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Resources and Guidance for Steel Bridge Design

ABCD Susquehanna Chapter Technical
Conference - 2013

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NSBA - Southeast Regional Director
garrell@steelbridges.org



Steel: The Bridge Material of Choice

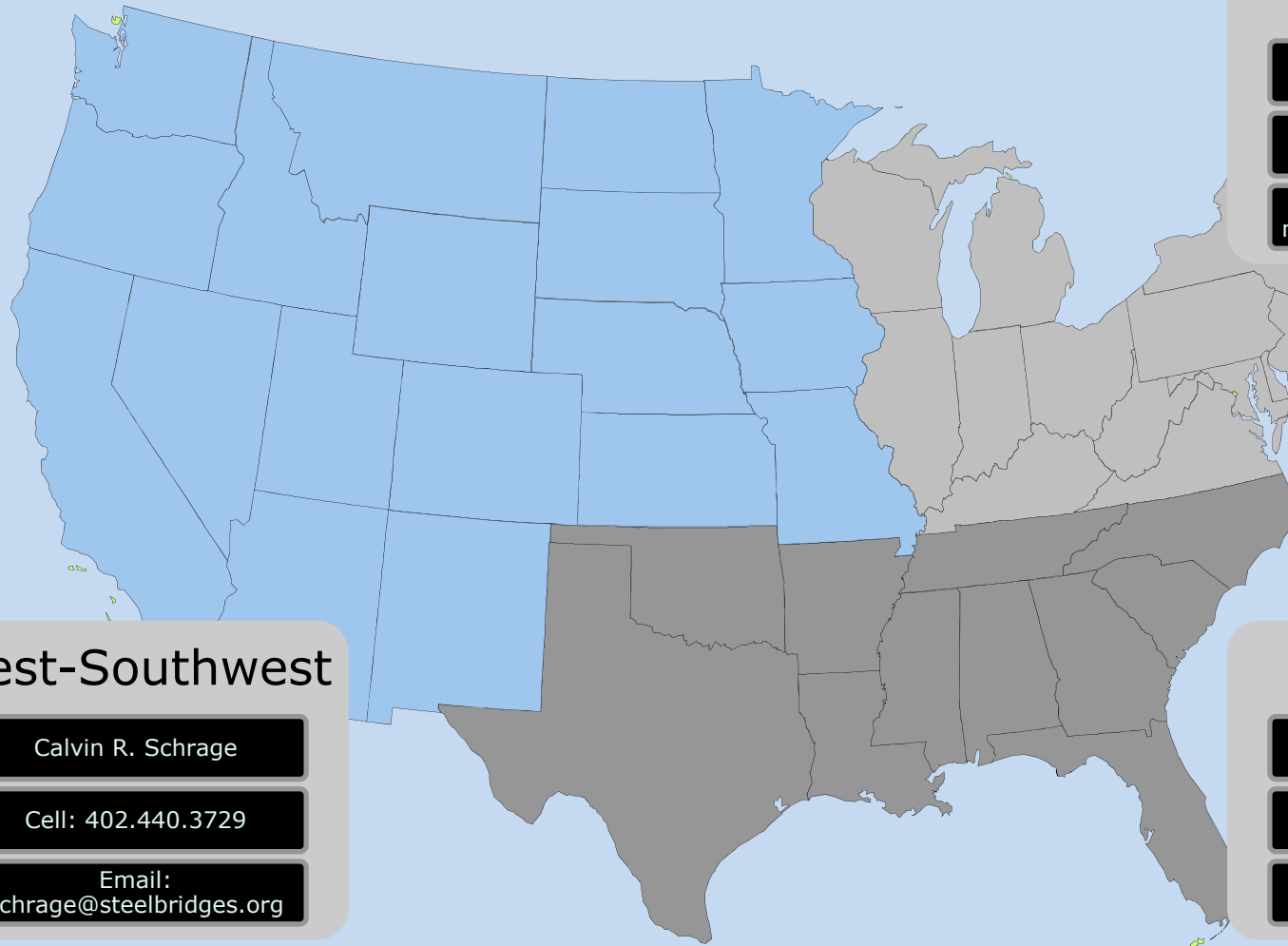
National Steel Bridge Alliance

A division of the American Institute of Steel Construction

www.steelbridges.org



NSBA Regions



Northeast

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Cell: 401.965.6341

Email:
mceleney@steelbridges.org

West-Southwest

Calvin R. Schrage

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Southeast

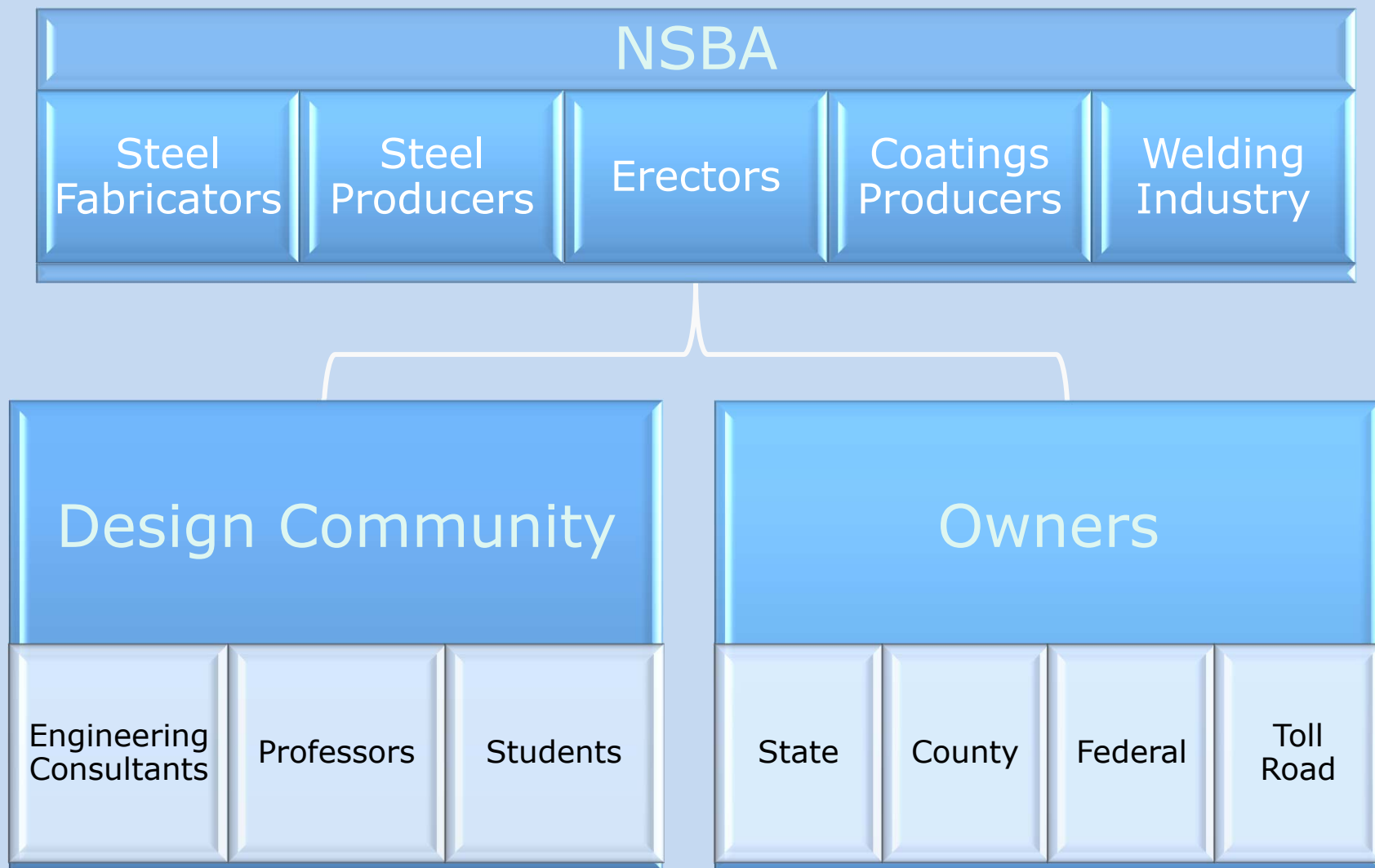
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NSBA Activities





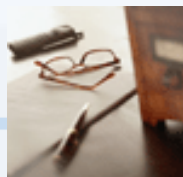
NSBA Activities

- Supporting Designers and Owners throughout the Bridge Lifecycle.

