

Resources and Guidance for Steel Bridge Design



SteelDay
High Steel Structures
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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 Regions

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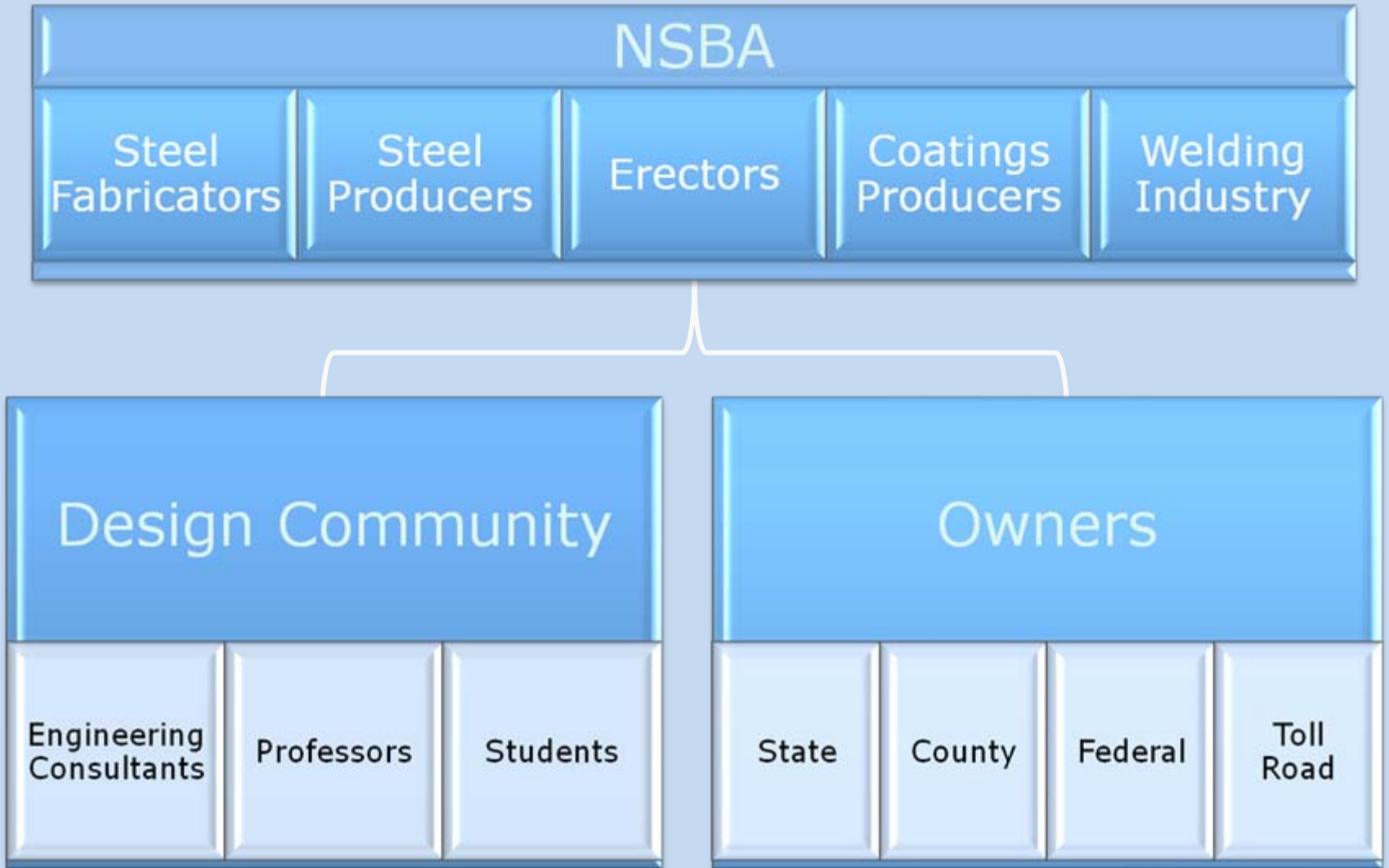
Southeast

