Steel Bridge Design & Fabrication

TEAM Conference

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National Steel Bridge Alliance
A division of the American Institute of Steel Construction
www.steelbridges.org

Steel Bridge Topics

- Steel Plate and Rolled Beam Availability and Price
- Design Considerations
- Bridge Girder Fit
- Bridge Connection Details
- Steel Plate Girder Fabrication
- Bolted Splice Design
- NSBA Overview & Resources for Designers

Steel Plate and Rolled Beam Availability and Price

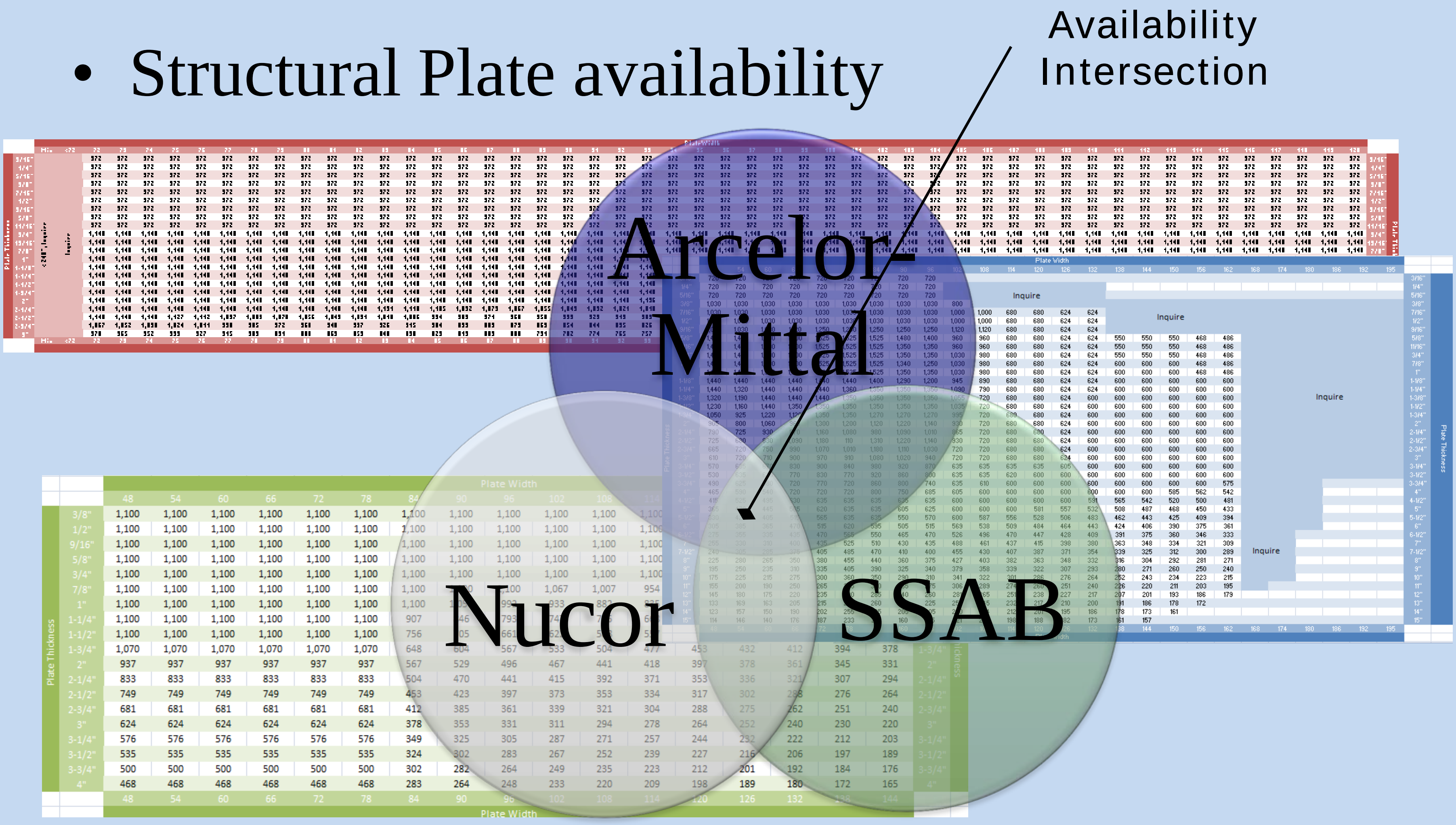
Steel Plate

Steel Plate

- Structural Plate availability

Steel Plate

- Structural Plate availability



Steel Plate

- Structural Plate availability

Producer	Maximum Thickness (in)	Maximum Width (in)
Arcelor-Mittal	4	195
Nucor Steel	4	136
SSAB	3	120

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

Steel Plate

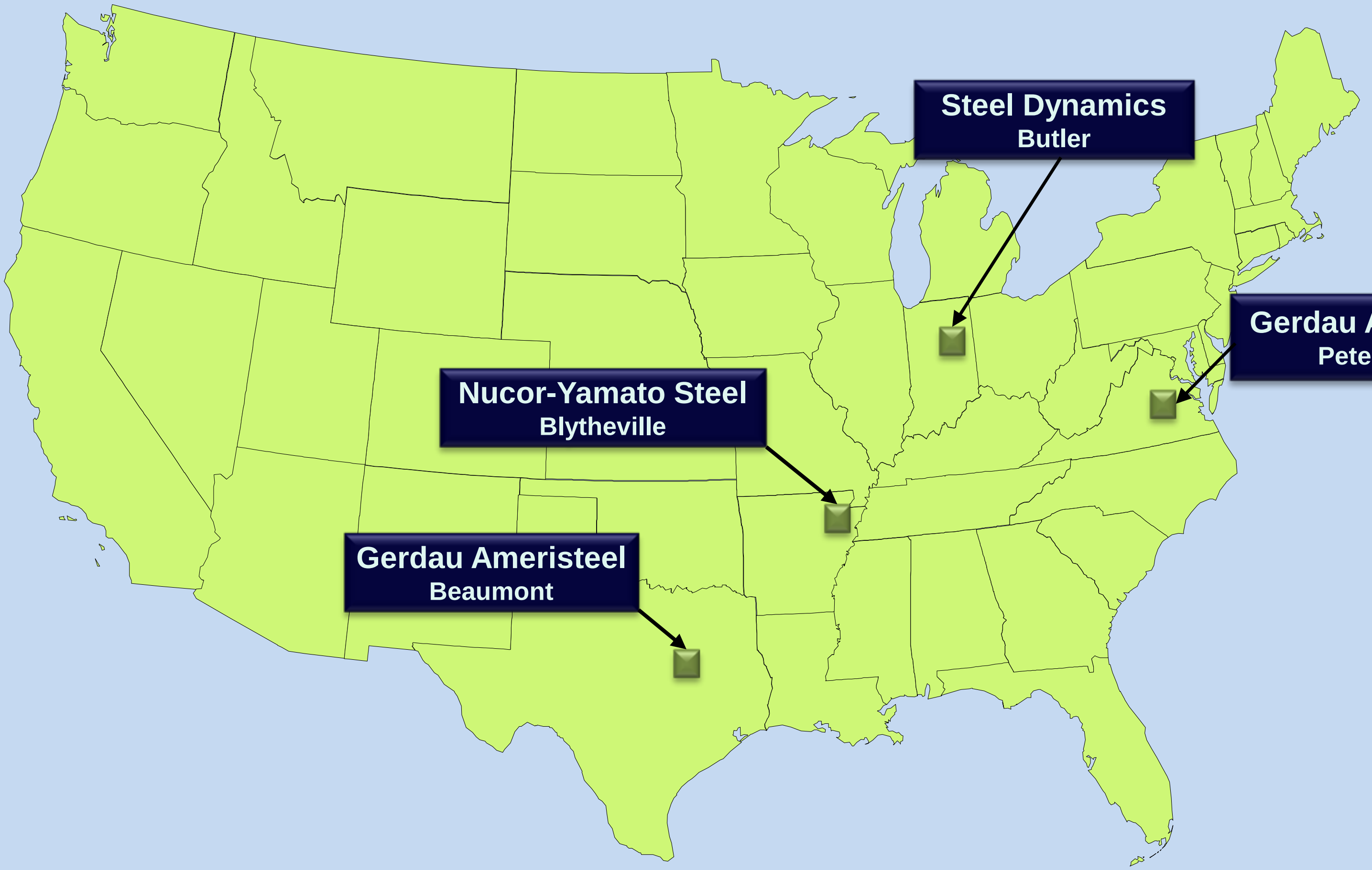
- Structural Plate availability

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.