Design



Planning

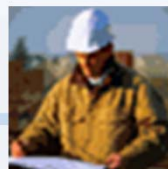


Design

Build



Fabrication

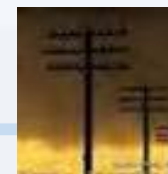


Construction

Operate



Management



Maintenance



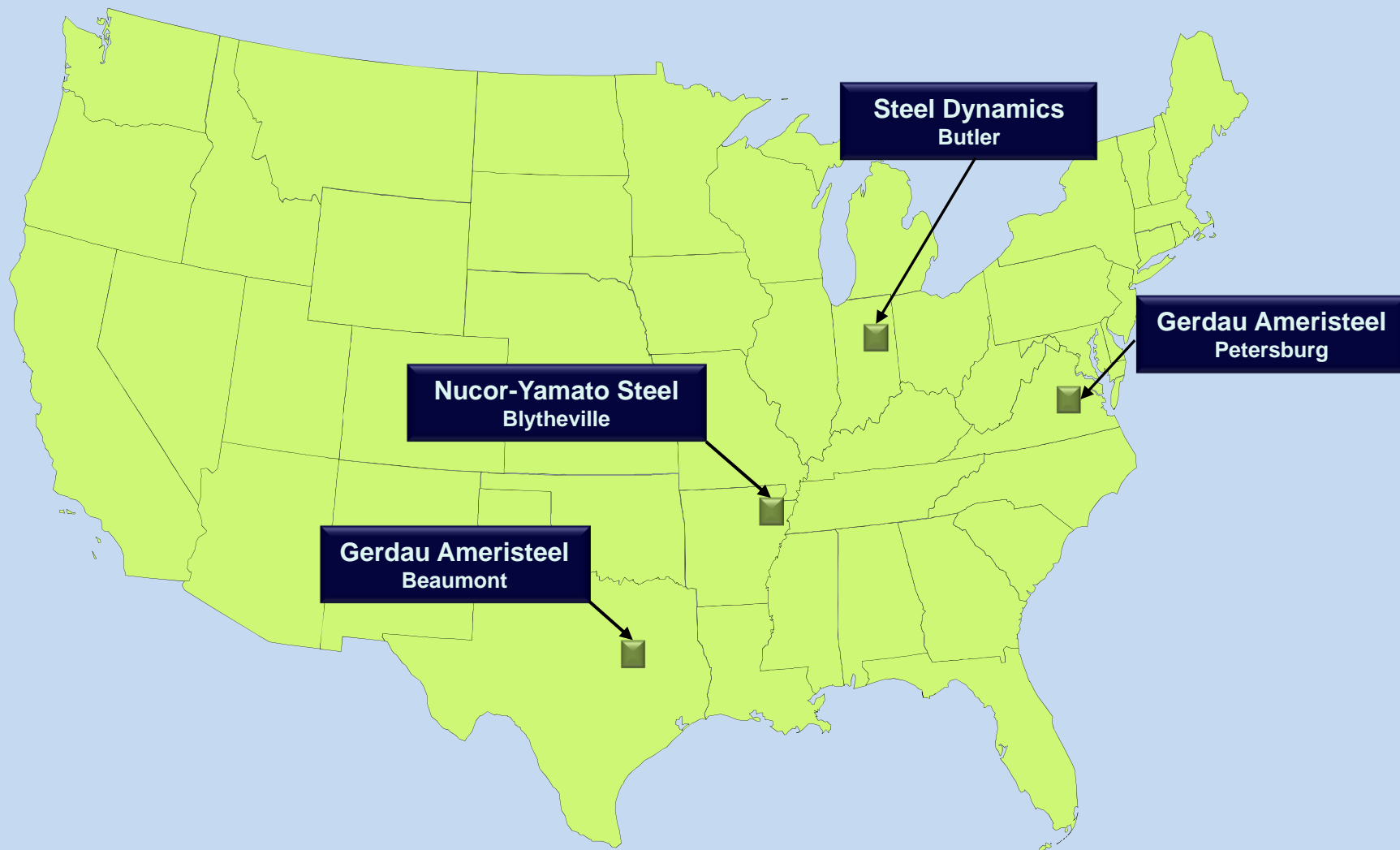


Material Availability and Guidelines

Structural Shapes and Plate



Structural Shape Availability





Structural Shape Availability

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

Producer**	Maximum Depth (in)	Length (ft)
Nucor-Yamato Steel	44	120*
Gerdau Ameristeel	36	
Steel Dynamics	36	

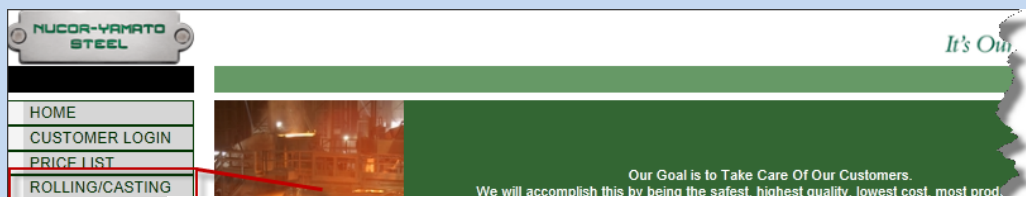
* Maximum length for some beam sizes may be shorter.

** 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.



Nucor-Yamato Proposed Roll/Cast Schedule * ISO 9001:2008 Registered * July 27, 2011

Week Beginning		24-Jul	31-Jul	7-Aug	14-Aug	21-Aug	28-Aug	4-Sep	11-Sep	
NYS Fiscal Month		July	Aug	Aug	Aug	Aug	Sep	Sep	Sep	
NYS Fiscal Week		30	31	32	33	34	35	36	37	
Wide Flange Sections	Prod. Mill	roll wk - cast date	roll wk - cast date	roll wk - cast date	roll wk - cast date	roll wk - cast date	roll wk - cast date	roll wk - cast date	roll wk - cast date	Approximate Next Roll Week
W44x16x230-335	2	33 Cast							shutdown	10/16-10/23 Wks
W40x16x199x431	2	33 Cast							shutdown	10/16-10/23 Wks
W40x12x149-327	2	33 Cast							shutdown	10/23-10/30 Wks
W36x16.5x231-441	2	33 Cast	33 Cast				35 O		shutdown	10/23-10/30 Wks
W36x12x135-256	2		33 Cast		34 1/2		35 O		shutdown	10/2-10/9 Wks



Mill Plate Availability





Mill Plate Availability

- Plate Availability Maximums

Producer	Maximum Thickness (in)	Maximum Width (in)
Arcelor-Mittal	4	195
Evrast	4	144
Nucor Steel	3	123
SSAB	3	120

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



Mill Plate Availability

- Rationalize all mill plate tables

Availability Intersection



Mill Plate Availability

- Composite Mill Plate Tables

Plate Availability Chart: Minimum Composite									
	Plate Width								
Plate Thickness	72"	78"	84"	90"	96"	102"	108"	114"	120"
3/8"	972	972	972	972	972	800	972	972	750
1/2"	972	972	972	972	972	972	972	680	680
9/16"	972	972	972	972	972	972	972	680	680
5/8"	972	972	972	972	972	960	960	680	680
3/4"	1,100	1,100	1,100	1,100	1,100	1,030	980	680	680
7/8"	1,100	1,100	1,100	1,100	1,100	1,030	980	680	680
1"	1,100	1,100	1,100	1,058	992	933	882	680	680
1-1/4"	1,100	994	907	846	793	747	705	668	635
1-1/2"	1,077	828	756	705	661	622	588	557	529
1-3/4"	924	710	648	604	567	533	504	477	453
2"	808	621	567	529	496	467	441	418	397
2-1/4"	718	552	504	470	441	415	392	371	353
2-1/2"	646	110	453	423	397	373	353	334	317
2-3/4"	588	452	412	385	361	339	321	304	288
3"	539	414	378	353	331	311	294	278	264

* 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.





Industry Capability

Domestic Steel Bridge Fabrication



Industry Capability

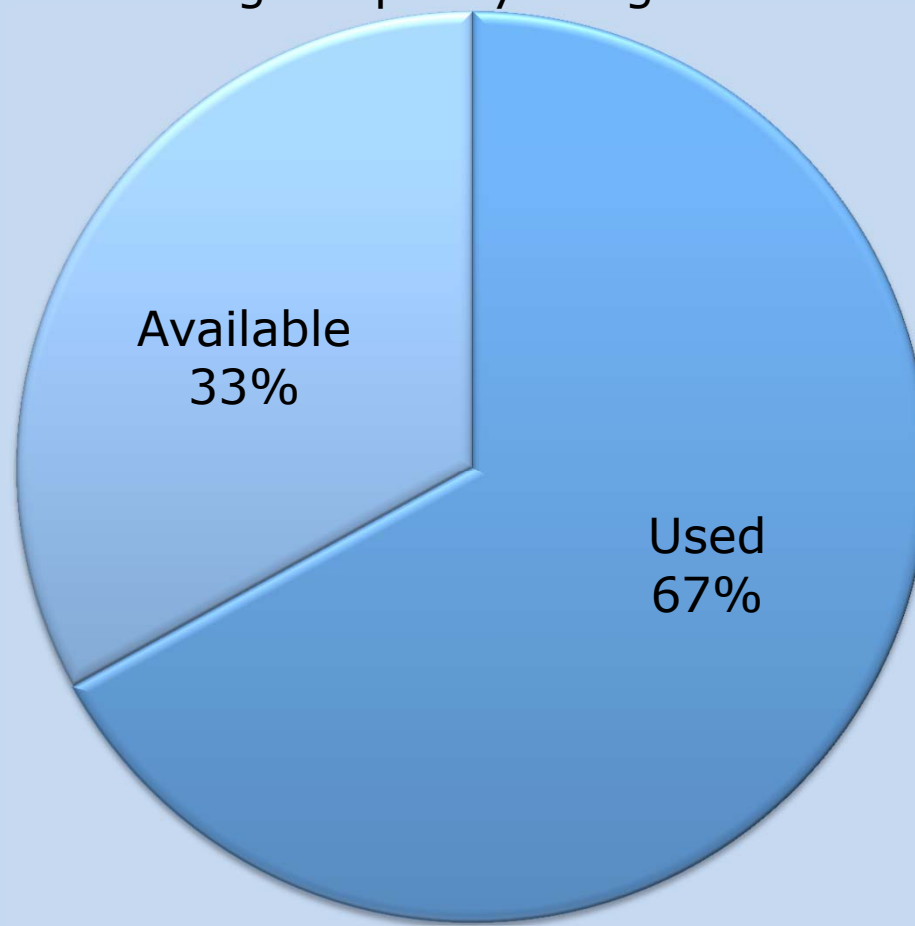
- Nationwide Survey – 2012
 - Survey of Nation’s Significant Steel Bridge Fabricators.
 - Collect Average Capacity Usage for 2010.
 - American Recovery and Reinvestment Act (ARRA) created higher demand in 2010.
 - Plant use as percentage of overall capacity.