Christopher Garrell, PE,
LEED AP

Cell: 484.557.2949

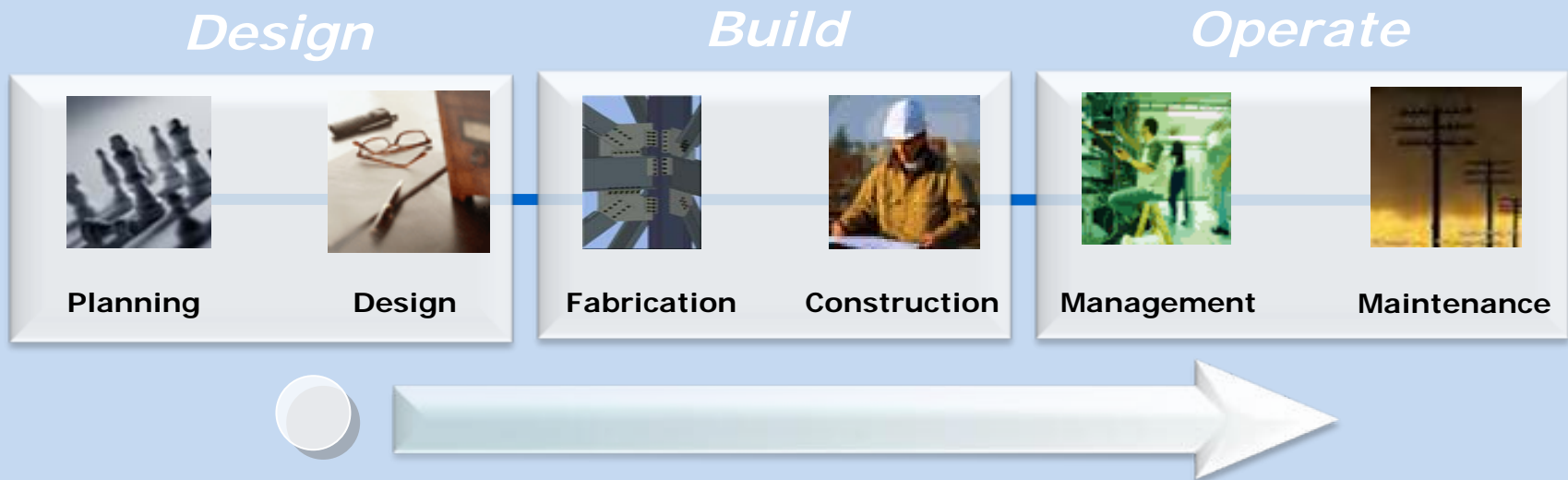
Email:
garrell@steelbridges.org

NSBA Activities



NSBA Activities

- Supporting Designers and Owners throughout the Bridge Lifecycle

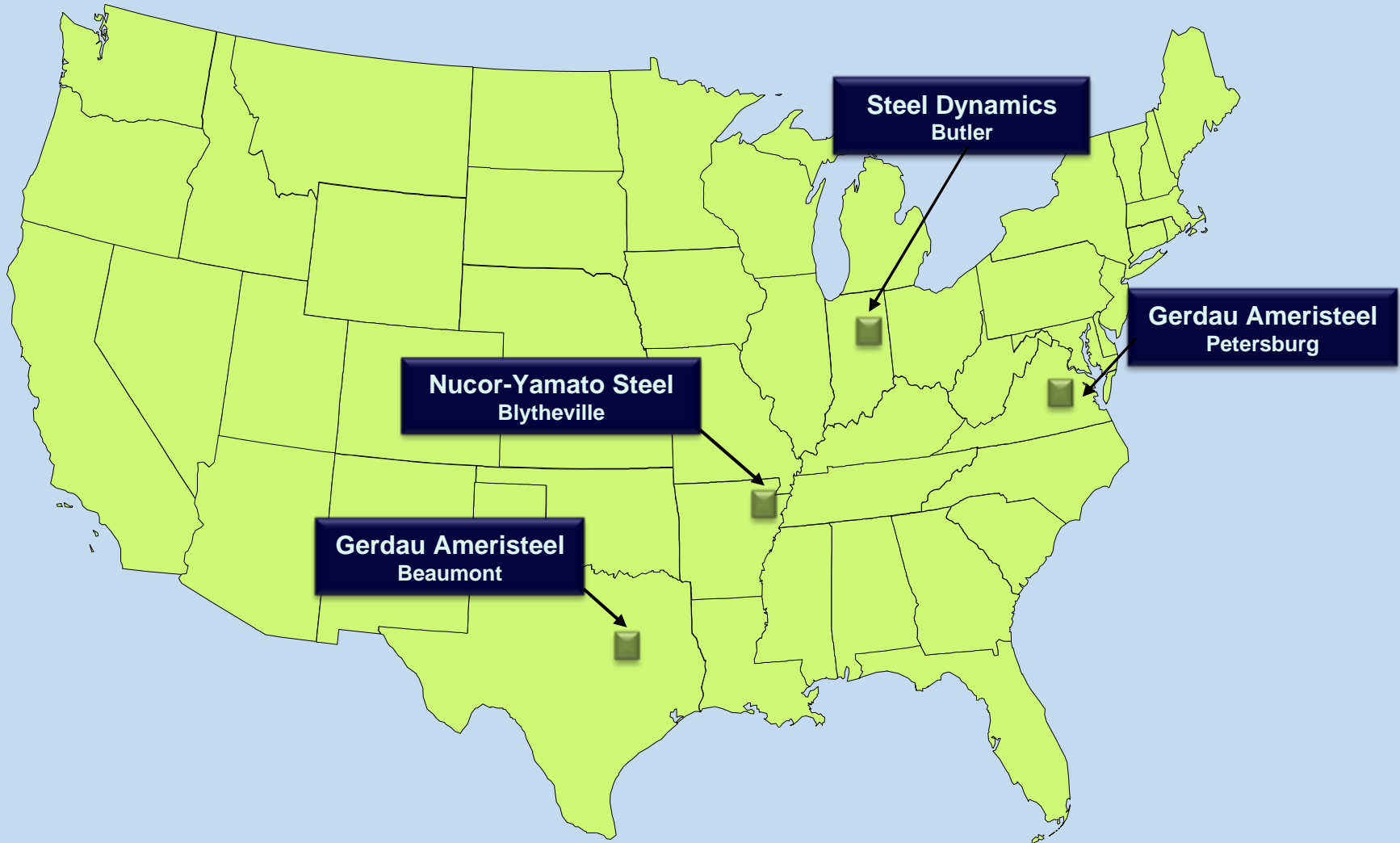




Material Availability and Guidelines

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	152
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

Plate Thickness	Plate Width																												Plate Thickness	
	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210		216
3/8"	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
1/2"	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
9/16"	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
5/8"	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
3/4"	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
7/8"	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
1"	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1058	992	933	882	835															
1-1/4"	1100	1100	1100	1100	1100	1100	1100	1100	907	846	793	747	705	668																
1-1/2"	1100	1100	1100	1100	1100	1100	1100	756	705	661	622	588	557																	
1-3/4"	1070	1070	1070	1070	1070	1070	1070	648	604	567	533	504	477																	
2"	937	937	937	937	937	937	937	567	529	496	467	441	415	392	371	353	336	321	307	294										
2-1/4"	833	833	833	833	833	833	833	504	470	441	415	392	371	353	336	321	307	294												
2-1/2"	749	749	749	749	749	749	749	453	423	397	373	353	334	317	302	288	276	264												
2-3/4"	681	681	681	681	681	681	681	412	385	361	339	321	304	288	275	262	251	240												
3"	624	624	624	624	624	624	624	378	353	331	311	294	278	264	252	240	230	220												
3-1/4"	576	576	576	576	576	576	576	349	325	305	287	271	257	244	232	222	212	203												
3-1/2"	535	535	535	535	535	535	535	324	302	283	267	252	239	227	216	206	197	189												
3-3/4"	500	500	500	500	500	500	500	302	282	264	249	235	223	212	201	192	184	176												
4"	468	468	468	468	468	468	468	283	264	248	233	220	209	198	189	180	172	165	4"											

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	410	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





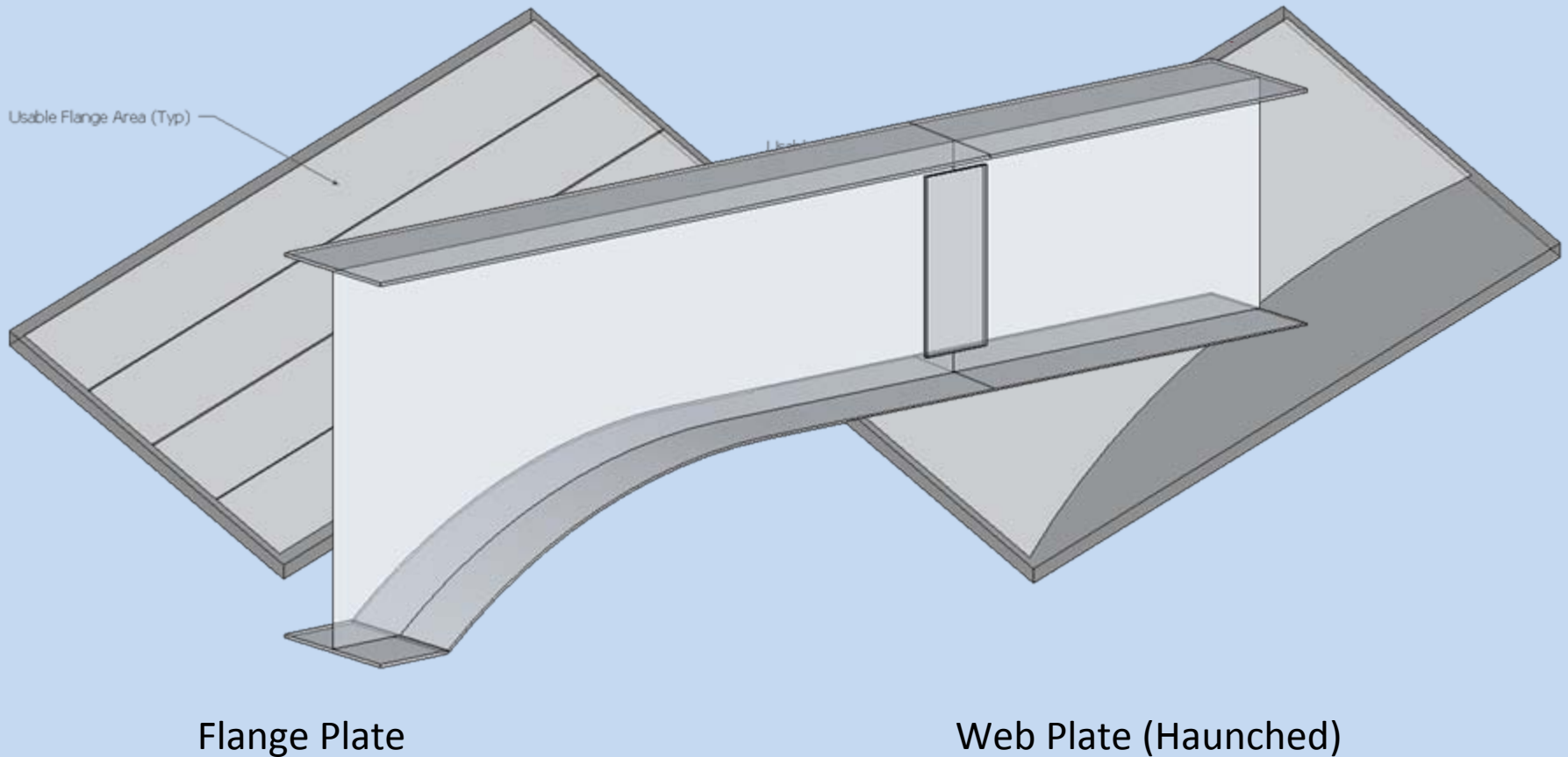
Girder Proportioning

Design and Shipping Considerations

Design Considerations



- Usable Plate Area



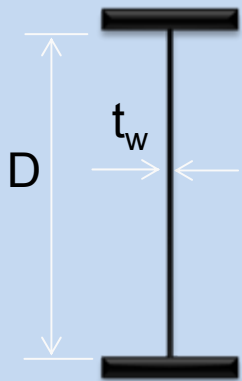
Design Considerations



- 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)