Rolled Shapes

- Structural Shape availability



Rolled Shapes

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

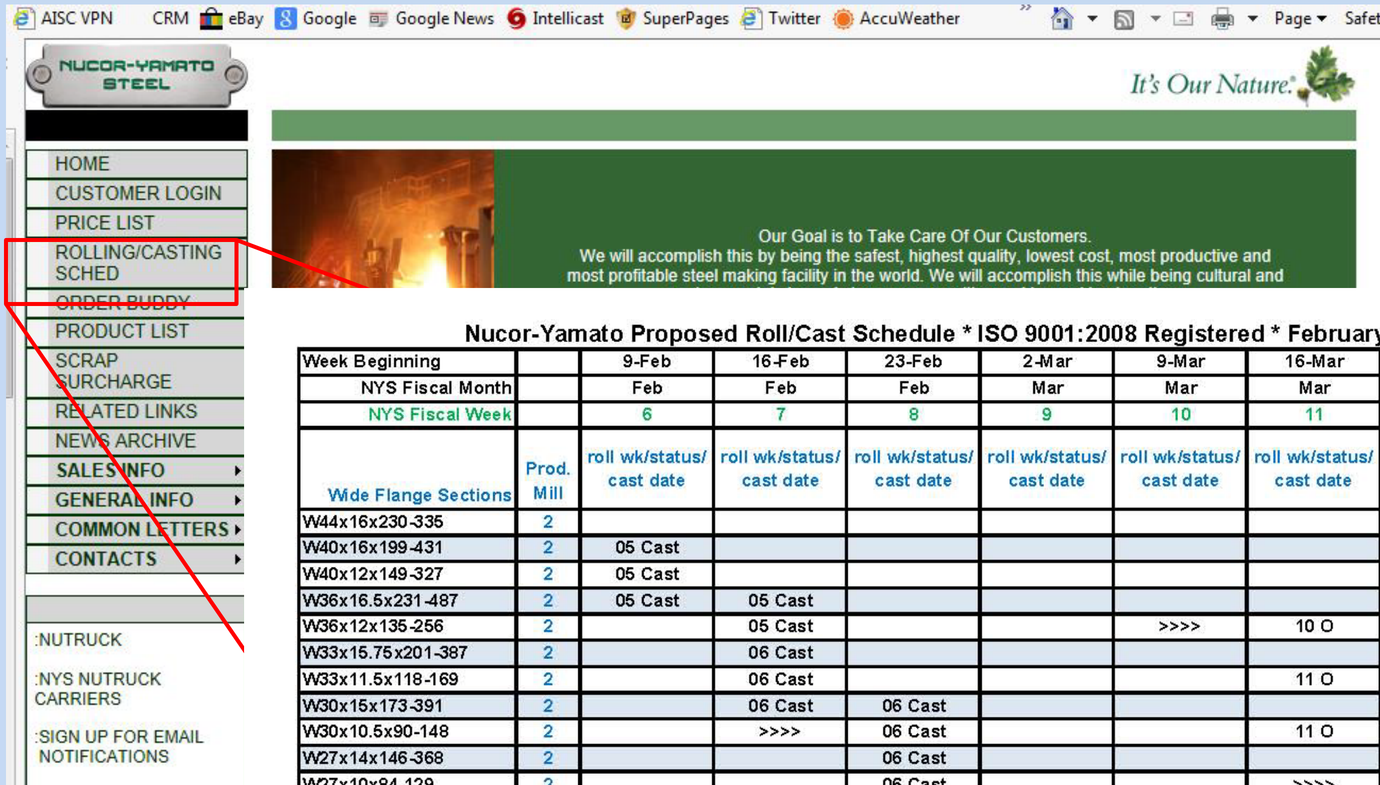
Producer**	Maximum Depth (in)	Length (ft)
Nucor-Yamato Steel	44	
Gerdau Ameristeel	36	120*
Steel Dynamics	36	

* Maximum length for some beam sizes may be shorter.

** These mills account for over 90% of all wide flange shapes produced in the US

Rolled Shapes

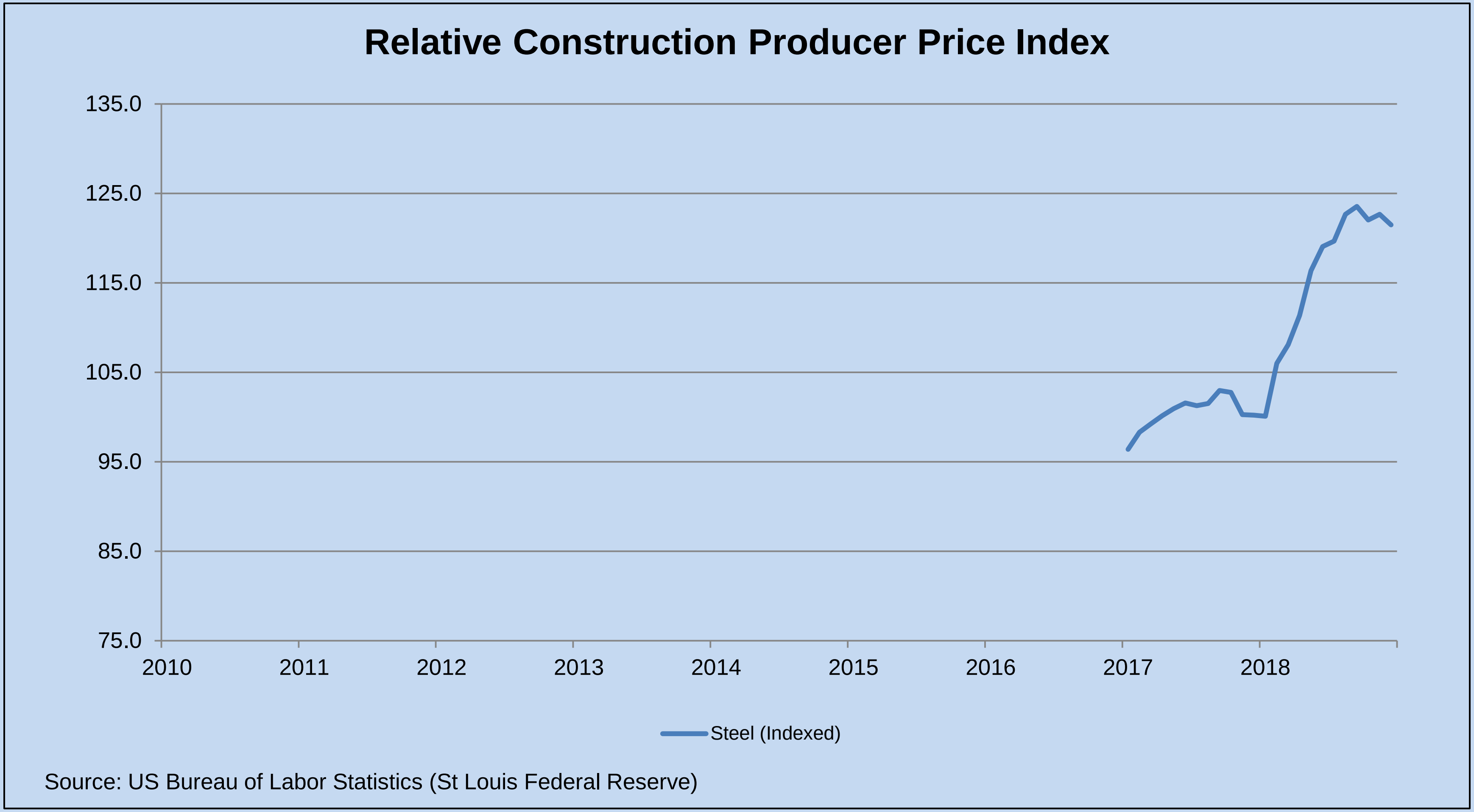
- Structural Shape availability



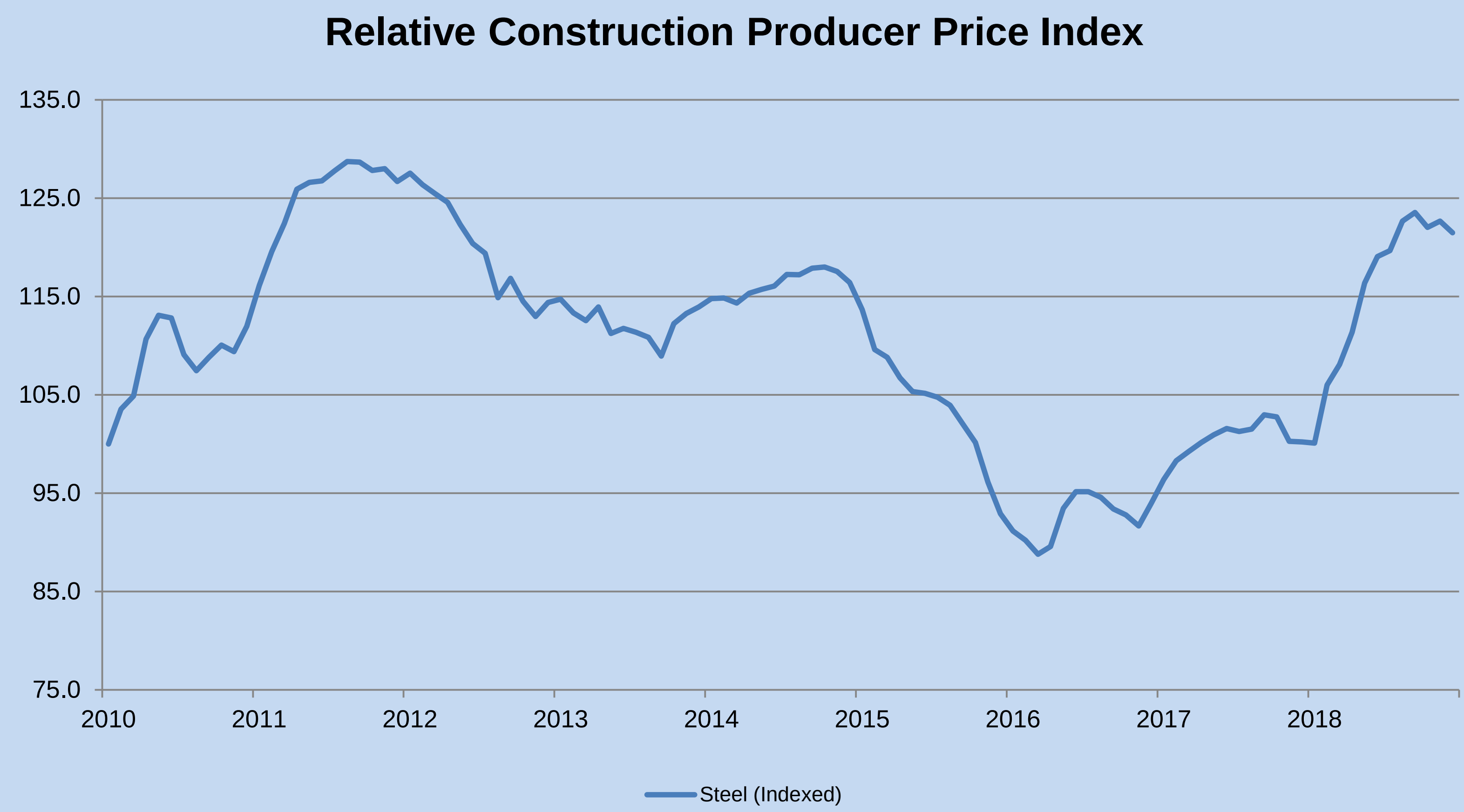
Nucor-Yamato Proposed Roll/Cast Schedule * ISO 9001:2008 Registered * February 12, 2014