Industry Capability

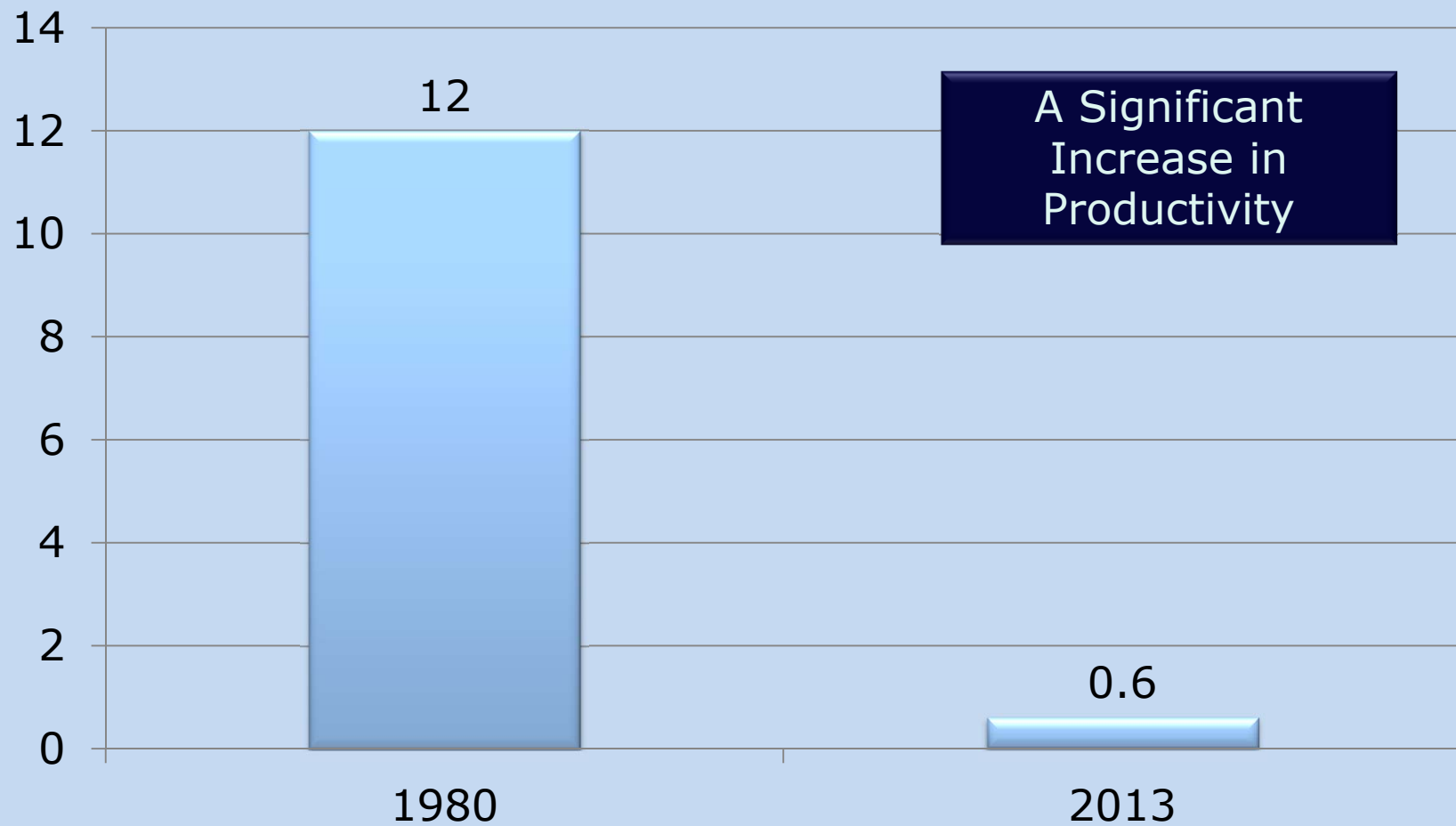
Domestic Steel Bridge Fabrication Average Capacity Usage - 2010