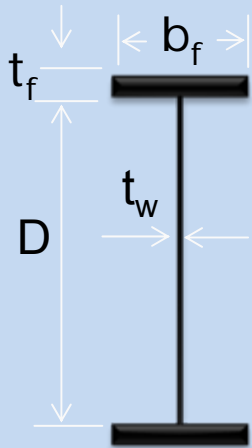


Without Longitudinal Stiffeners	$\frac{D}{t_w} \leq 150$
With Longitudinal Stiffeners	$\frac{D}{t_w} \leq 300$

- Industry Preferred Web Thickness Minimum = 1/2"

Proportioning – Flanges

- AASHTO Limits for Flanges (Art. 6.10.2.2)



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

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

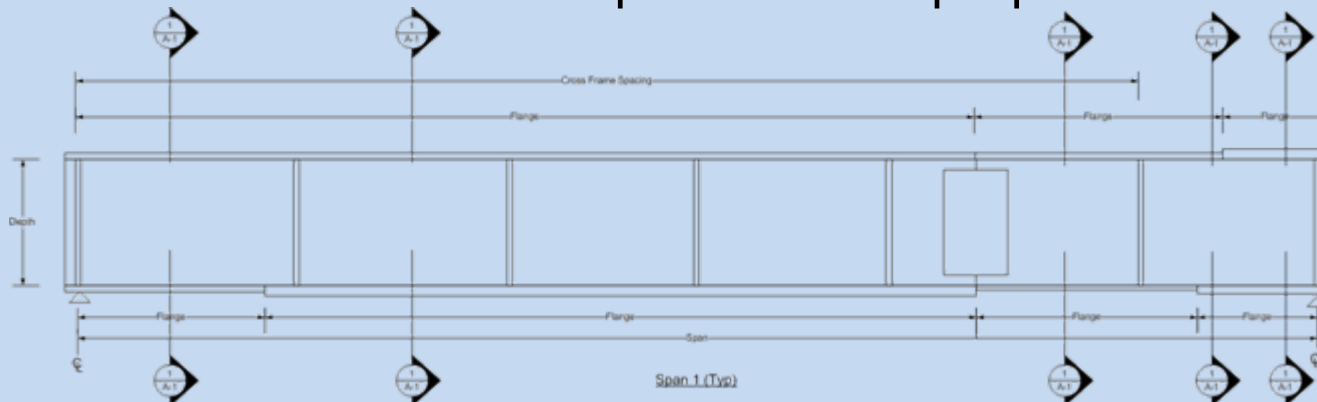
$$t_f \geq 1.1 t_w$$

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

- Industry Preferred Flange Dimensions
 - $b_f \geq 12"$; $t_f \geq 3/4"$

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







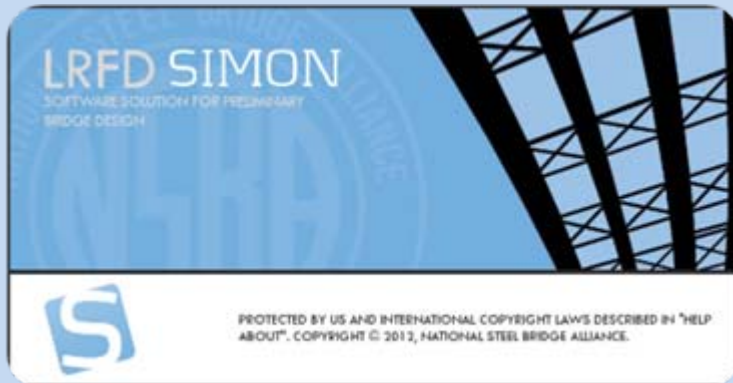
NSBA Steel Bridge Suite

Complete Solution for Steel Bridge Analysis and Design

Suite Overview



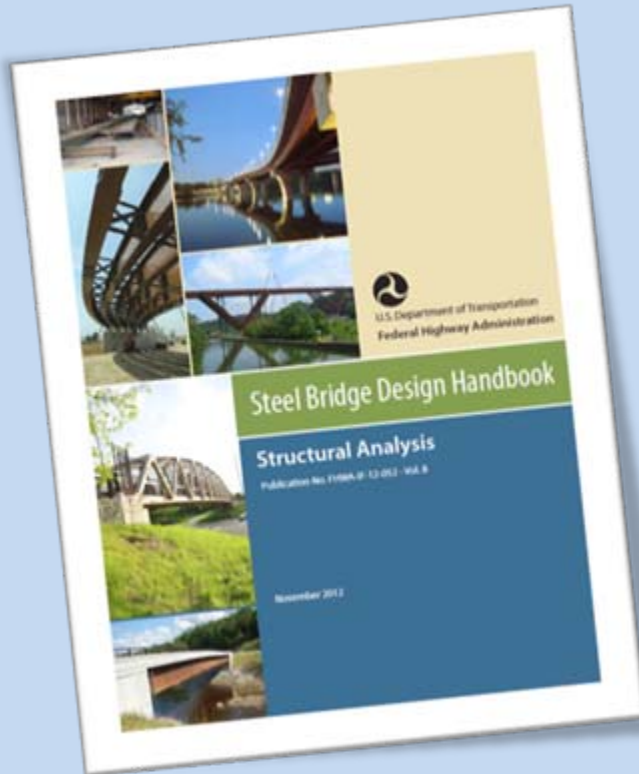
- Steel Bridge Design & Analysis Software
 - LRFD Simon
 - NSBA Bolted Splice



Suite Overview



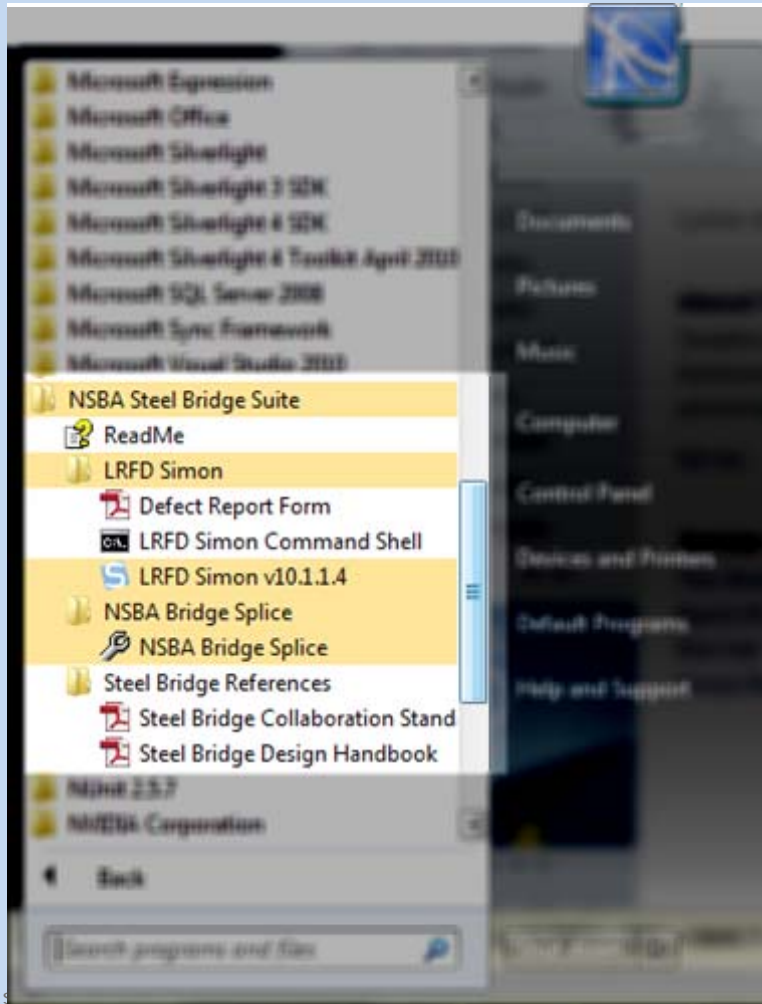
- Steel Bridge Design & Analysis Reference Library
 - Steel Bridge Design Handbook.
 - AASHTO/NSBA Collaboration Standards.