Week Beginning		9-Feb	16-Feb	23-Feb	2-Mar	9-Mar	16-Mar	23-Mar	30-Mar	
NYS Fiscal Month		Feb	Feb	Feb	Mar	Mar	Mar	Mar	Mar	
NYS Fiscal Week		6	7	8	9	10	11	12	13	
Wide Flange Sections	Prod. Mill	roll wk/status/ cast date	roll wk/status/ cast date	roll wk/status/ cast date	roll wk/status/ cast date	roll wk/status/ cast date	roll wk/status/ cast date	roll wk/status/ cast date	roll wk/status/ cast date	Approximate Next Roll Week
W44x16x230-335	2									4/6-4/13 Wks
W40x16x199-431	2	05 Cast								4/6-4/13 Wks
W40x12x149-327	2	05 Cast								4/13-4/20 Wks
W36x16.5x231-487	2	05 Cast	05 Cast							4/13-4/20 Wks
W36x12x135-256	2		05 Cast			>>>>	10 O			4/13-4/20 Wks
W33x15.75x201-387	2		06 Cast							4/13-4/20 Wks
W33x11.5x118-169	2		06 Cast				11 O			4/20-4/27 Wks
W30x15x173-391	2		06 Cast	06 Cast						4/20-4/27 Wks
W30x10.5x90-148	2		>>>>	06 Cast			11 O	11 O		4/20-4/27 Wks
W27x14x146-368	2			06 Cast						4/20-4/27 Wks
W27x10x84-129	2			06 Cast			>>>>	11 O		4/20-4/27 Wks
W24x12.75x104-370	2			07 Cast	07 Cast		>>>>	11 O		4/20-4/27 Wks
W24x9x56-103	2			>>>>	07 I 2/19			12 O		4/27-5/4 Wks
W24x7x55-62	1		07 Cast PS	07 Cast PS						4/20-4/27 Wks
W21x12.25x101-275	2					09 O	09 O			5/11-5/18 Wks
W21x8.25x48-93	1		>>>>	07 Cast PS						4/27-5/4 Wks
W21x6.5x44-57	1			07 Cast PS	07 Cast PS					4/27-5/4 Wks

Historic Material Costs

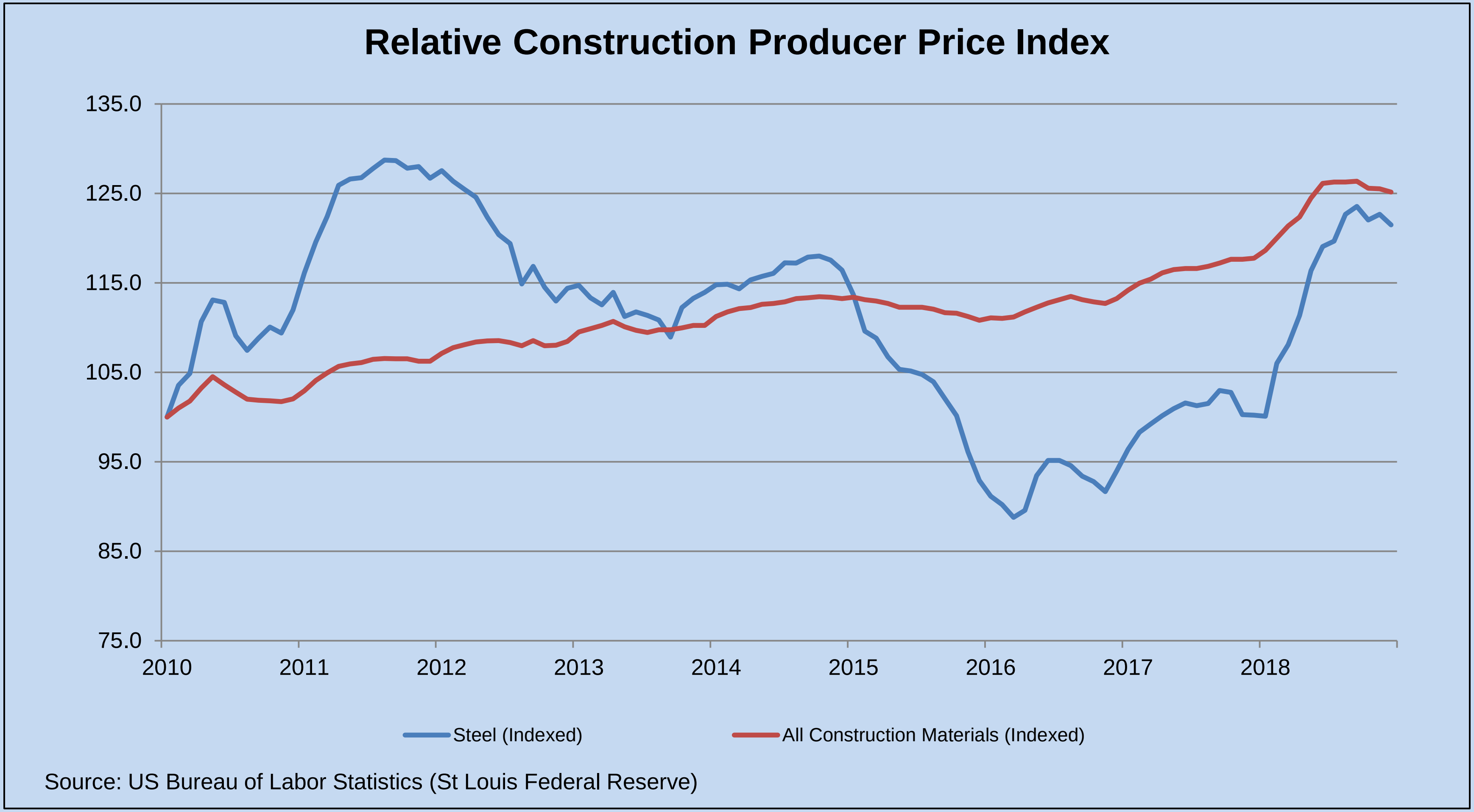


Historic Material Costs

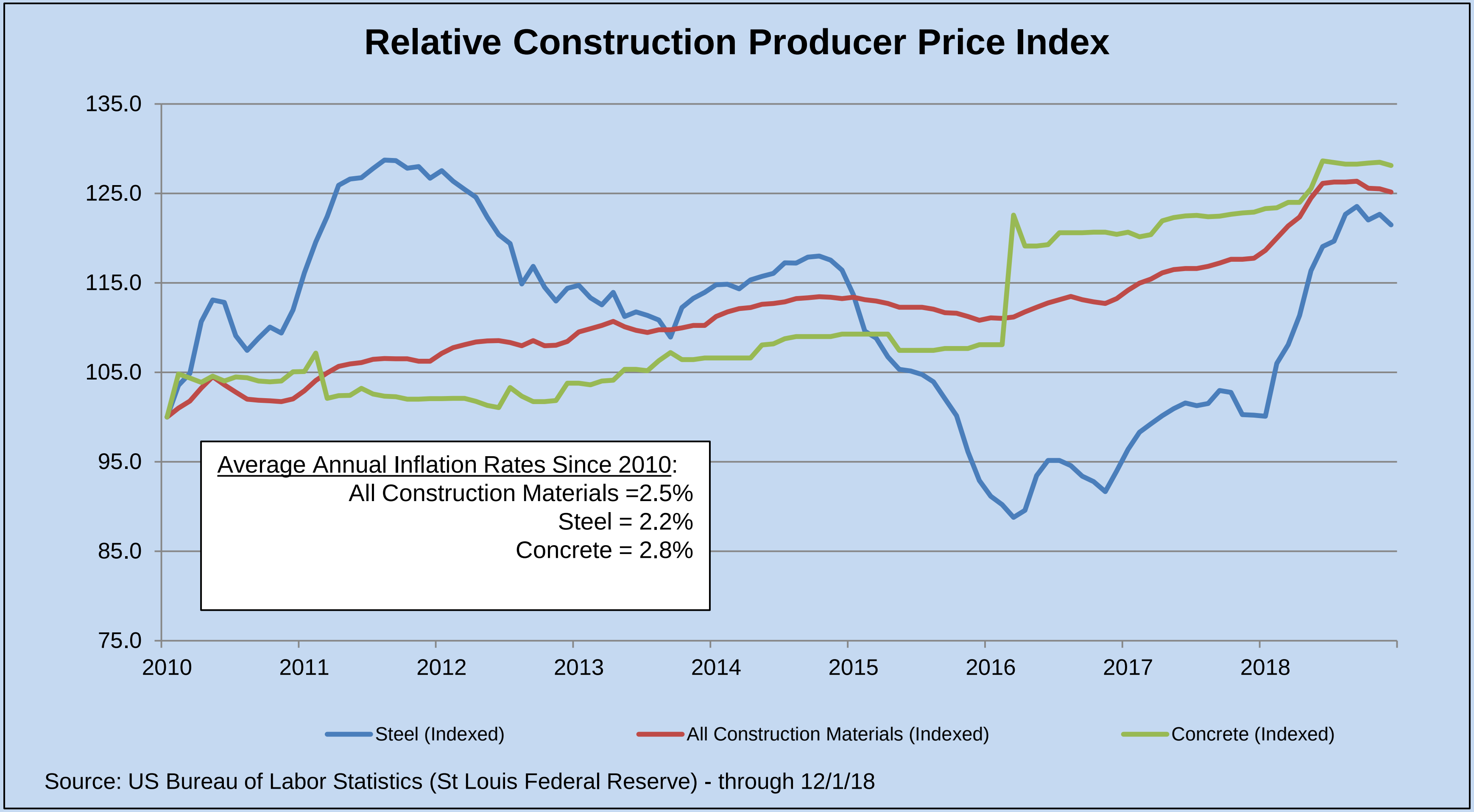


Source: US Bureau of Labor Statistics (St Louis Federal Reserve)