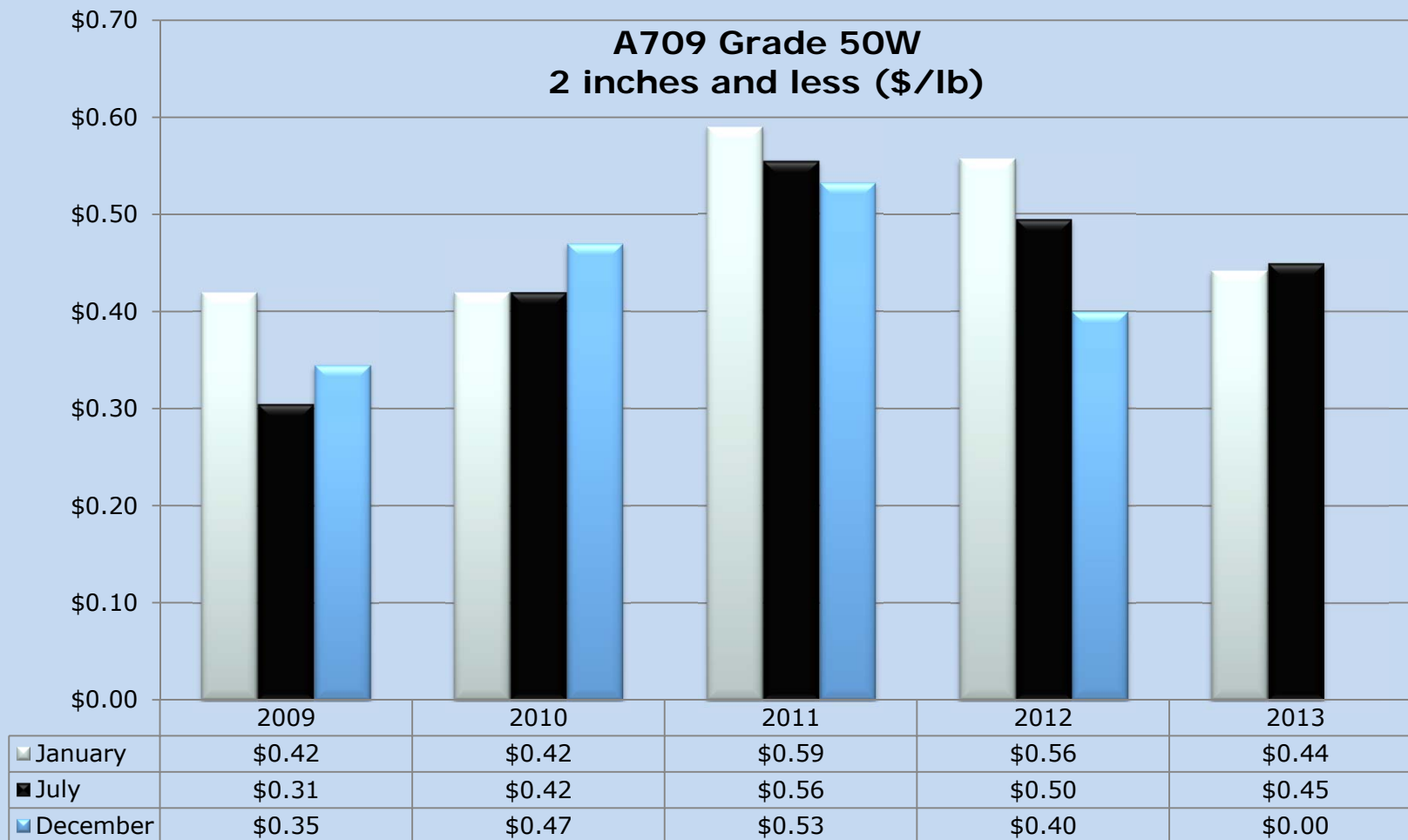
Industry Capability

Production Effort Man-hour Per Ton





Historic Mill Plate Material Costs



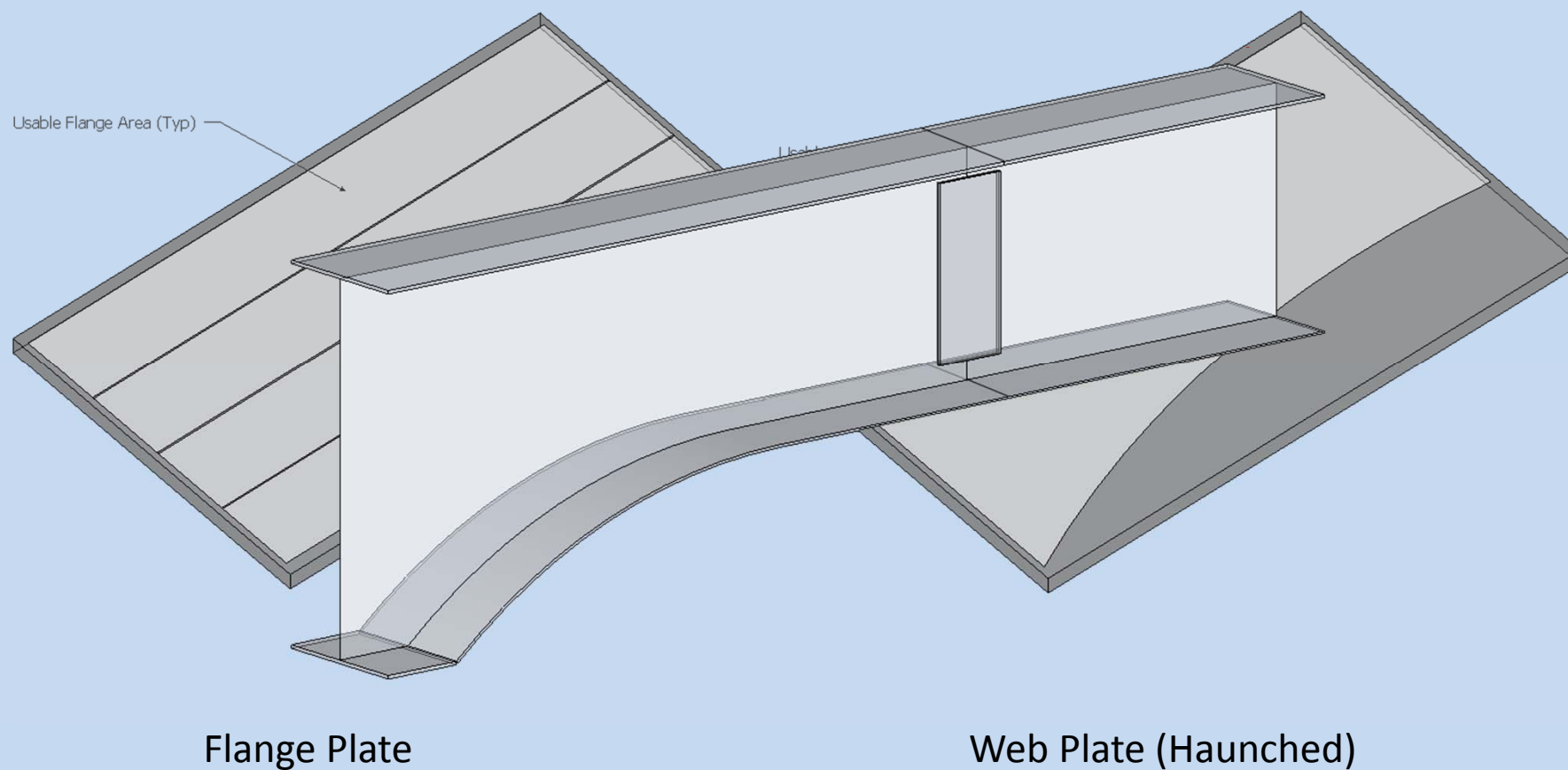


Girder Proportioning

Design and Shipping Considerations

Design Considerations

- Usable Plate Area



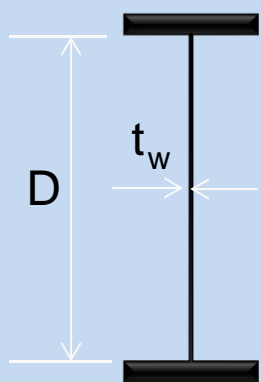


Design Considerations

- Usable Mill Plate Area
 - Web Plate
 - Width: 1" – 4"
 - Length: 1" – 6"
 - Material loss will increase if web is haunched or cambered.
 - Flange Plate
 - 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

- Web Thickness (Art. 6.10.2.1)

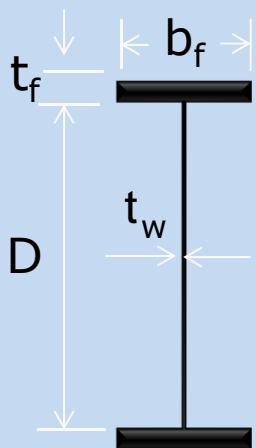


Without Longitudinal Stiffeners	—
With Longitudinal Stiffeners	—

- 1/2" minimum thickness preferred by fabricators.

Proportioning – Flanges

- Proportioning Requirements (Art. 6.10.2.2)



$$\frac{b_f}{2t_f} \leq 12$$

$$b_f \geq \frac{D}{6}$$

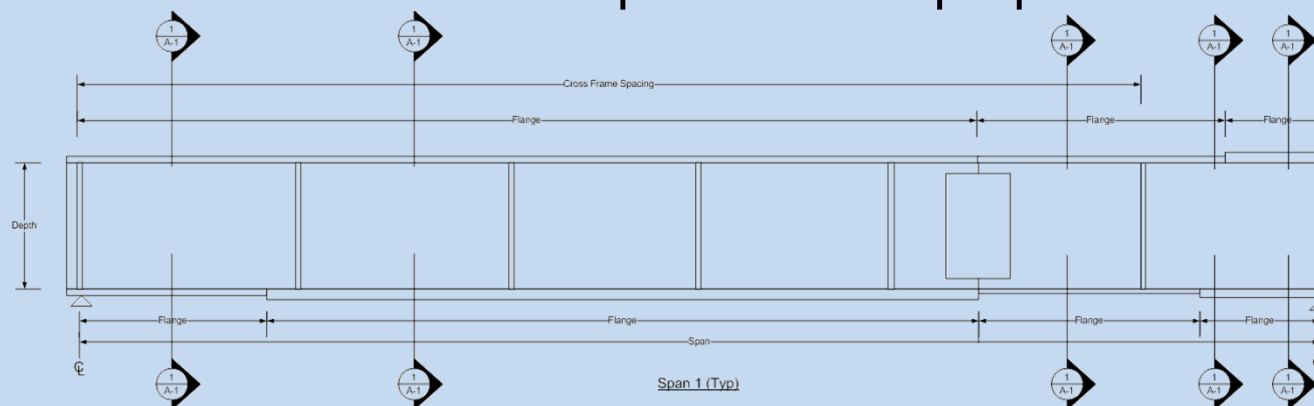
$$t_f \geq 1.1 t_w$$

$$0.1 \leq \frac{I_{yc}}{I_{yt}} \leq 10$$

- $b_f \geq 12''$ and $t_f \geq 3/4''$ preferred by fabricators.

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.
 - 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.