Suite Installation



www.steelbridges.org/softwareregistration



- LRFD Simon
- NSBA Bridge Splice
- Steel Bridge References

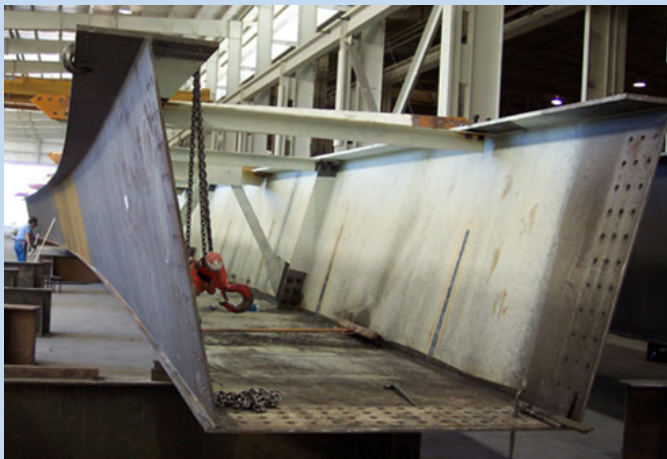


LRFD Simon

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

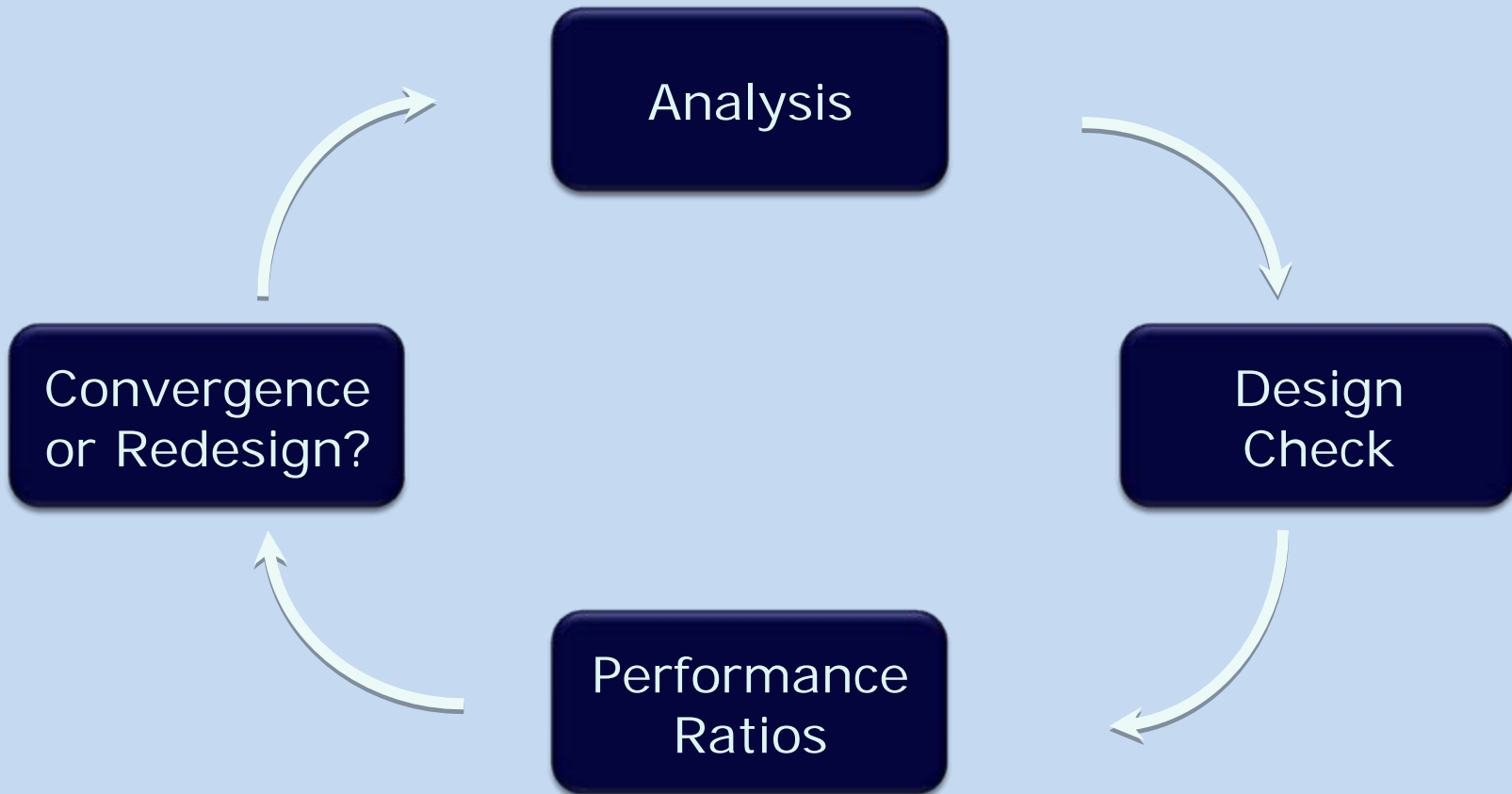


- Simple span or up to 12 continuous spans
- 20 nodes per span
- 1/10th point influence lines
- Partial or full-length dead loads
- AASHTO or user-defined live loads
- Transversely stiffened webs with or without longitudinal stiffeners or unstiffened webs
- Bearing stiffeners
- Parabolic or linear web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

Optimization Methods



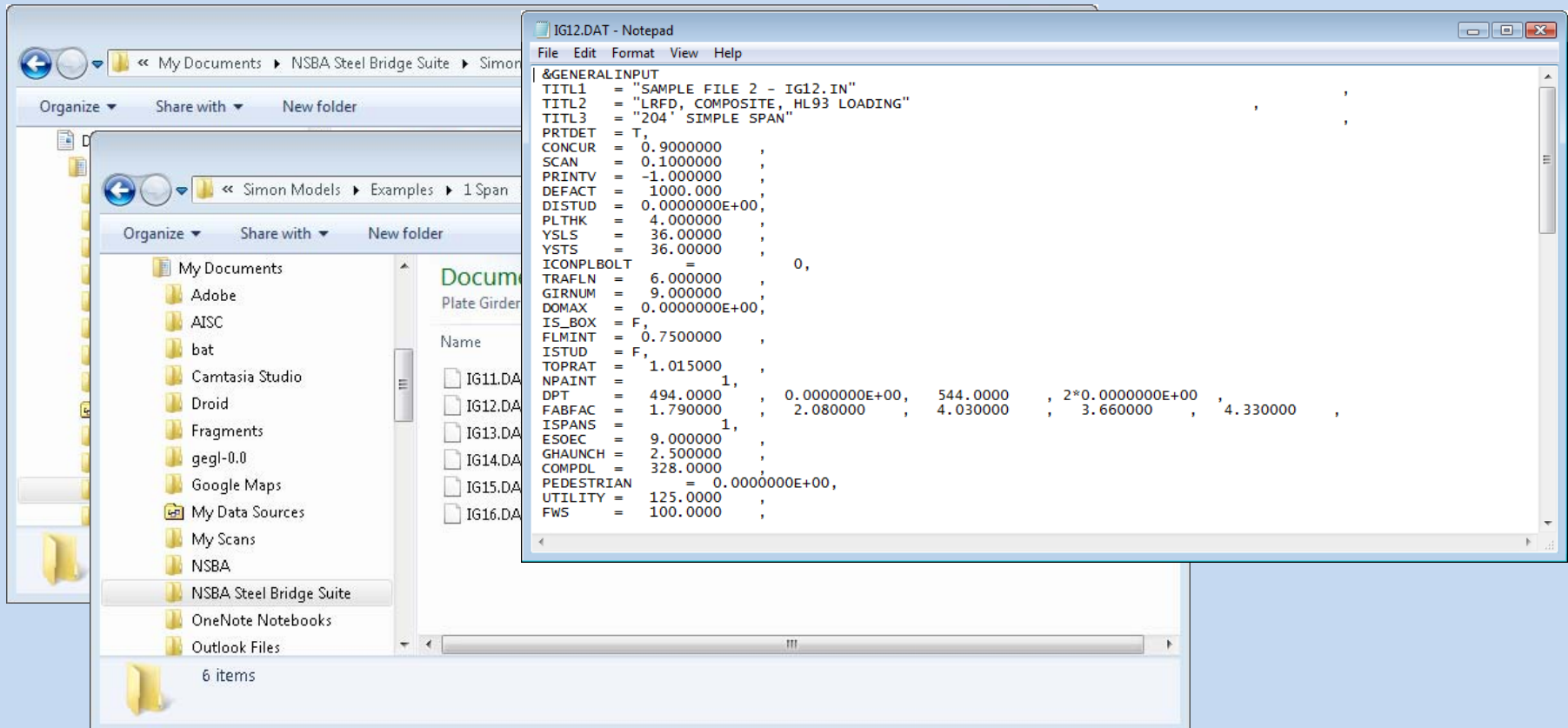
- Incremental design changes to achieve convergence to satisfactory solution.