Historic Material Costs



Historic Material Costs



Design Considerations

Design

- Rolled Beam vs. Plate Girder
  - Rolled beam generally more economical
    - Dependent on availability – rolling schedules, etc
  - Allow plate girder alternate (show on bid documents)

eSPAN140™

www.espan140.com

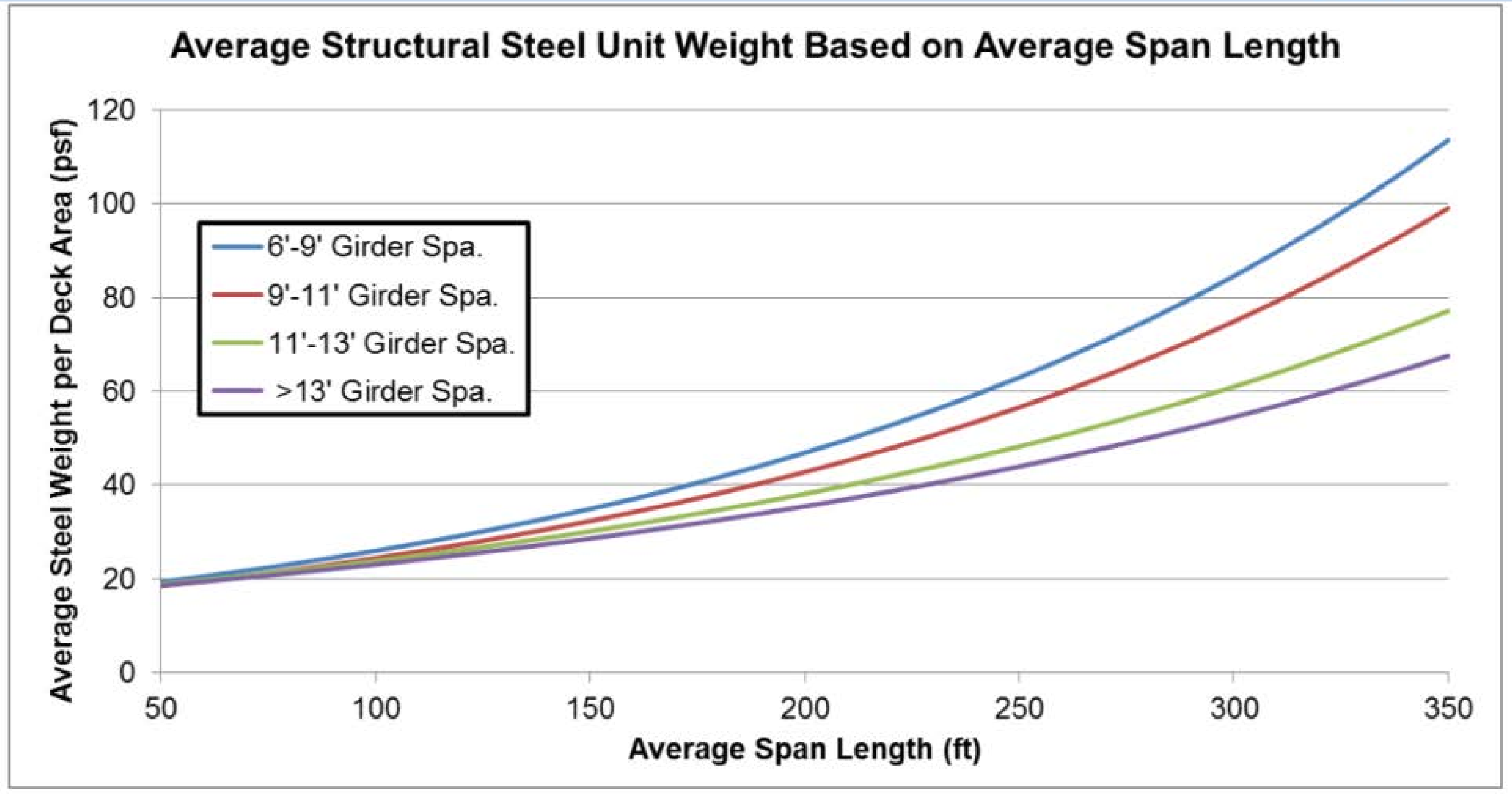
Welded Plate Option Allowed

- For horizontally curved members with a radius less than 1,200’
- For members requiring camber greater than ¼ of the depth of the member (e.g., 6″ camber for a 24″deep member)
- If cover plates are required for the rolled beam option
- Length should be a consideration (over 60′ length)
- Availability on short notice

Design

- Girder Spacing
  - Wider is more economical
  - A reduced number of girders to be detailed, fabricated, coated, transported, erected, inspected and maintained
    - Fewer bolts, x-frames, bearings, and less welding
  - Stiffer structure with smaller relative girder deflection
  - Reduced out-of-plane rotations

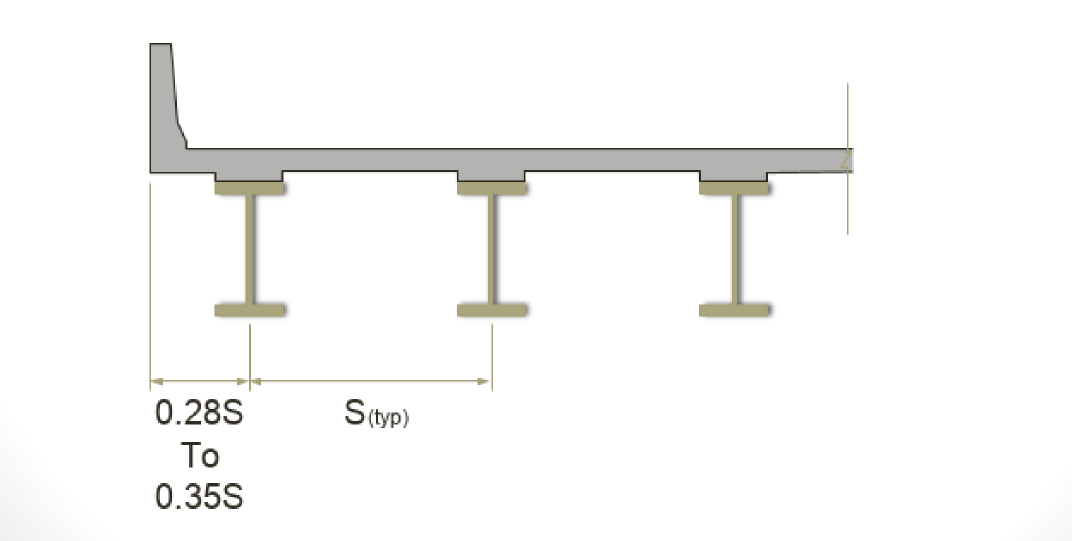
Design



- Use 10’ to 13’ with spans less than 175’
  (not a lot of appreciable difference in structural steel unit weight)
- Use 11’ to 13’ with spans greater than 175’

Design

- Girder Spacing Considerations
  - Thicker deck may be required for larger spacings
  - Spacing larger than 13’ may require stringers
  - Consider future redecking under traffic
  - Balancing loads for exterior and interior girders



• Girder Spacing

Design

- Minimum Thicknesses
  - Plate girder webs
    - 1/2” minimum
  - Plate girder flanges
    - 3/4” minimum
  - Stiffeners, connection plates
    - 1/2” minimum

Design

- 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

Plate Girders

- Plate Girder Flange Sizing
  - Shop butt splices within a shipping piece – when to change area?
    - No more than 2 butt splices or 3 different flange thickness for an individual flange between field splices
    - Flange Thickness
      - 1/8 ” increments up to 2½”
      - ¼” increments over 2½”
    - Maximum change; thinner piece at least 1/2 of thicker…
    - <u>ONLY</u> when material cost saved > labor cost spent

Flange Sizing – when to change area?