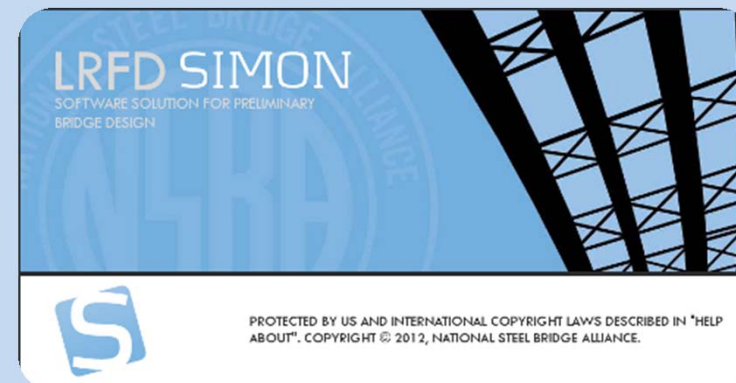
NSBA Steel Bridge Suite

Complete Solution for Steel Bridge Analysis and Design



Suite Overview

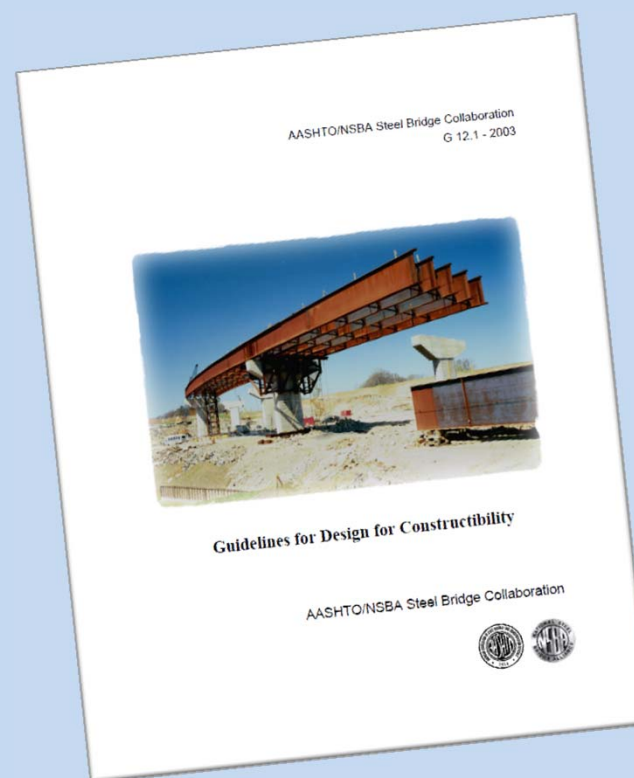
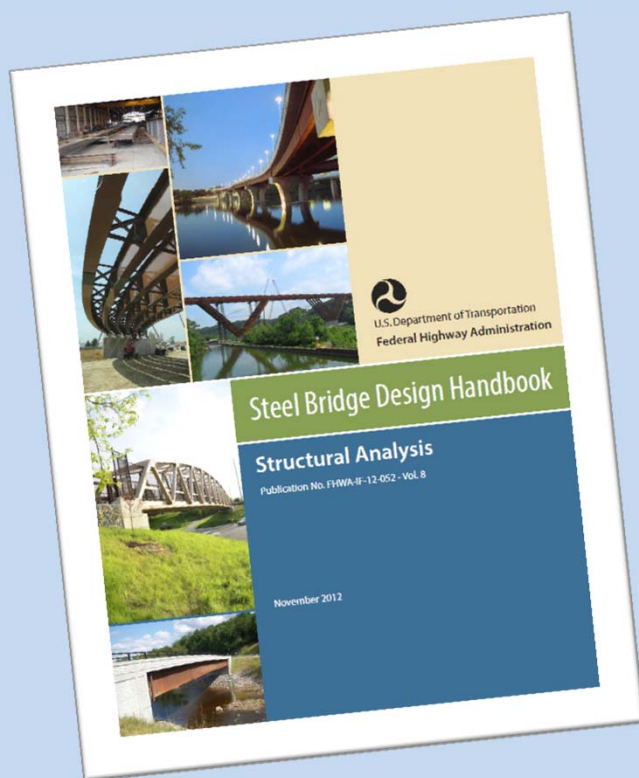
- Steel Bridge Design and Analysis Software
 - LRFD Simon.
 - NSBA Bolted Splice.





Suite Overview

- Steel Bridge Design and Analysis References
 - Steel Bridge Design Handbook.
 - AASHTO/NSBA Collaboration Standards.





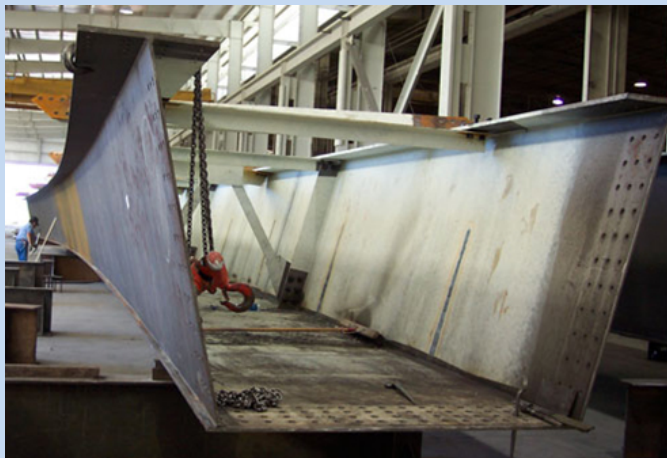
LRFD Simon

Software Solution for Steel Girder Analysis and Design



What is LRFD Simon?

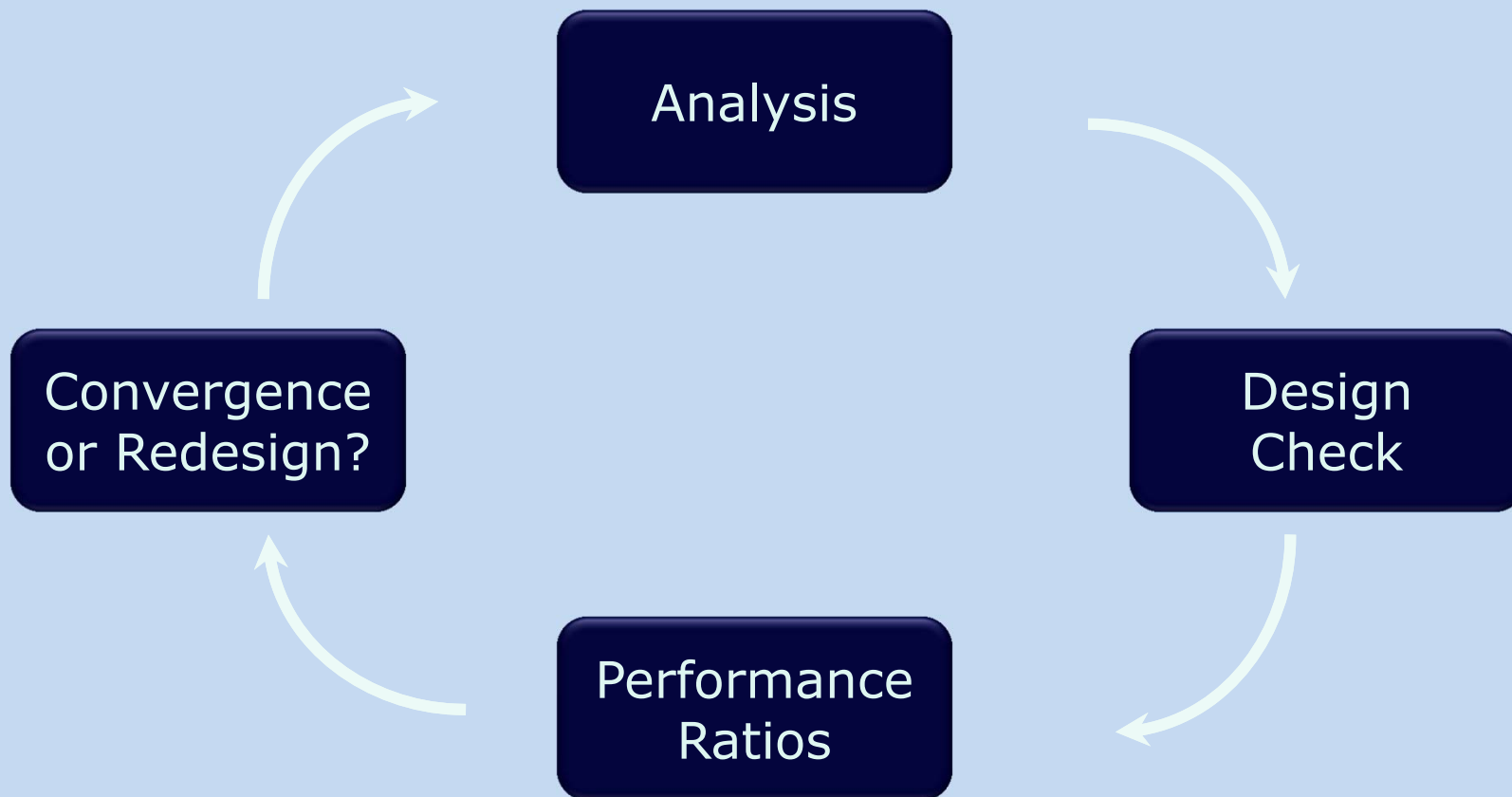
- Preliminary Analysis and Design Program.
 - Line Girder Analysis.
 - Plate Girder and Box Girders.
 - Linear and Parabolic Haunch.
 - AASHTO LRFD Specification - 5th Edition.