Product Tour



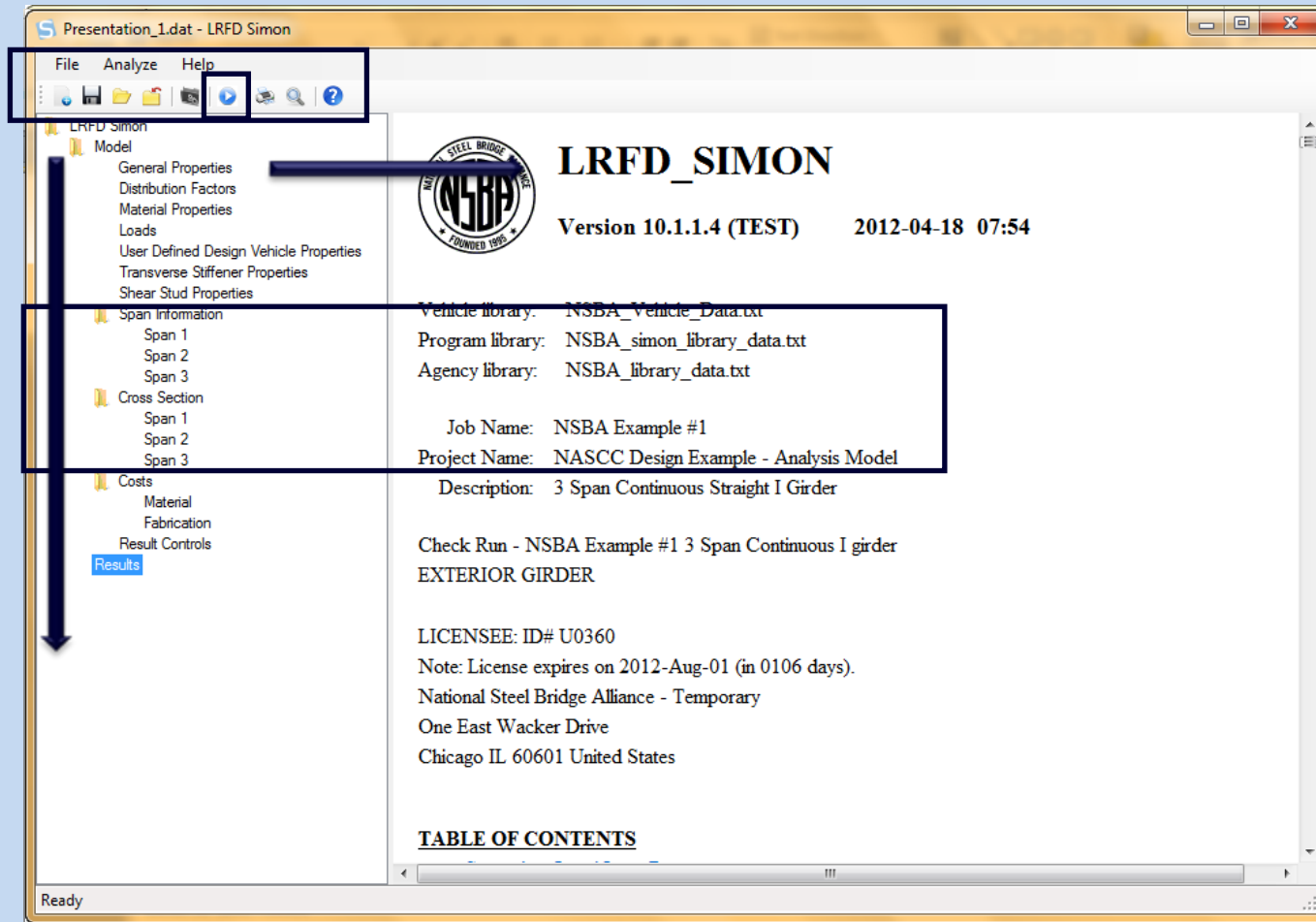
- 34 Delivered Examples
 - 1, 2, 3 and 4 Span Configurations
 - Plate Girder and Box Girder



Product Tour



- Workflow



Product Tour

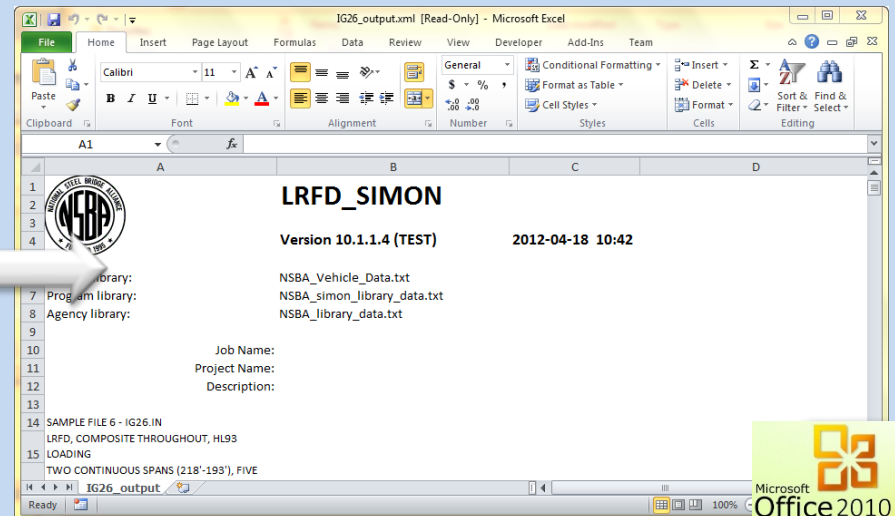
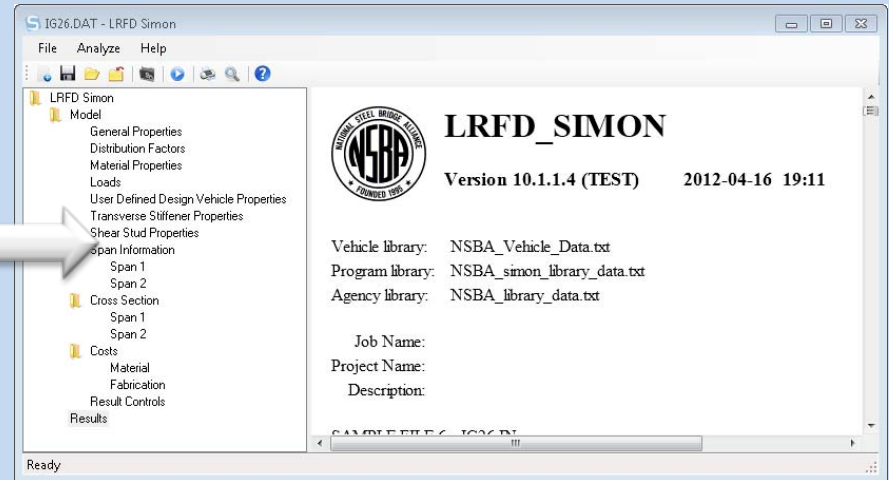
- XML Results

