- **State/Province**: West Virginia
- **Roadway Name**: Main Street
- **Bridge Span Length**:
  - 82 Feet
  - 4 Inches

[Button] Next > [Link] Return to Projects
Design Example (cont’d)

- Project Details (general dimensions)

<table>
<thead>
<tr>
<th># of Striped Traffic Lanes*</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Width*</td>
<td>30 Feet, 0 Inches</td>
</tr>
<tr>
<td>Individual Parapet Width</td>
<td>1 Feet, 3 Inches</td>
</tr>
<tr>
<td>Individual Deck Overhang Width</td>
<td>3 Feet, 0 Inches</td>
</tr>
</tbody>
</table>
Design Example (cont’d)

- Project Details (pedestrian access option)
Design Example (cont’d)

- Project Details (remaining details)

![Design Example](image-url)
Customized Solutions Book is Provided (pdf)

Standard Design and Details of Short Span Steel Bridges Solutions
  • Rolled Beam Recommendations
  • Plate Girder Recommendations

Standard Design and Details of Corrugated Steel Pipe and Structural Plate Solutions

Manufacturer’s Steel Solutions (SSSBA Partners)
  • Customized Solutions from Members of the SSSBA

Durability Solutions (SSSBA Partners)
  • Galvanized & Paint
  • Weathering Steel

Additional Contact Information from SSSBA members
Steel Bridge Solutions

Steel Bridge Example

Test Test

Test Member Account

6/19/2012 10:23 AM

www.ShortSpanSteelBridges.org | www.eSPAN140.com
### Project Input Details

<table>
<thead>
<tr>
<th><strong>User Name:</strong></th>
<th>Test Test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>User Company:</strong></td>
<td>Test Member Account</td>
</tr>
<tr>
<td><strong>User Input Date:</strong></td>
<td>09/10/2012</td>
</tr>
<tr>
<td><strong>Project Name:</strong></td>
<td>Steel Bridge Example</td>
</tr>
<tr>
<td><strong>City:</strong></td>
<td>Washington</td>
</tr>
<tr>
<td><strong>State/Province:</strong></td>
<td>DC</td>
</tr>
<tr>
<td><strong>Roadway:</strong></td>
<td>Lincoln Road over Route 35</td>
</tr>
</tbody>
</table>

| **Span Length:** | 61' 3" |
| **Number of Striped Traffic Lanes:** | 2 |
| **Roadway Width:** | 26' 0" |
| **Total Parapet Width:** | 3' 2" |
| **Total Deck Overhang Width:** | 8' 5"
| **Pedestrian Access:** | Yes |
| **Number of Sidewalks:** | 1 |
| **Total Width of Each Sidewalk:** | 7' 2" |
| **Skew Angle:** | 0.0000 degrees |
| **Average Daily Traffic (ADT):** | 501-2,000 |
| **Design Speed:** | 0-45 mph |
| **Waterway Area:** | 8' 8" |
| **Height of Cover:** | 4' 0" |

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**Disclaimer**

This document has been prepared in accordance with information made available to the Short Span Steel Bridge Alliance (SSSBA) at the time of its preparation. While it is believed to reasonably reflect the present state of knowledge as to the subject, it has not been prepared for conventional use as an engineering or construction document and should not be used or relied upon for any specific application without competent professional examination and verification of its accuracy, suitability, and applicability by a licensed engineer, architect, or other professional. SSSBA disclaims any liability arising from information provided by others or from the unauthorized use of the information contained in this document, and does not accept any obligation to issue supplements or corrections in the event of errors being discovered or advances being made in the techniques discussed in this document.

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**Notes**

- Short span standards for rolled beam solutions are only available for input lengths between 40 and 130 feet and skew angles under 20 degrees.
- Short span standards for homogeneous plate girder solutions are only available for input lengths between 60 and 140 feet and skew angles under 20 degrees.
- Short span standards for hybrid plate girder solutions are only available for input lengths between 60 and 140 feet and skew angles under 20 degrees.
- Design standards for rolled beam and plate girder solutions are rounded in five (5) foot increments.
- Corrugated steel pipes and structural plate standards are only available for input lengths under 85 feet.

*Customized prefabricated manufactured solutions are available for all lengths and skew angles.*

*For bridges/curtains outside of this range, standard designs will not appear in your solutions book.*

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Design Example (cont’d)

• Sample plate girder (homogeneous) elevation:

COMPOSITE PLATE GIRDER WITH PARTIALLY STIFFENED WEB - 4 GIRDERS AT 8’ 10” GIRDER SPACING, HOMOGENEOUS
Design Example (cont’d)

- Sample plate girder (homogeneous) data:

<table>
<thead>
<tr>
<th>SPAN (L) - ft</th>
<th>TOP FLANGE - in</th>
<th>PLATE GIRDER SIZE</th>
<th>DIAPHRAGM SPACING (C) - ft</th>
<th>SHEAR STIFFENERS</th>
<th>SHEAR CONNECTOR MAX. SPACING</th>
<th>INDIVIDUAL GIRDER WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>14 x 3/4&quot;</td>
<td>14 x 1&quot;</td>
<td>17&quot;</td>
<td>14 x 2&quot;</td>
<td>51&quot;</td>
<td>32 x 1/2&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STEEL D.L. CAMBER - in</th>
<th>TOTAL D.L. CAMBER - in</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>0.261&quot;</td>
<td>0.469&quot;</td>
</tr>
</tbody>
</table>
Design Example (cont’d)