Optimization Methods

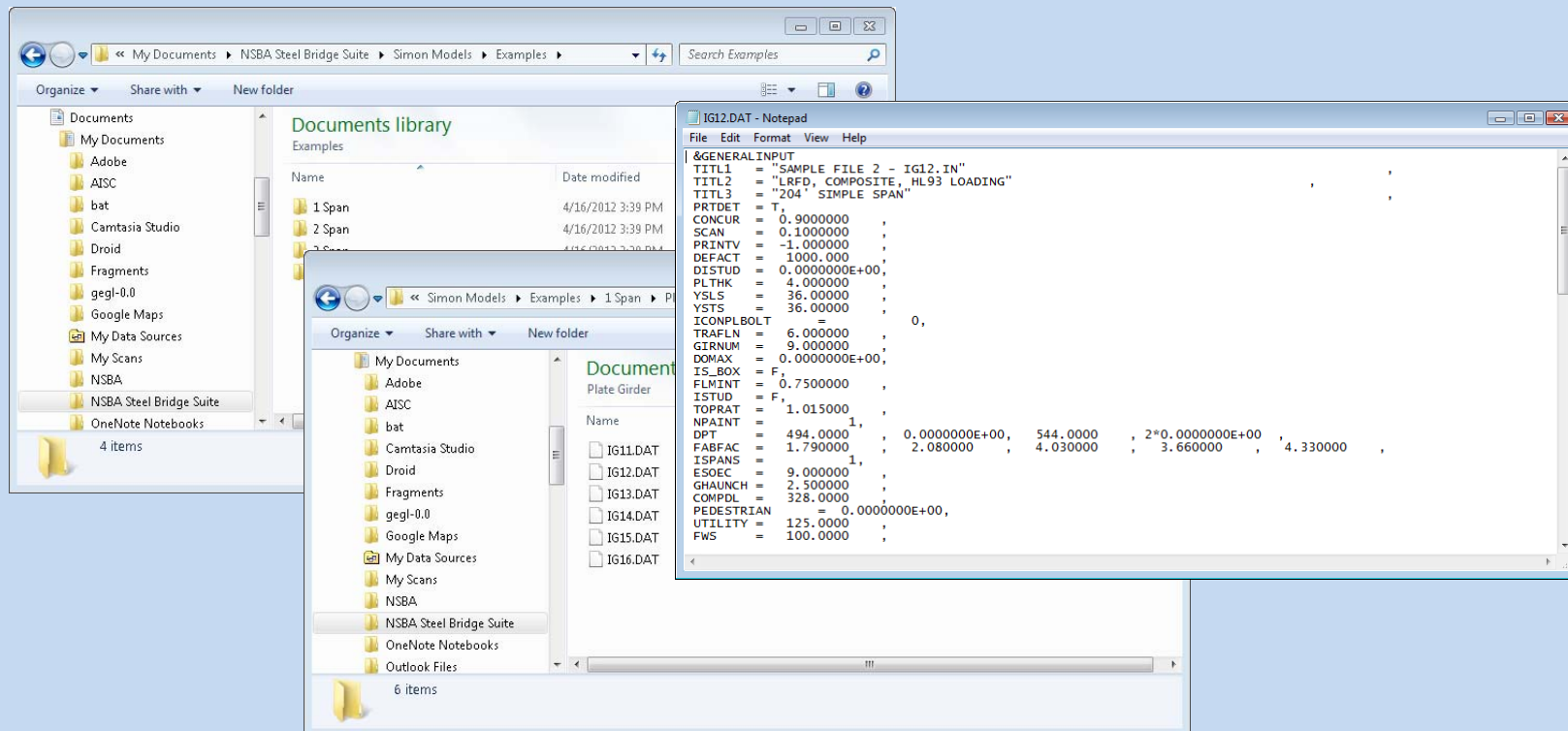
- Incremental design changes to achieve convergence to satisfactory solution.





Product Tour

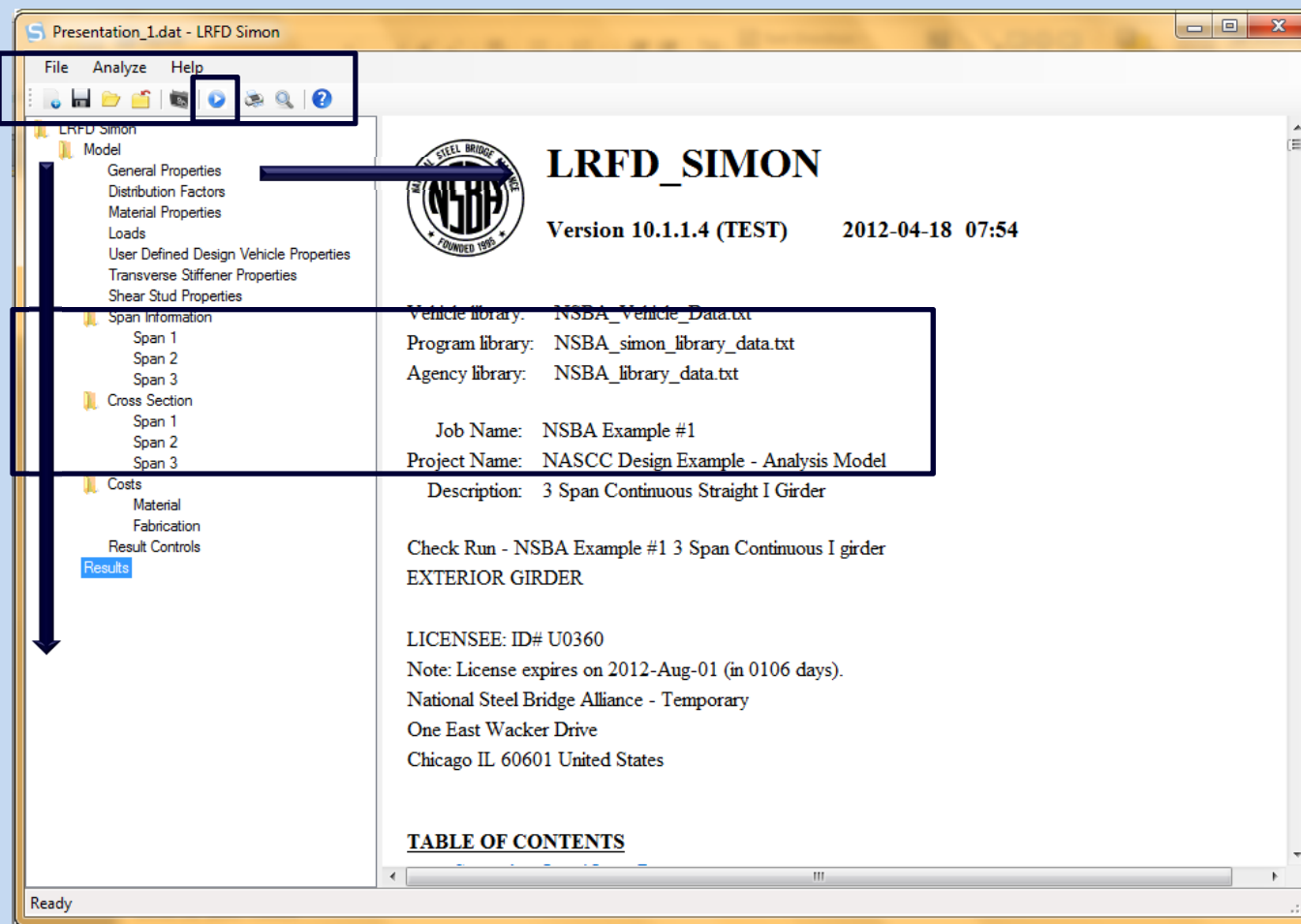
- 34 Delivered Examples
 - 1, 2, 3 and 4 Span Configurations.
 - Plate Girder and Box Girder.





Product Tour

- Workflow





Product Tour

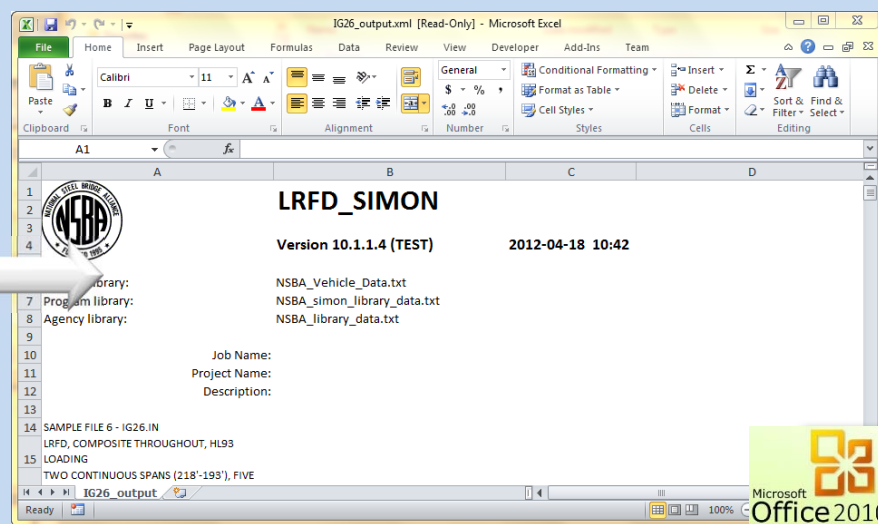
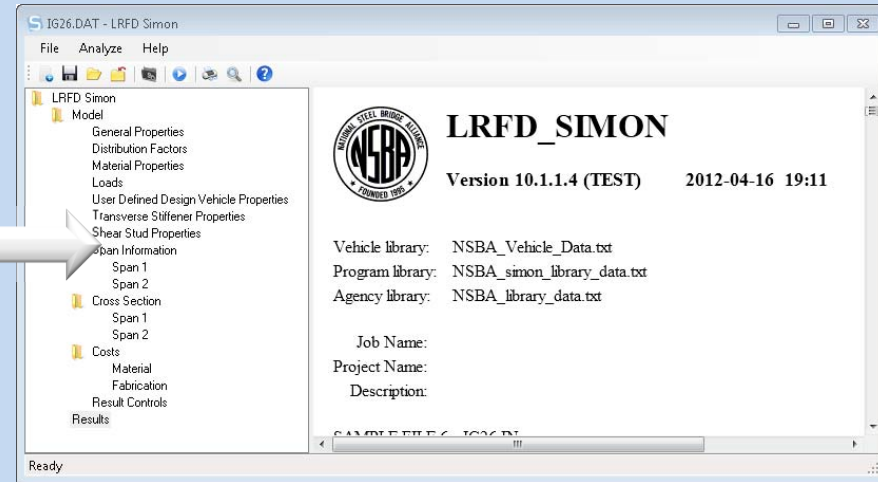
- XML Results