Results

XML

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<?xml-stylesheet type="text/xsl" href="SIMON_output.xsl"?>
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  xmlns:xsl="http://www.w3.org/2001/XMLSchema-instance"
  >
  <run_information>
    <control_system_version>1.19</control_system_version>
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    <version>10.1.1.4 (TEST)</version>
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    <run_time>07:25</run_time>
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      <output>IG26.OUT</output>
      <vehicle>NSBA_vehicle_data.txt</vehicle>
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      <library>NSBA_library_data.txt</library>
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  </run_information>
  <input>
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      <description></description>
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  </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





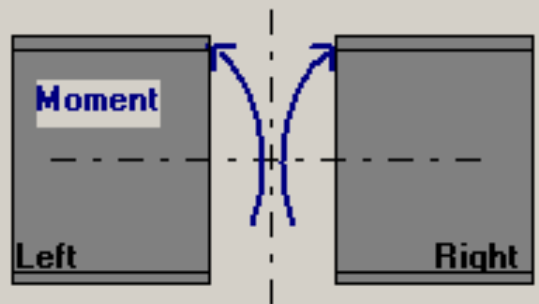
Moment and Shear at Splice

Loading...

AASHTO LRFD Distributed, Unfactored Loads at the Splice Centerline

	Moment (K-ft)	Shear (Kip)
Dead Load acting on Girder BEFORE Deck Hardening DC1	-51.8	-60.8
Dead Load acting on Girder During Deck Casting or Placing DC0	0.0	0.0
Construction Loads: equipments, falsework, temporary supports CL	0.0	0.0
Superimposed Additional Dead Load AFTER Deck Hardening..... DC2	15.5	-8.7
Future Wearing Surface Load DW	18.8	-10.6
Positive Live Load including Impact LL ⁺ + I	1307.8	14.5
Negative Live Load including Impact LL ⁻ + I	-953.3	-91.1
Positive Fatigue Load (include 15% dynamic load allowance) LL ⁺ + I	394.3	5.0
Negative Fatigue Load (include 15% dynamic load allowance) LL ⁻ + I	-284.0	-33.4

Positive Convention for Distributed, Unfactored Loads at the Splice Centerline



< Back	Next >
Save	Exit



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, V_n 305.64 Kip

Right Girder

Identical to Left Girder

M270 Gr50

M270 Gr50

1.25 in

14.0 in

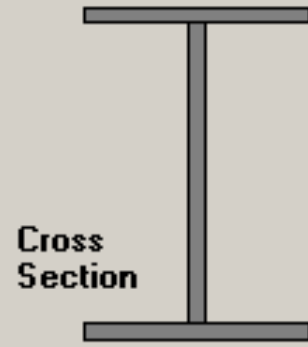
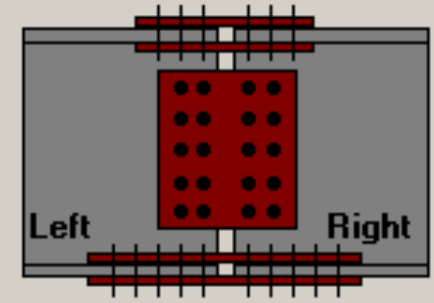
1.375 in

14.0 in

0.5 in

54.0 in

305.64 Kip



Cross Section

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Save	Exit

Connection and Deck Details

Additional Properties...

Minimum Clearances

Assembly Clearance... in

Web Clearance..... in

Alignment Details

Girder Clear Gap..... in

Web Center Top Bottom

Traffic Frequency

Average Daily Truck Traffic, ADTT..... Trucks

Number of Lanes Available to Trucks:

1 2 3 or more

Connection Bolts

▾

Web Bolt Threads
 Excluded Included

Flange Bolt Threads
 Excluded Included

Faying Surface Class...
 ▾

Reinforced Concrete Slab

Composite Noncomposite

Lightweight Concrete

Reinforcing Steel Area.. in²

Reinforcing Steel Centroid Location..... in

Reinforcing Steel Fy..... ksi

Compressive Strength, fc'..... ksi

Slab Thickness..... in

Effective Width..... in

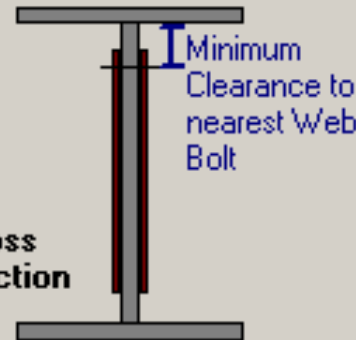
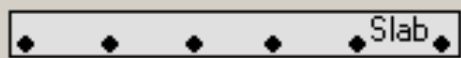
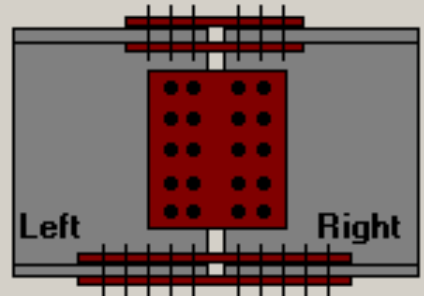
Haunch Depth..... in

Span Details

Span Length..... ft

Splice Location

Near Interior Support
 Elsewhere



Cross Section

< Back Execute

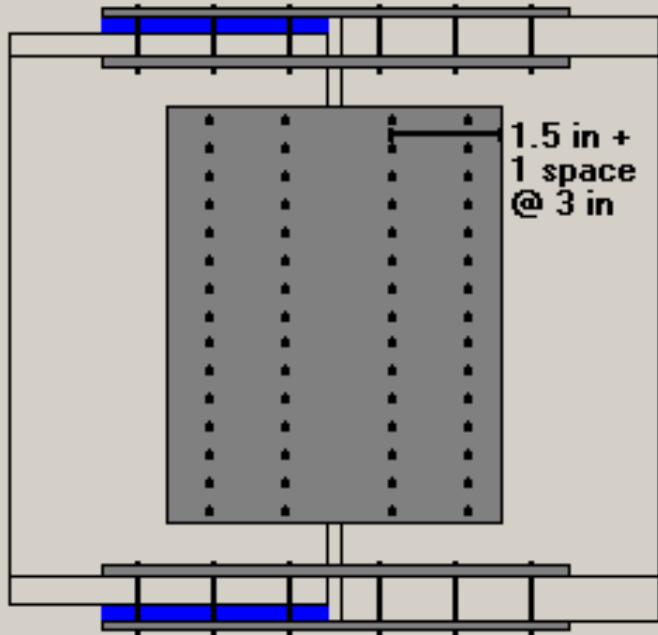
Save Exit

Solution



NSBA SPLICE Design Summary...

3 rows of 4 @ 3 in



3 rows of 4 @ 3 in

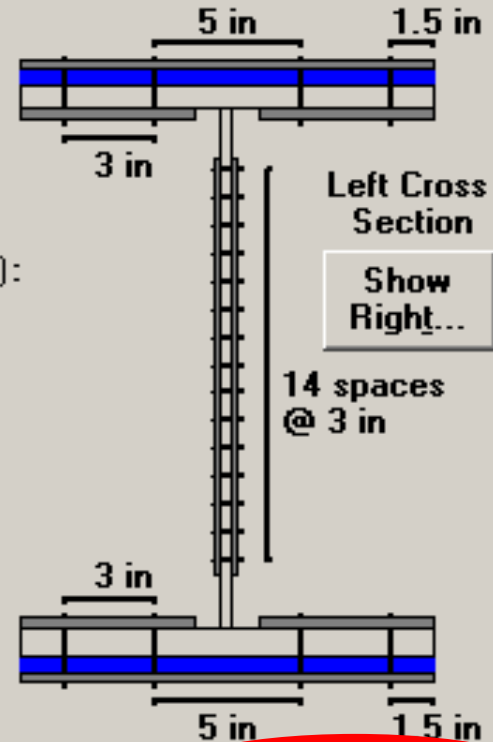
7/8 in AASHTO M164 BOLTS
(A325-X Flanges)
(A325-N Web)
Faying Surface Class = B

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 × 14 × 9 in
- (1) 0.5 × 14 × 9 in



Left Cross Section

Show Right...