Multiply weight savings/inch x flange width (length of butt weld)							
Thinner Plate at Splice (inches)	**Thicker Plate at Splice (inches)**						
	1.0	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**
1.0	70	70	70				
1.5		80	80	80	80		
2.0			90	90	90	70	70
2.5				100	100	80	80
3.0					110	90	90
3.5						110	110
4.0							130

Weight Saving Factor Per Inch of Plate Width
for ASTM A709-Gr 50 Non-Fracture Critical Flanges Requiring Zone 1 CVN Testing

Plate Girders

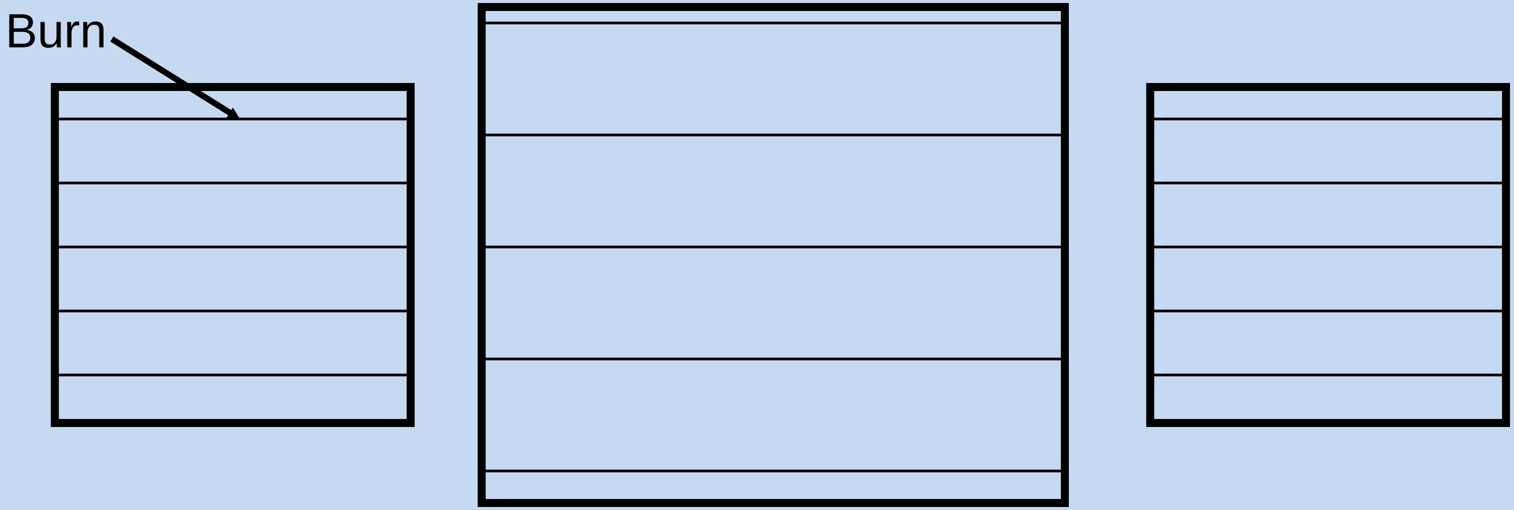
- Plate Girder Flange Sizing
  - Shop butt splices within a shipping piece – how to change area? width or thickness?
    - Keep width constant (i.e., to change cross section area, change thickness)
    - WHY ?
    - compare changing width vs. changing thickness