Results

XML

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<?xml version="1.0"?>
<xml-stylesheet type="text/xsl" href="SIMON_output.xsl"?>
<program_output_data programtype="LRFD_SIMON"
  xmlns:xsl="http://www.w3.org/2001/XMLSchema-instance"
  >
  <run_information>
    <control_system_version>1.19</control_system_version>
    <engineering_program>LRFD_SIMON</engineering_program>
    <version>10.1.1.4 (TEST)</version>
    <run_date>2012-04-16</run_date>
    <run_time>07:25</run_time>
    <files>
      <input>IG22.DAT</input>
      <output>IG22.OUT</output>
      <vehicle>NSBA_vehicle_data.txt</vehicle>
      <program>NSBA_simon_library_data.txt</program>
      <library>NSBA_library_data.txt</library>
    </files>
  </run_information>
  <input>
    <gui_model_info>
      <jobname></jobname>
      <projectname></projectname>
      <description></description>
    </gui_model_info>
  </input>
</program_output_data>
```

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.





NSBA Bolted Splice

- Input Wizard
 - Un-factored moments and shears.
 - Girder Properties.
 - Bolt, Concrete Slab, Clearance Properties and etc.

The screenshot displays the software interface for the NSBA Bolted Splice Input Wizard, showing several overlapping windows:

- Loading... AASHTO LRFD Distributed, Unfactored Loads at the Splice Centerline:** A table for inputting loads. The table has columns for load type, Moment (K-ft), and Shear (Kip).

AASHTO LRFD Distributed, Unfactored Loads at the Splice Centerline	Moment (K-ft)	Shear (Kip)
Dead Load acting on Girder BEFORE Deck Hardening DC1		
Dead Load acting on Girder During Deck Casting or Placing DC0		
Construction Loads: equipments, falsework, temporary supports CL		
Superimposed Additional Dead Load AFTER Deck Hardening..... DC2		
Future Wearing Surface Load DW		
Positive Live Load including Impact LL*+		
Negative Live Load including Impact LL*+		
Positive Fatigue Load (include 15% dynamic load allowance) LL*+		
Negative Fatigue Load (include 15% dynamic load allowance) LL*+		
- Girder Properties...:** A window for defining girder properties for the Left and Right Girders. It includes fields for Flange Steel, Web Steel, Top and Bottom Flange Thickness and Width, Web Thickness and Depth, and Shear Strength (Vn).

Property	Left Girder	Right Girder
Flange Steel	M270 Gr50W	M270 HPS Gr70W
Web Steel	M270 Gr50W	M270 HPS Gr70W
Top Flange Thickness	1.0 in	1.0 in
Top Flange Width	16.0 in	18.0 in
Bottom Flange Thickness	1.375 in	1.0 in
Bottom Flange Width	18.0 in	20.0 in
Web Thickness	0.5 in	0.5625 in
Web Depth	69.0 in	69.0 in
Shear Strength, Vn	468.0 Kip	468.0 Kip
- Additional Properties...:** A window for defining additional properties such as Minimum Clearances, Reinforced Concrete Slab, Alignment Details, Traffic Frequency, Connection Bolts, Span Details, and Splice Location. It includes fields for Assembly Clearance, Web Clearance, Girder Clear Gap, Reinforcing Steel Area, Centroid Location, Rebar Yield Strength, Compressive Strength, Slab Thickness, Effective Width, Haunch Depth, Span Length, and Splice Location.
- Cross Section:** A diagram showing the cross-section of the girder and slab, with labels for Left, Right, and Slab. A note indicates "Minimum Clearance to nearest Web Bolt".



NSBA Bolted Splice

- Results Screen and Output
 - View report text viewed in application window.
 - Print graphics and given properties.