14 spaces @ 3 in

Top Flange Splice (in):

- M270 Gr50 Plates
- 1- 0.375 × 14 × 18.5
- 2- 0.4375 × 6 × 18.5
- 3 Rows of 4 Bolts @ 3 in Pitch

Bottom Flange Splice (in):

- M270 Gr50 Plates
- 1- 0.375 × 14 × 18.5
- 2- 0.4375 × 6 × 18.5
- 3 Rows of 4 Bolts @ 3 in Pitch

Web Splice (in):

- M270 Gr50 Plates
- 2- 0.375 × 13.25 × 45
- 2 Rows of 15 Bolts @ 3 in Spacing

Adjust Design

< Back

View Report

Print Splice

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*

City/County*

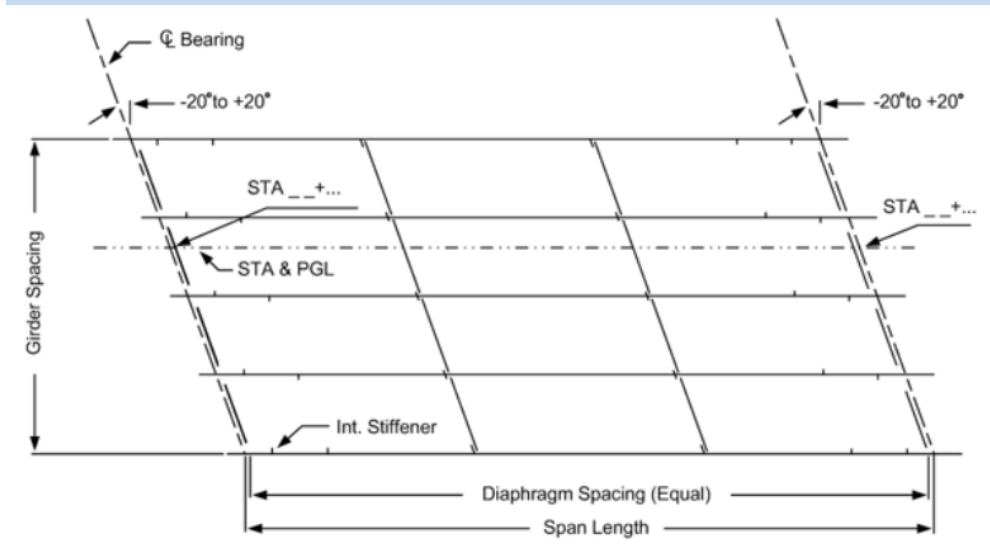
State/Province* 

Roadway Name

Bridge Span Length* 

Feet *Inches*

[Return to Projects](#)




eSPAN140 Input




- Step 2: Project Details (general dimensions)


of Striped Traffic Lanes*

Roadway Width* 

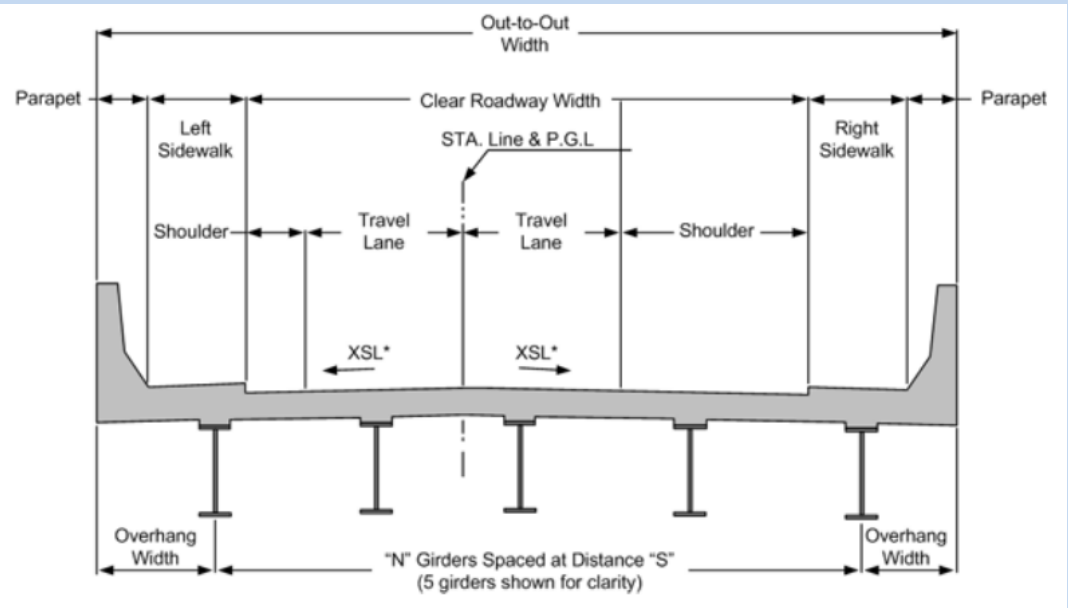
Feet *Inches*

Individual Parapet Width 

Feet *Inches*

Individual Deck Overhang Width 

Feet *Inches*



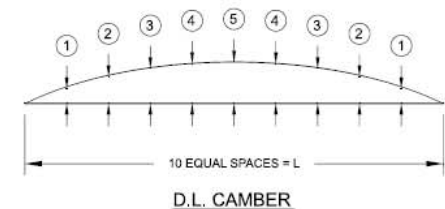
eSPAN140 Results



- 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"

