Resources and Guidance for Steel Bridge Design

SteelDay
High Steel Structures
October 4, 2013

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Steel: The Bridge Material of Choice
National Steel Bridge Alliance
a division of the American Steel of Construction
www.steelbridges.org
NSBA Activities

• Supporting Designers and Owners throughout the Bridge Lifecycle
Material Availability and Guidelines
Structural Shapes and Plate
Structural Shape Availability

- ASTM A992; ASTM A709, Grade 50S
  - Minimum Yield = 50 ksi
  - No HPS

- Maximums

<table>
<thead>
<tr>
<th>Producer**</th>
<th>Maximum Depth (in)</th>
<th>Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucor-Yamato Steel</td>
<td>44</td>
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<tr>
<td>Gerdau Ameristeel</td>
<td>36</td>
<td>120*</td>
</tr>
<tr>
<td>Steel Dynamics</td>
<td>36</td>
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</table>

* Maximum length for some beam sizes may be shorter.
** These mills account for over 90% of all wide flange shapes produced in the United States.
Structural Shape Availability

- Rolled beam generally more economical
- Except with hard curve or camber
- Availability dependent on rolling schedules
Mill Plate Availability

- **Plate Availability Maximums**

<table>
<thead>
<tr>
<th>Producer</th>
<th>Maximum Thickness (in)</th>
<th>Maximum Width (in)</th>
</tr>
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<tbody>
<tr>
<td>Arcelor-Mittal</td>
<td>4</td>
<td>195</td>
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<tr>
<td>Evraz</td>
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<td>152</td>
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<td>Nucor Steel</td>
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<td>SSAB</td>
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</tbody>
</table>

* Approximately 700,000 tons of plate used annually for construction projects in the United States.
Mill Plate Availability

- Rationalize all mill plate tables

<table>
<thead>
<tr>
<th>Mill Plate Availability</th>
<th>Availability Intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arcelor-Mittal</td>
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<td>Nucor</td>
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<thead>
<tr>
<th>Plate Width</th>
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<th>66</th>
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National Steel Bridge Alliance
Mill Plate Availability

- Composite Mill Plate Tables

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<thead>
<tr>
<th>Plate Thickness</th>
<th>72&quot;</th>
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</tbody>
</table>

* A709-50 and A709-50W (Non-FC) Availability only.

** Refer to September 2011 issue of Modern Steel Construction Magazine.
Mill Plate Availability

Thickness Increments
- 1/8” for plate up to 2½” thick
- 1/4” for plate over 2½” thick

Width Preferences
- Fabricators prefer 72” and 96” widths
- Cost increases with width
Girder Proportioning

Design and Shipping Considerations
Design Considerations

- Usable Plate Area

Flange Plate  Web Plate (Haunched)
Design Considerations

• Usable Mill Plate Area
  – Web Plate ‘loss’
    • Width: 1” – 4”
    • Length: 1” – 6”
    • Material loss will increase if web is haunched or cambered
  – Flange Plate ‘loss’
    • Width: 1” – 4” total plus an additional 1/4" per burn
    • Length: 1” - 6”
    • A fabricator may choose to increase flange widths specified by the Engineer from 1/4" - 3/8"
  – Can vary from fabricator to fabricator and can be dependent on their capabilities and equipment
Proportioning – Web

- AASHTO Web Thickness Minimum (Art. 6.10.2.1)

<table>
<thead>
<tr>
<th>Without Longitudinal Stiffeners</th>
<th>With Longitudinal Stiffeners</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{D}{t_w} \leq 150$</td>
<td>$\frac{D}{t_w} \leq 300$</td>
</tr>
</tbody>
</table>

- Industry Preferred Web Thickness Minimum = $\frac{1}{2}$"
Proportioning – Flanges

- AASHTO Limits for Flanges (Art. 6.10.2.2)
  \[ \frac{b_f}{2t_f} \leq 12 \]
  \[ b_f \geq \frac{D}{6} \]
  \[ t_f \geq 1.1 \ t_w \]
  \[ 0.1 \leq \frac{I_{yc}}{I_{yt}} \leq 10 \]

- Industry Preferred Flange Dimensions
  - \[ b_f \geq 12''; \quad t_f \geq \frac{3}{4}'' \]
Proportioning – Flanges

- Flange transitions (@ welded shop splices):
  - Optimal ordered plate lengths usually ≤ 80 feet
  - Limit number of different plate thicknesses used for a given project
  - Avoid changing flange width at a welded shop splice
  - Reference Collaboration Constructability document to evaluate introduction of shop splices – two or fewer in a typical field section
  - Reduce flange thickness by no more than one-half the thickness of the thicker plate at shop splices
Field-Section Lengths

- Field sections: Girder sections fabricated and shipped to the bridge site
- Shipping and handling concerns are important and can affect field section lengths selected in design
  - Curved members can require additional field splices to reduce size of shipping piece
Field-Section Lengths I-Girders