• Sample rolled beam (lightest weight) elevation:

COMPOSITE ROLLED BEAM WITH PARTIALLY STIFFENED WEB - 4 GIRDERS AT 8' 10" GIRDER SPACING, LIGHTEST WEIGHT
Design Example (cont’d)

- Sample rolled beam (lightest weight) data:

<table>
<thead>
<tr>
<th>SPAN (L) - ft</th>
<th>SELECTED SECTIONS</th>
<th>DIAPHRAGM SPACING (C) - ft</th>
<th>SHEAR CONNECTOR MAX. SPACING</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>W36x247</td>
<td>21.26&quot;</td>
<td>36 @ 6&quot;</td>
<td>20,995 lbs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STEEL D.L. CAMBER - in</th>
<th>TOTAL D.L. CAMBER - in</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>0.219&quot;</td>
<td>0.416&quot;</td>
</tr>
</tbody>
</table>

The New Steel
Design Example (cont’d)

• Summary of lightest weight designs:

<table>
<thead>
<tr>
<th>SPAN (L) - ft.</th>
<th>GIRDER SPACING</th>
<th>SELECTED SECTIONS RECOMMENDED</th>
<th>DIAPHRAGM SPACING (C) - ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6'-6&quot;</td>
<td>7'-0&quot;</td>
<td>9'-0&quot;</td>
</tr>
<tr>
<td>40</td>
<td>W21x62</td>
<td>W21x73</td>
<td>W24x76</td>
</tr>
<tr>
<td>45</td>
<td>W24x68</td>
<td>W21x101</td>
<td>W27x84</td>
</tr>
<tr>
<td>50</td>
<td>W27x84</td>
<td>W21x111</td>
<td>W30x99</td>
</tr>
<tr>
<td>55</td>
<td>W30x90</td>
<td>W24x117</td>
<td>W30x116</td>
</tr>
<tr>
<td>60</td>
<td>W30x108</td>
<td>W27x129</td>
<td>W33x118</td>
</tr>
<tr>
<td>65</td>
<td>W33x118</td>
<td>W30x132</td>
<td>W36x135</td>
</tr>
<tr>
<td>70</td>
<td>W33x130</td>
<td>W30x148</td>
<td>W40x149</td>
</tr>
<tr>
<td>75</td>
<td>W36x135</td>
<td>W35x150</td>
<td>W40x167</td>
</tr>
<tr>
<td>80</td>
<td>W40x149</td>
<td>W35x160</td>
<td>W36x210</td>
</tr>
<tr>
<td>85</td>
<td>W40x167</td>
<td>W35x182</td>
<td>W35x210</td>
</tr>
<tr>
<td>90</td>
<td>W40x183</td>
<td>W40x183</td>
<td>W40x211</td>
</tr>
<tr>
<td>95</td>
<td>W40x211</td>
<td>W40x199</td>
<td>W40x235</td>
</tr>
<tr>
<td>100</td>
<td>W44x230</td>
<td>W40x211</td>
<td>W40x249</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Design Example (cont’d)

• Typical girder elevation:
Design Example (cont’d)

- Typical stiffener details:

  SEE STANDARD CLIPS & WELD TERMINATION DETAIL

  CLIP NOT REQUIRED

  NOTE 3

  FIT TO BEAR. NOTE 2

  CLIP NOT REQUIRED

  BEARING STIFFENER
  (N.T.S.)

  BEARING STIFFENER TO FLANGE WELDING IS REQUIRED IF A DIAPHRAGM OR CROSS FRAME IS ATTACHED TO THE STIFFENER

  SEE STANDARD CLIPS & WELD TERMINATION DETAIL

  OPTION 1  OPTION 2

  SHEAR STIFFENER
  (N.T.S.)

  CONNECTION STIFFENER
  (N.T.S.)

  $\frac{1}{6} " \times 5"$
Design Example (cont’d)

- Typical diaphragm details:
Design Example (cont’d)

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

• Typical bearing details:

<table>
<thead>
<tr>
<th>ELASTOMERIC BEARING DETAILS - in</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>16&quot;</td>
</tr>
</tbody>
</table>

SOLE, ELASTOMERIC BEARING
EXISTING BEARING SEAT (IN GOOD CONDITION)

ABUTMENT STEM

BEARING ELEVATION
OPTION "A"
(N.T.S.)
Design Example (cont’d)

• CSP & Structural Plate Standards:
Manufacturer’s Solutions
Durability Solutions

- Weathering steel
- Galvanized steel
- Painted steel
The 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.
eSPAN140 Designed Bridges
(a few examples)
1st Direct Application of eSPAN140 – start to finish

Jesp 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
Other eSPAN140 Bridges

- Boone County, Missouri (Local)
  - High Point Lane Bridge
  - 102 feet (2 lane rural road plate girder bridge)
  - 44” weathering steel plate girders (4 lines)
  - Constructed in summer 2013

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

- eSPAN140 allows the owner or designer to determine a preliminary simple-span steel girder bridge design in minutes

- The design incorporates common rolled shapes or uses common plate sizes for girders for availability and economy

- Practical & economical design details are used for ease of fabrication, erection and cost
Summary

- eSPAN140 allows the owner or designer to determine a preliminary simple-span steel girder bridge design in minutes

- The design incorporates common rolled shapes or uses common plate sizes for girders for availability and economy

- Practical & economical design details are used for ease of fabrication, erection and cost

Cost comparisons between concrete and steel alternatives is now much easier for more competition and better use of bridge funds
Need More Information?

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Thank You