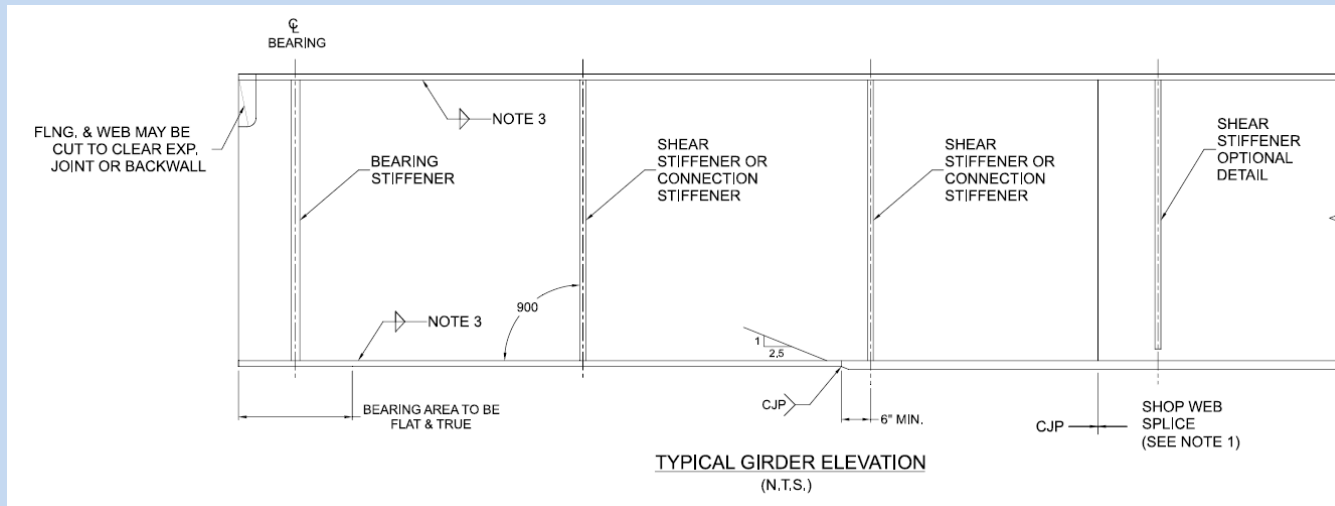


Design Summary

eSPAN140 Results



- Typical Girder and Bridge Details

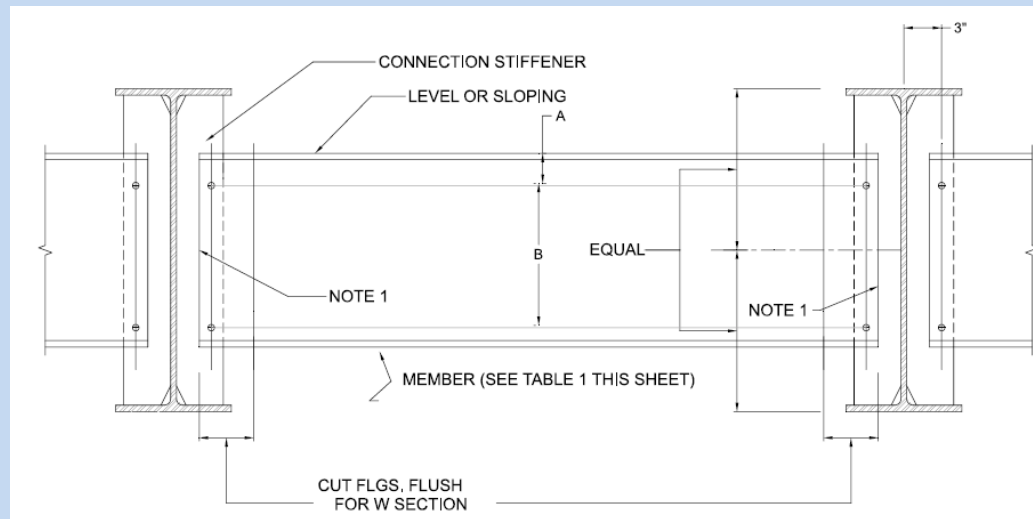


Girder Elevation

eSPAN140 Results



- Typical Girder and Bridge Details

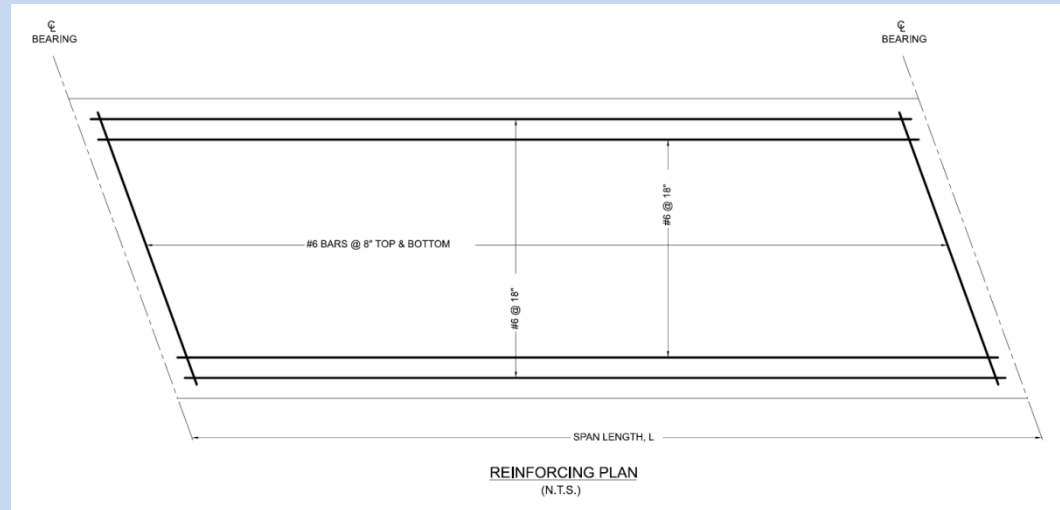
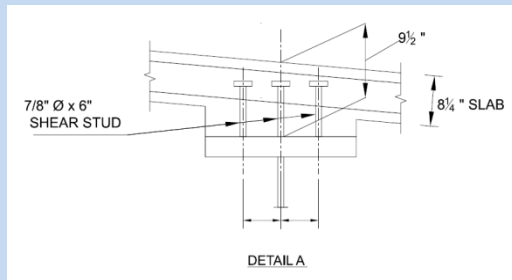


Bridge Section

eSPAN140 Results



- Typical Girder and Bridge Details



Deck Information



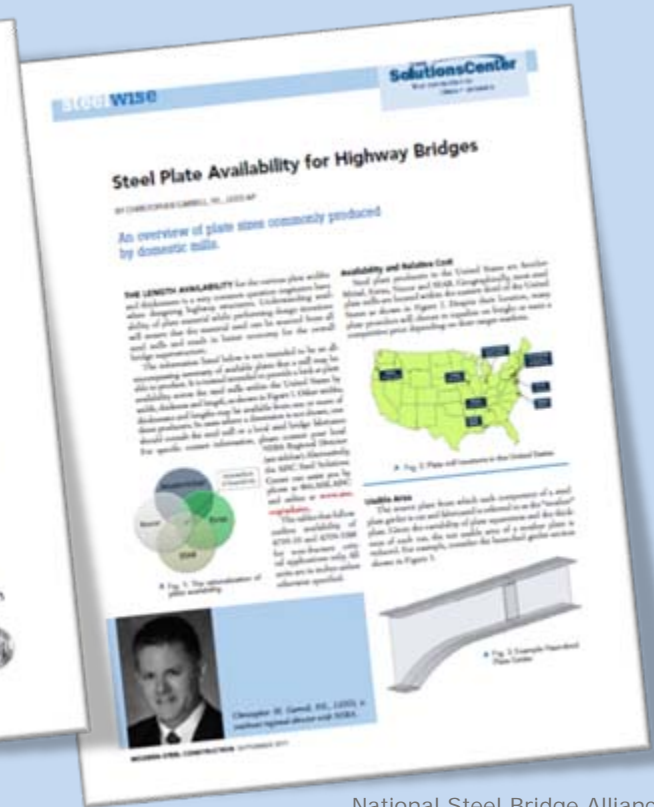
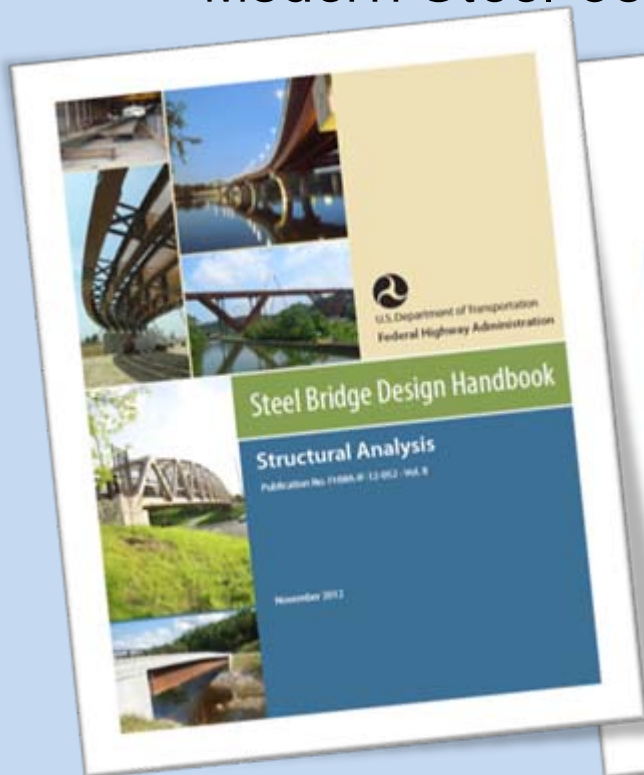
More Information

Physical and Online Resources

More Information



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



More Information



WORLD STEEL BRIDGE SYMPOSIUM

NASCC: THE **STEEL** CONFERENCE
Annual Stability Conference
Technology in Steel Construction Conference



Metro Toronto Convention Centre
March 26–29, 2014



National Steel Bridge Alliance

More Information



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 - www.steelbridges.org
- eSPAN140
 - www.espan140.com
- Modern Steel Construction Magazine
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