- Shipment by truck is the most common means
  - 175 ft. Possible, 80 ft. Comfortable
  - 100 Tons Maximum, 40 Tons No Permit
  - 16 ft. Width Maximum
  - 10 ft. Height
NSBA Steel Bridge Suite

Complete Solution for Steel Bridge Analysis and Design
Suite Overview

- Steel Bridge Design & Analysis Software
  - LRFD Simon
  - NSBA Bolted Splice
Suite Overview

- Steel Bridge Design & Analysis Reference Library
  - Steel Bridge Design Handbook.
  - AASHTO/NSBA Collaboration Standards.
Suite Installation

www.steelbridges.org/softwareregistration

- LRFD Simon
- NSBA Bridge Splice
- Steel Bridge References
LRFD Simon

Software Solution for Steel Girder Analysis and Design
What is LRFD Simon?

- Preliminary Analysis and Design Program
  - Line Girder Analysis
  - Plate Girder and Box Girders
  - Linear and Parabolic Haunch
  - AASHTO LRFD Specification - 5th Edition
LRFD SIMON Capabilities

- Simple span or up to 12 continuous spans
- 20 nodes per span
- 1/10th point influence lines
- Partial or full-length dead loads
- AASHTO or user-defined live loads
- Transversely stiffened webs with or without longitudinal stiffeners or unstiffened webs
- Bearing stiffeners
- Parabolic or linear web haunches
- Homogenous or hybrid cross-sections
• Incremental design changes to achieve convergence to satisfactory solution.
Product Tour

- 34 Delivered Examples
  - 1, 2, 3 and 4 Span Configurations
  - Plate Girder and Box Girder
Product Tour

• Workflow
Product Tour

• XML Results

XML Results

Results

XML

XML Style Sheet
NSBA Bolted Splice
Software Solution for Splice Analysis and Design
NSBA Bolted Splice

- Analysis and design of bolted field splices.
  - Design mode sizes and optimizes the splice plates and bolts
  - Analysis mode determines the adequacy of given splice plates and bolts
  - Can Be Used to Verify or Modify Existing Designs

- AASHTO LRFD Specification - 6th Edition
# Moment and Shear at Splice

## AASHTO LRFD Distributed, Unfactored Loads at the Splice Centerline

<table>
<thead>
<tr>
<th>Loading</th>
<th>Moment (K-ft)</th>
<th>Shear (Kip)</th>
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</thead>
<tbody>
<tr>
<td>Dead Load acting on Girder BEFORE Deck Hardening</td>
<td>-51.8</td>
<td>-60.8</td>
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<tr>
<td>Dead Load acting on Girder During Deck Casting or Placing</td>
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<td>0.0</td>
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<tr>
<td>Construction Loads: equipments, falsework, temporary supports</td>
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<tr>
<td>Superimposed Additional Dead Load AFTER Deck Hardening</td>
<td>15.5</td>
<td>-8.7</td>
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<tr>
<td>Future Wearing Surface Load</td>
<td>18.8</td>
<td>-10.6</td>
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<td>Positive Live Load including Impact</td>
<td>1307.8</td>
<td>14.5</td>
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<tr>
<td>Negative Live Load including Impact</td>
<td>-953.3</td>
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<tr>
<td>Positive Fatigue Load (include 15% dynamic load allowance)</td>
<td>394.3</td>
<td>5.0</td>
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<tr>
<td>Negative Fatigue Load (include 15% dynamic load allowance)</td>
<td>-284.0</td>
<td>-33.4</td>
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<table>
<thead>
<tr>
<th>Positive Convention for Distributed, Unfactored Loads at the Splice Centerline</th>
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<tbody>
<tr>
<td>Left</td>
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<td>Right</td>
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## Input of Girder Cross Section

### Girder Properties...

#### Left Girder
- **Flange Steel**: M270 Gr50
- **Web Steel**: M270 Gr50
- **Top Flange Thickness**: 0.75 in
- **Top Flange Width**: 14.0 in
- **Bottom Flange Thickness**: 0.875 in
- **Bottom Flange Width**: 14.0 in
- **Web Thickness**: 0.5 in
- **Web Depth**: 54.0 in
- **Shear Strength, Vn**: 305.64 Kip

#### Right Girder
- **Flange Steel**: M270 Gr50
- **Web Steel**: M270 Gr50
- **Top Flange Thickness**: 1.25 in
- **Top Flange Width**: 14.0 in
- **Bottom Flange Thickness**: 1.375 in
- **Bottom Flange Width**: 14.0 in
- **Web Thickness**: 0.5 in
- **Web Depth**: 54.0 in
- **Shear Strength, Vn**: 305.64 Kip

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[Diagram of Cross Section]
Connection and Deck Details