Flange Sizing - change width

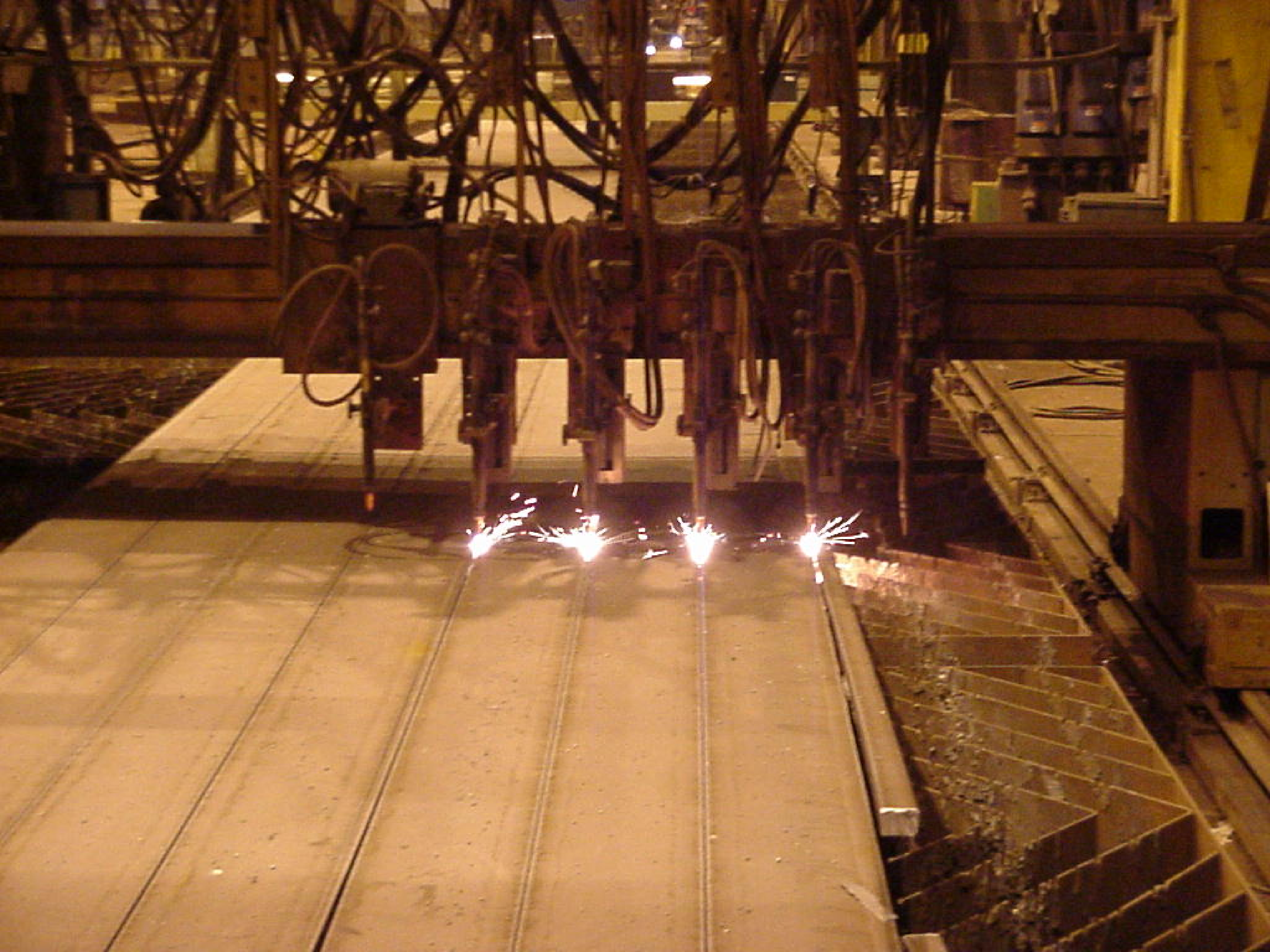
FABRICATE 4 FLANGE ASSEMBLIES

STEP 1: Bevel (4) plate edges

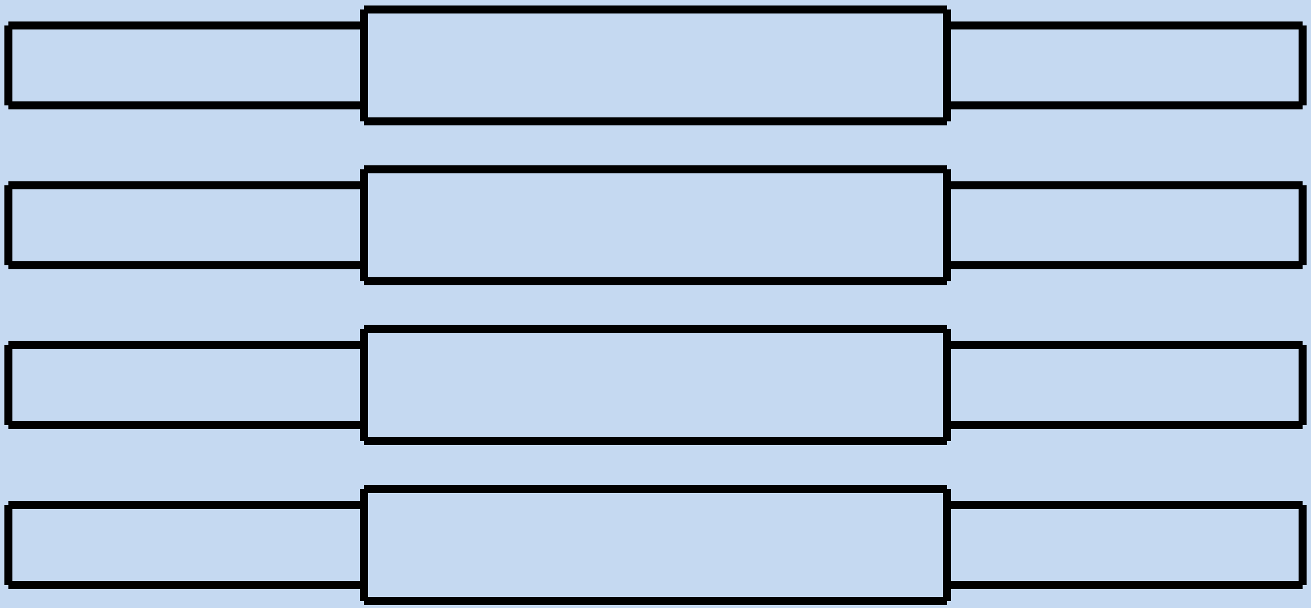
Flange Sizing - change width



STEP 2: Burn 12 pieces from 3 plates

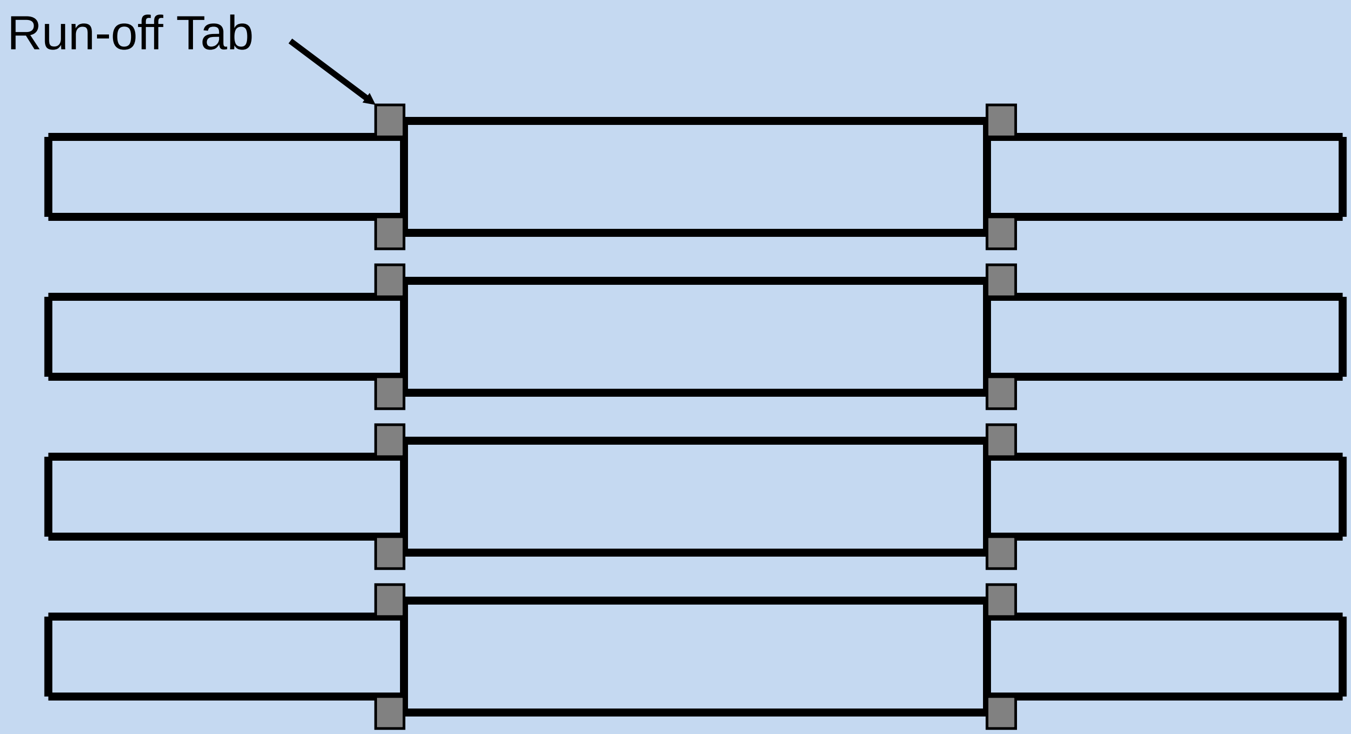


Flange Sizing - change width

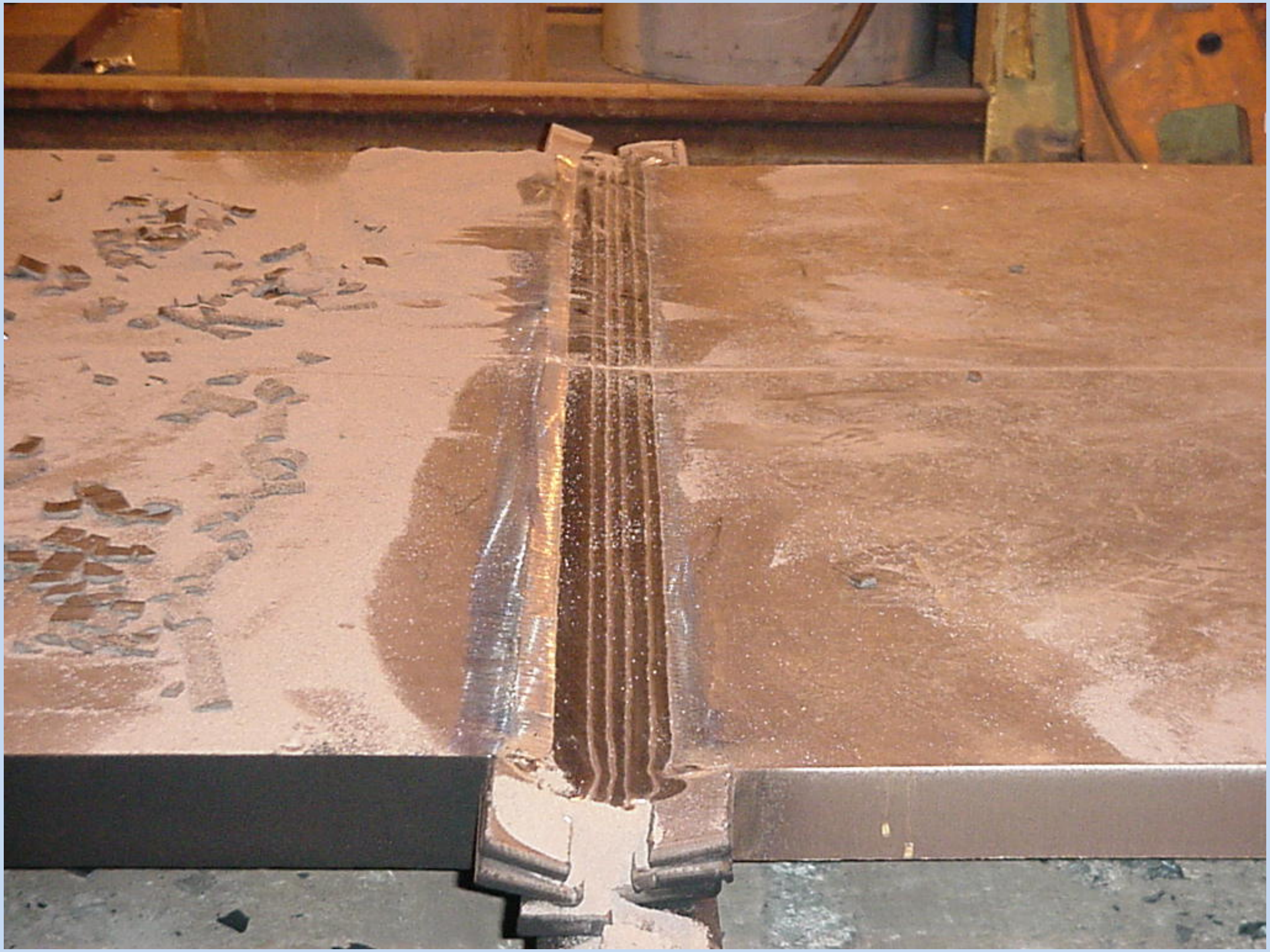


STEP 3: Fit up and tack weld 4 flange assemblies

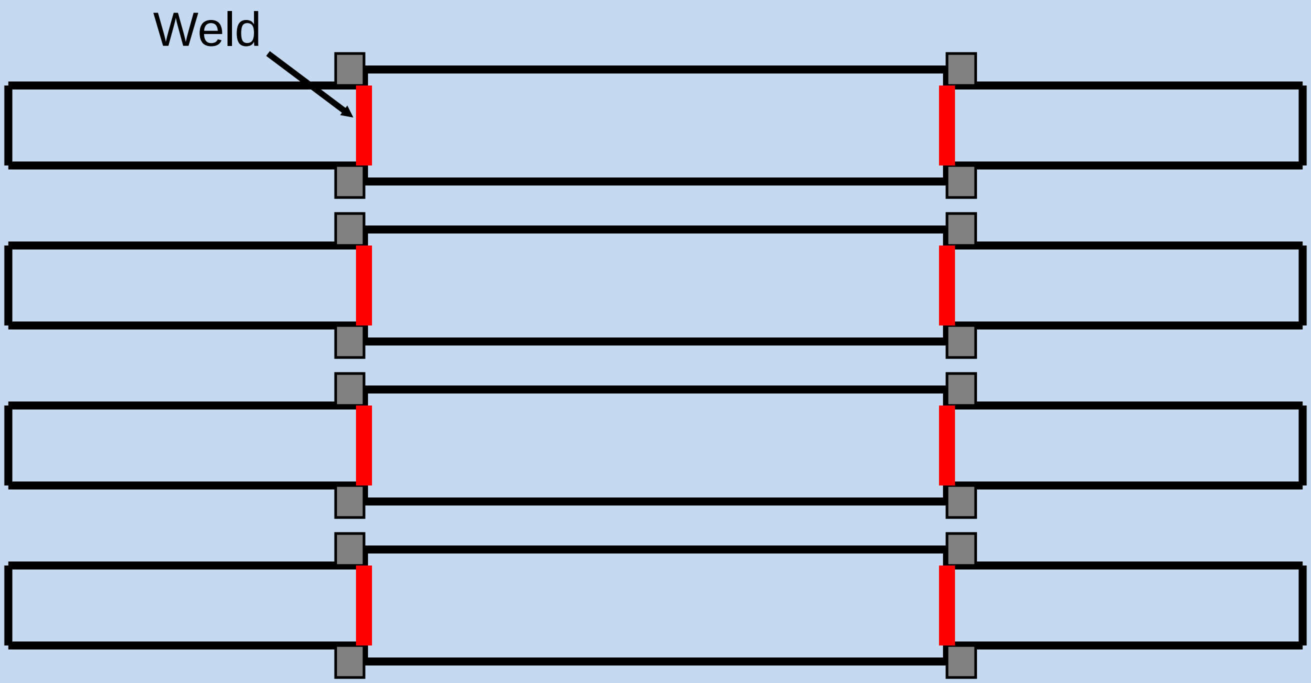