 - Design refinement with Adjust Design feature.

NSBA SPLICE Design Summary...

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

PERFORMANCE RATIOS (NG,OK):

Top Flange Bolts.....	0.90
Top Flange Plates.....	0.95
Bottom Flange Bolts.....	0.87
Bottom Flange Plates.....	0.94
Web Bolts.....	0.97
Web Plates.....	0.67

REQUIRED FILLERS (in blue):
(1) 0.375 x 18 x 18 in

Top Flange Splice (in):
M270 Gr50w/ Plates
1- 0.4375 x 16 x 18.5
2- 0.5 x 7 x 18.5
3 Rows of 4 Bolts @ 3in Pitch

Bottom Flange Splice (in):
M270 Gr50w/ Plates
1- 0.625 x 18 x 36.5
2- 0.6875 x 8 x 36.5
6 Rows of 4 Bolts @ 3in Pitch

Web Splice (in):
M270 Gr50w/ Plates
2- 0.375 x 14 x 61.75
2 Rows of 14 Bolts @ 4.5in Spacing

3 rows of 4 @ 3 in
1.625 in + 1 space @ 3 in
5 in
4 in
1.5 in
Left Cross Section
13 spaces @ 4.5 in
5 in
5 in
1.5 in

Adjust Design
< Back View Report
Print Splice Exit

NSBA SPLICE Report

PROJECT NAME: NHI 130081 Design Example
PROJECT NUMBER: 130081
INPUT FILE NAME: C:\Users\garrell\Documents\NSBA Steel Bridge Suite\Splice Models\Examples\Girder Splice Example.dat
RUN DATE & TIME: Monday, Sep 10, 2012, 11:36 AM

1. PROBLEM DEFINITION:
=====

Analysis Type: Splice Design
Unit Preference: Customary (US)
AASHTO Analysis/Design Method: AASHTO LRFD 6th Edition
Span Type: Continuous Span

Load Factors (AASHTO 3.4.1&2):

Strength I DC Maximum/Minimum:	1.25, 0.90
Strength I & IV DW Maximum/Minimum:	1.50, 0.65
Strength I LL+IM:	1.75
Strength IV DC Maximum/Minimum:	1.50, 0.90
Service II DC and DW:	1.00
Service II LL+IM:	1.30
Service II DW Minimum:	0.00
Fatigue-I LL+IM:	1.50
Fatigue-II LL+IM:	0.75
Fatigue Life :	75
Construction Loads (Permanent Loads):	1.25
Construction Loads (Temporary Loads):	1.50

< Back Save Report
Print Report 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).
 - 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

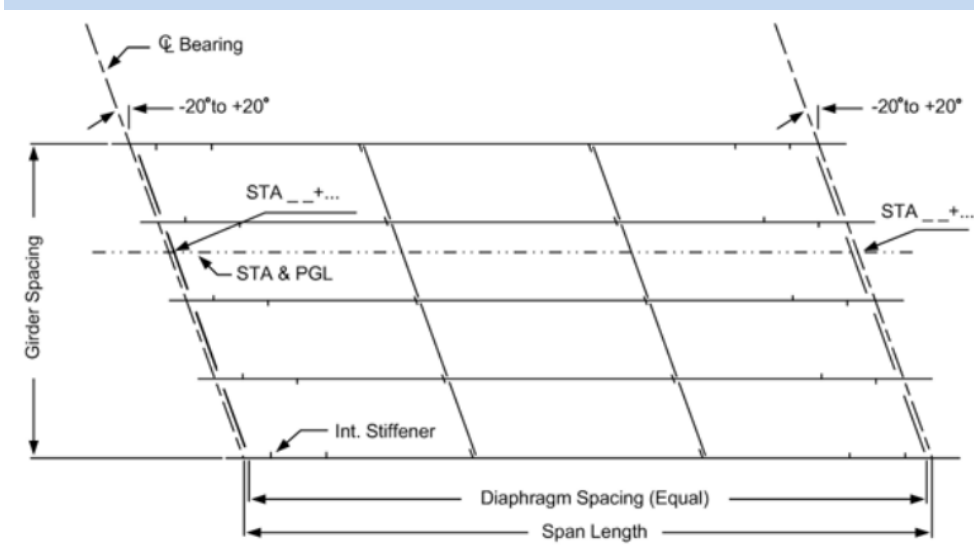
City/County*
Morgantown

State/Province* 
West Virginia

Roadway Name
Main Street

Bridge Span Length* 
82 Feet 4 Inches

[Next >](#) [Return to Projects](#)







eSPAN140 Input

- Step 2: Project Details (general dimensions)


of Striped Traffic Lanes*

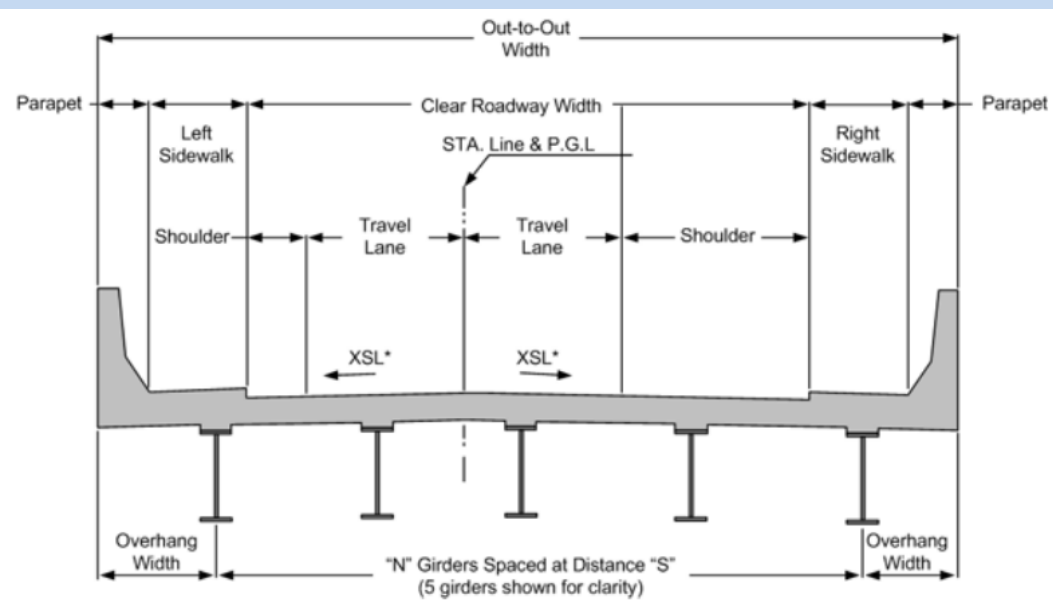
Roadway Width* 

Feet *Inches*

Individual Parapet Width 

Feet *Inches*

Individual Deck Overhang Width 

Feet *Inches*

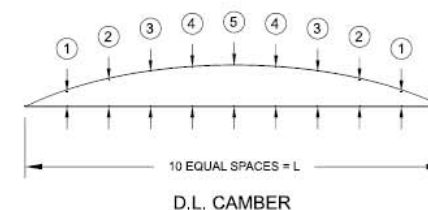


eSPAN140 Results

- Typical Girder and Bridge Details

SPAN (L) - ft	PLATE GIRDER SIZE						DIAPHRAGM SPACING (C) - ft	SHEAR STIFFENERS		SHEAR CONNECTOR MAX. SPACING		INDIVIDUAL GIRDER WEIGHT
	TOP FLANGE - in	BOTTOM FLANGE (F)		BOTTOM FLANGE (G)		WEB PLATE - in		X (NO. REQ'd)	Y - ft. (SPACING)	D	E	
		PLATE - in	LENGTH - Ft	PLATE - in	LENGTH - Ft							
85	14 x 3/4"	14 x 1"	17'	14 x 2"	51'	32 x 1/2"	21.25'	-	-	34 @ 6"	9"	14,144 lbs

STEEL D.L. CAMBER - in					TOTAL D.L. CAMBER - in				
1	2	3	4	5	1	2	3	4	5
0.251"	0.469"	0.636"	0.742"	0.778"	1.803"	3.358"	4.538"	5.288"	5.545"



(N.I.S.)

Design Section



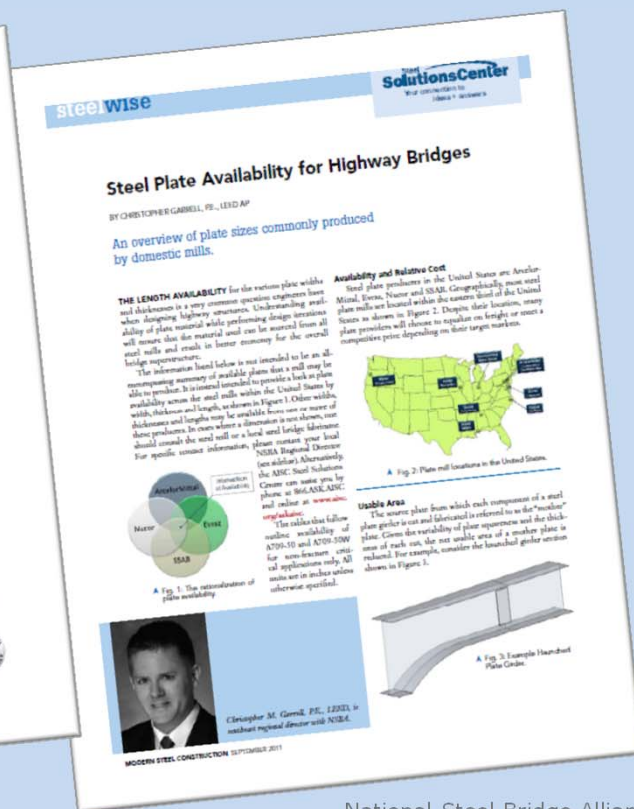
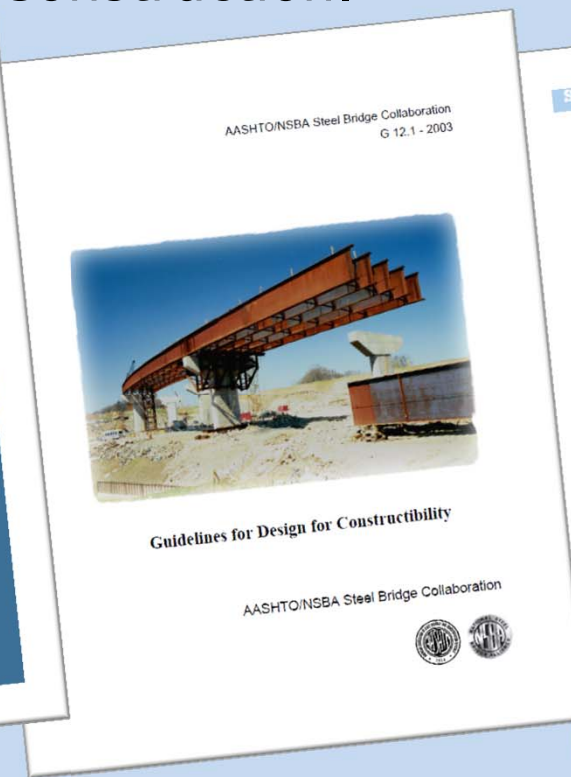
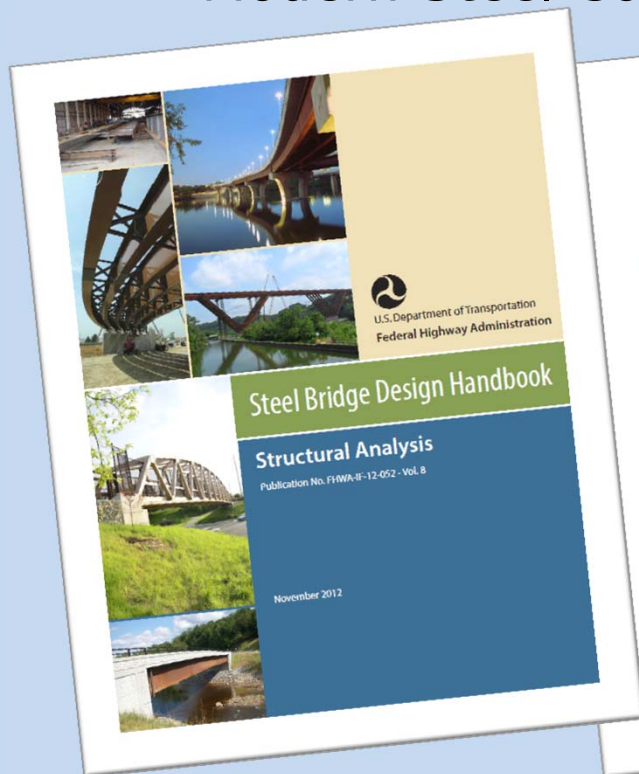
More Information

Physical and Online Resources



More Information

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



More Information



- National Steel Bridge Alliance
 - www.steelbridges.org
- American Institute of Steel Construction
 - www.aisc.org
- eSPAN140
 - www.espan140.com
- Modern Steel Construction Magazine
 - www.modernsteel.com