- **Minimum Clearances**
  - Assembly Clearance: 5.0 in
  - Web Clearance: 0.75 in

- **Alignment Details**
  - Girder Clear Gap: 0.5 in
  - Web Center / Top / Bottom

- **Traffic Frequency**
  - Average Daily Truck Traffic: 3000 Trucks
  - Number of Lanes Available to Trucks: 1, 2, 3 or more

- **Reinforced Concrete Slab**
  - Composite / Noncomposite
  - Lightweight Concrete
  - Reinforcing Steel Area: 12.772 in²
  - Reinforcing Steel Centroid Location: 4.00 in
  - Reinforcing Steel Fy: 60.0 ksi
  - Compressive Strength, fc': 4.0 ksi
  - Slab Thickness: 8.00 in
  - Effective Width: 103.00 in
  - Haunch Depth: 3.50 in

- **Connection Bolts**
  - 7/8 in AASHTO M164 (A325)
  - Web Bolt Threads: Excluded / Included
  - Flange Bolt Threads: Excluded / Included

- **Span Details**
  - Span Length: 120.0 ft

- **Splice Location**
  - Near Interior Support / Elsewhere
Solution

NSBA SPLICE Design Summary...

3 rows of 4 @ 3 in

1.5 in + 1 space @ 3 in

7/8 in AASHTO M164 BOLTS
(A325-X Flanges)
(A325-N Web)
Faying Surface Class = B

PERFORMANCE RATIOS (NG, OK):
Top Flange Bolts................. 0.83
Top Flange Plates............... 0.84
Bottom Flange Bolts............ 0.94
Bottom Flange Plates........... 0.98
Web Bolts....................... 0.96
Web Plates..................... 0.77

REQUIRED FILLERS (in blue):
(1) 0.5 x 14 x 9 in
(1) 0.5 x 14 x 9 in

Top Flange Splice (in):
M270 Gr50 Plates
1- 0.375 x 14 x 18.5
2- 0.4375 x 6 x 18.5
3 Rows of 4 Bolts @ 3in Pitch

Bottom Flange Splice (in):
M270 Gr50 Plates
1- 0.375 x 14 x 18.5
2- 0.4375 x 6 x 18.5
3 Rows of 4 Bolts @ 3in Pitch

Web Splice (in):
M270 Gr50 Plates
2- 0.375 x 13.25 x 45
2 Rows of 15 Bolts @ 3in Spacing

Left Cross Section
14 spaces @ 3 in

Adjust Design
View Report
Print Splice
Back
Exit
eSPAN 140
Web Based Design Solution for Short Span Steel Bridge
eSPAN140 Overview

• Goal
  • Economically competitive
  • Expedite and Economize the Design Process
  • Simple Repetitive Details and Member Sizes

• Bridge Parameters
  • Span Lengths: 40 ft to 140 ft (in 5’ increments)
    • 40’ to 100’ – rolled beam
    • 80’ to 140’ – plate girder
  • Girder Spacing: 6 ft, 7.5 ft, 9 ft and 10.5 ft.
  • Homogeneous and hybrid plate girders with limited plate sizes
  • Limited depth and lightest weight rolled sections
  • Selective Cross-Frame Placement & Design
eSPAN140 Input

- **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

  ![Diagram of bridge cross-section with labels for STA, STA & PGL, and diaphragm spacing]

  [Next >] [Return to Projects]
eSPAN140 Input

• Step 2: Project Details (general dimensions)

- # of Striped Traffic Lanes*: 2
- Roadway Width*: 30 Feet, 0 Inches
- Individual Parapet Width: 1 Feet, 3 Inches
- Individual Deck Overhang Width: 3 Feet, 0 Inches
eSPAN140 Results

- Typical Girder and Bridge Details

Design Summary
eSPAN140 Results

• Typical Girder and Bridge Details

Girder Elevation
eSPAN140 Results

• Typical Girder and Bridge Details

Bridge Section
eSPAN140 Results

• Typical Girder and Bridge Details

Deck Information
More Information

Physical and Online Resources
More Information

- Steel Bridge Design References
  - Steel Bridge Design Handbook
  - AASHTO/NSBA Collaboration Standards
  - Modern Steel Construction
More Information

SAVE the DATE

WORLD STEEL BRIDGE SYMPOSIUM
NASCC: THE STEEL CONFERENCE
Annual Stability Conference
Technology in Steel Construction Conference

TORONTO
Canada

Metro Toronto Convention Centre
March 26–29, 2014
More Information

- Bill McEleney
  - 401.943.5660
  - mceleney@steelbridges.org

- High Steel
  - www.highsteel.com

- National Steel Bridge Alliance
  - www.steelbridges.org

- eSPAN140
  - www.espan140.com

- Modern Steel Construction Magazine
  - www.modernsteel.com