Flange Sizing - change width



STEP 4: Attach 16 run-off tabs

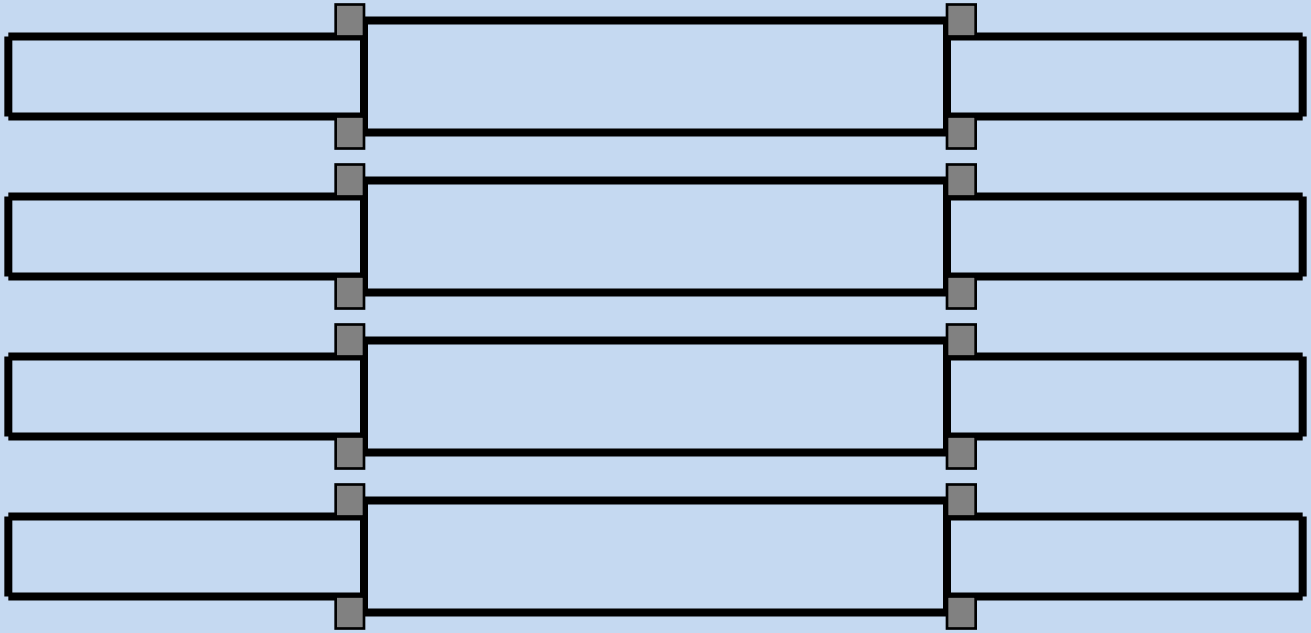


Flange Sizing - change width



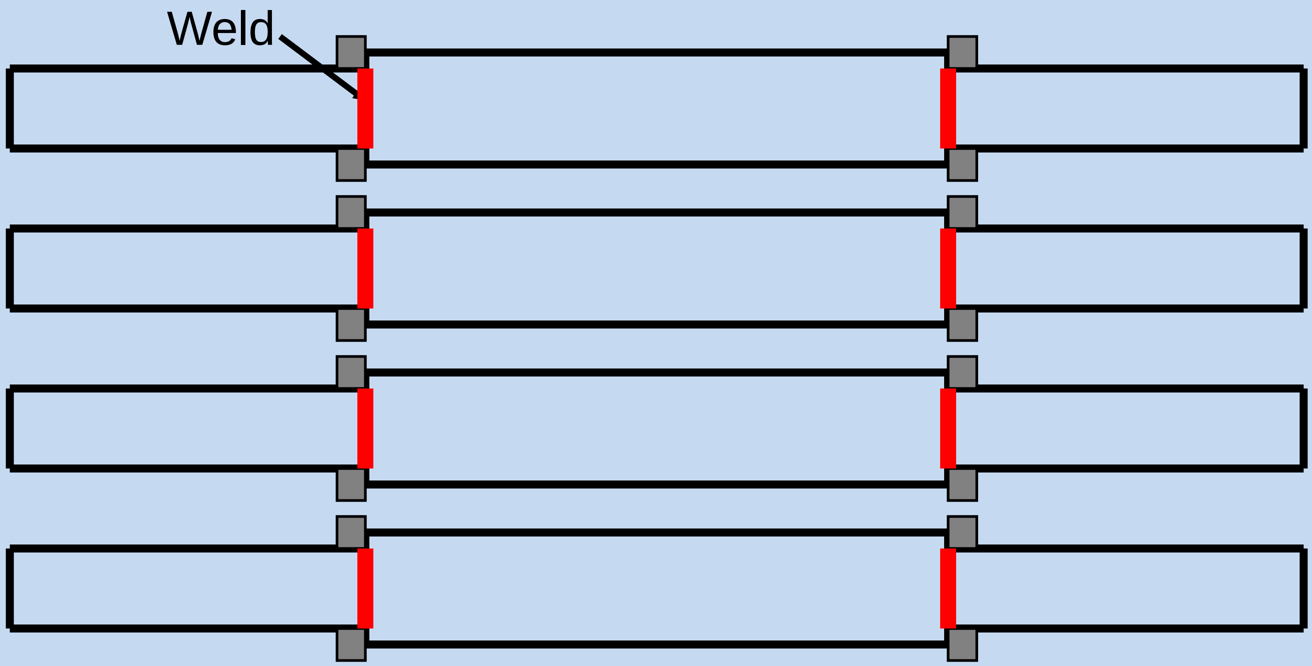
STEP 5: Weld and grind 8 splices

Flange Sizing - change width



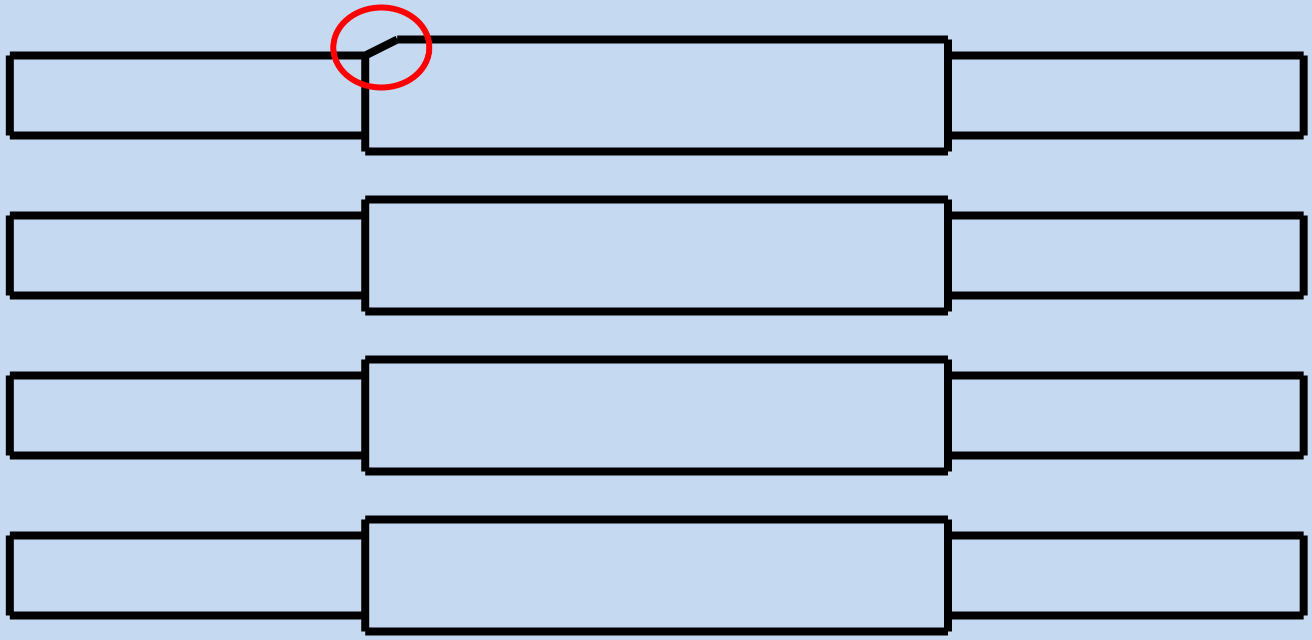
STEP 6: Turn over 4 flange assemblies

Flange Sizing - change width



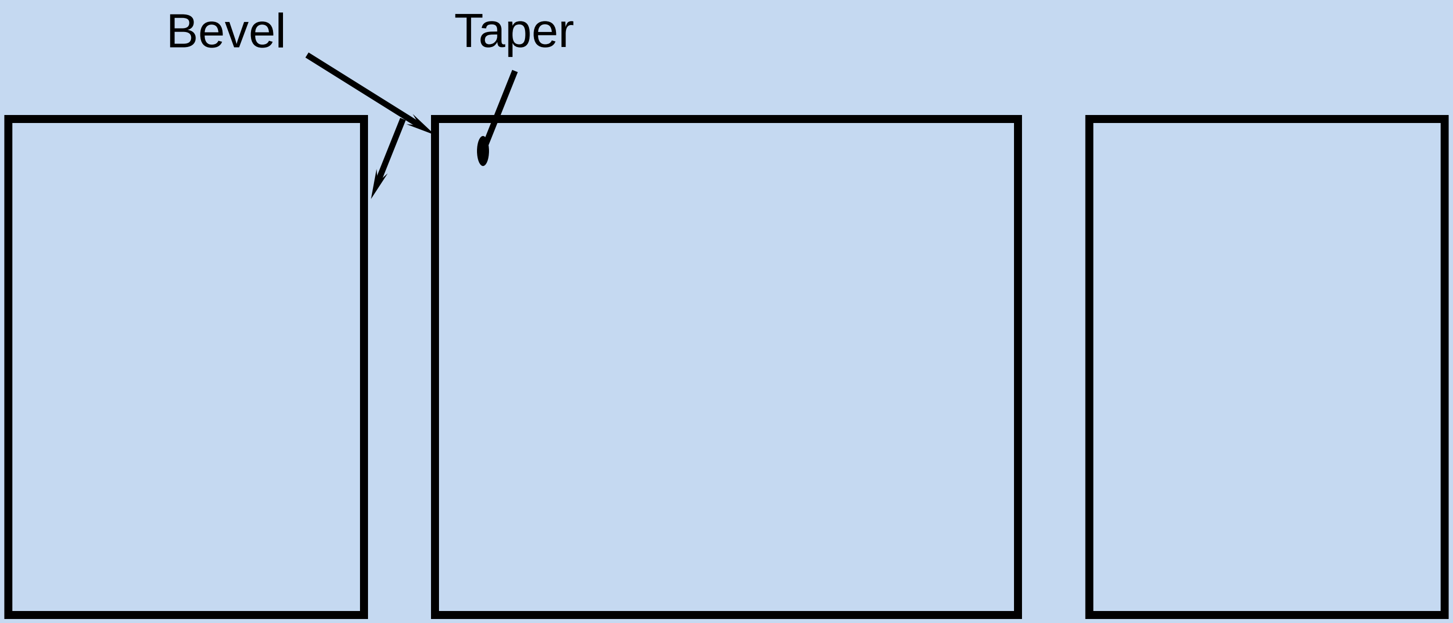
STEP 7: Back gouge, weld and grind 8 butt joints

Flange Sizing - change width



STEP 8: Remove and grind 16 run-off tabs, taper wider plates

Flange Sizing - change thickness



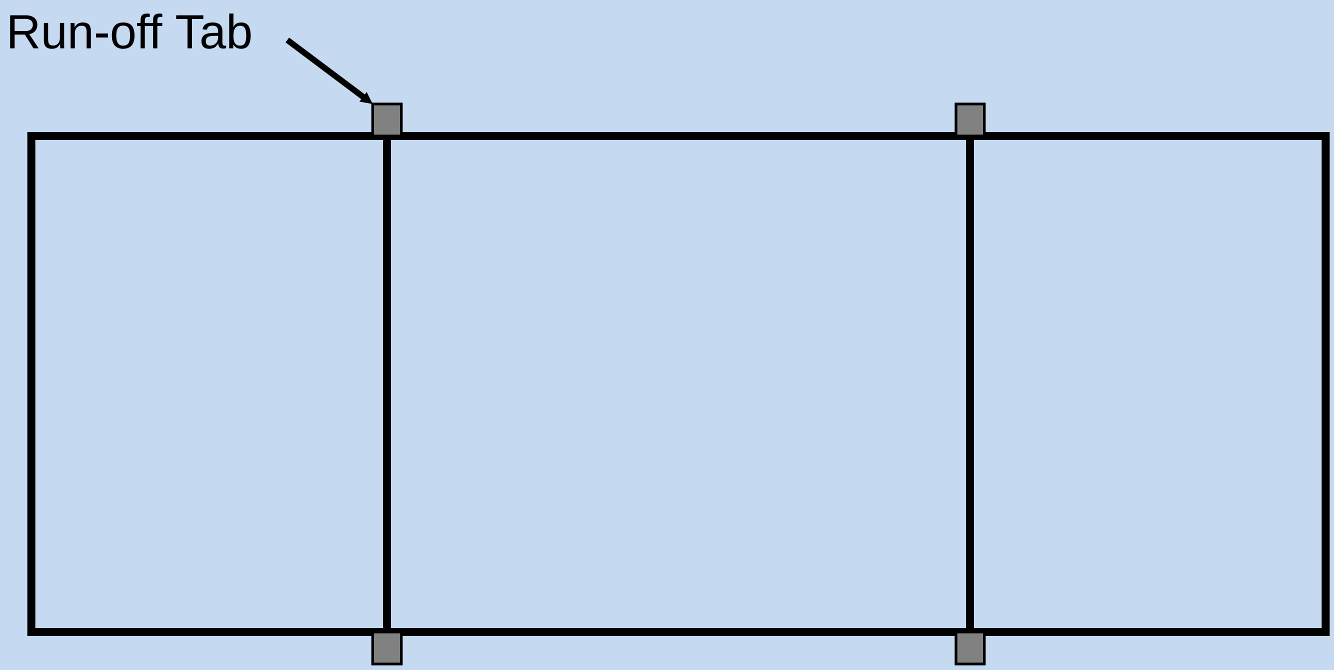
CHANGE THICKNESS

STEP 1: Bevel (4) and taper (2) plate edges

Flange Sizing - change thickness

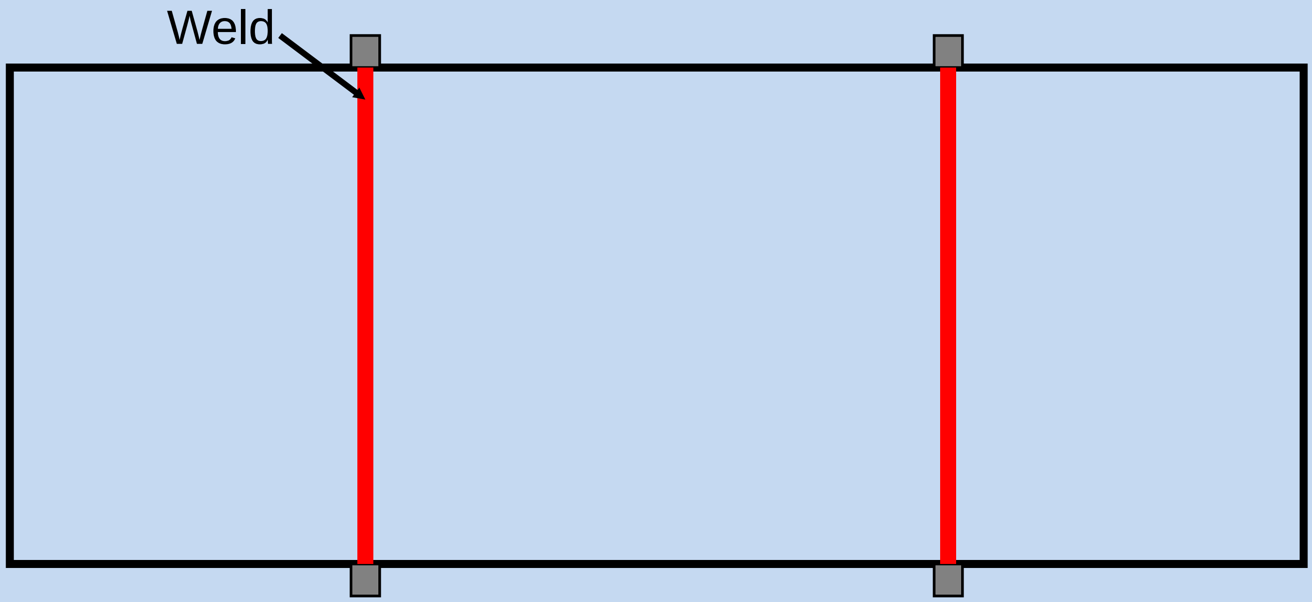
STEP 2: Fit up and tack weld 3 plates

Flange Sizing - change thickness



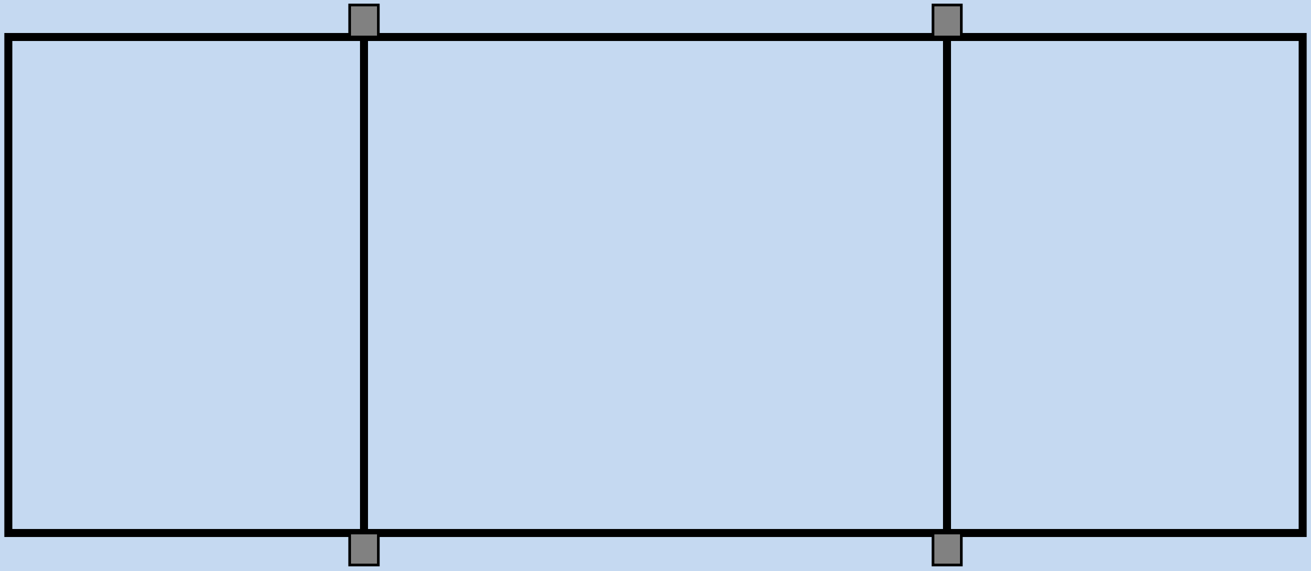
STEP 3: Attach 4 run-off tabs

Flange Sizing - change thickness



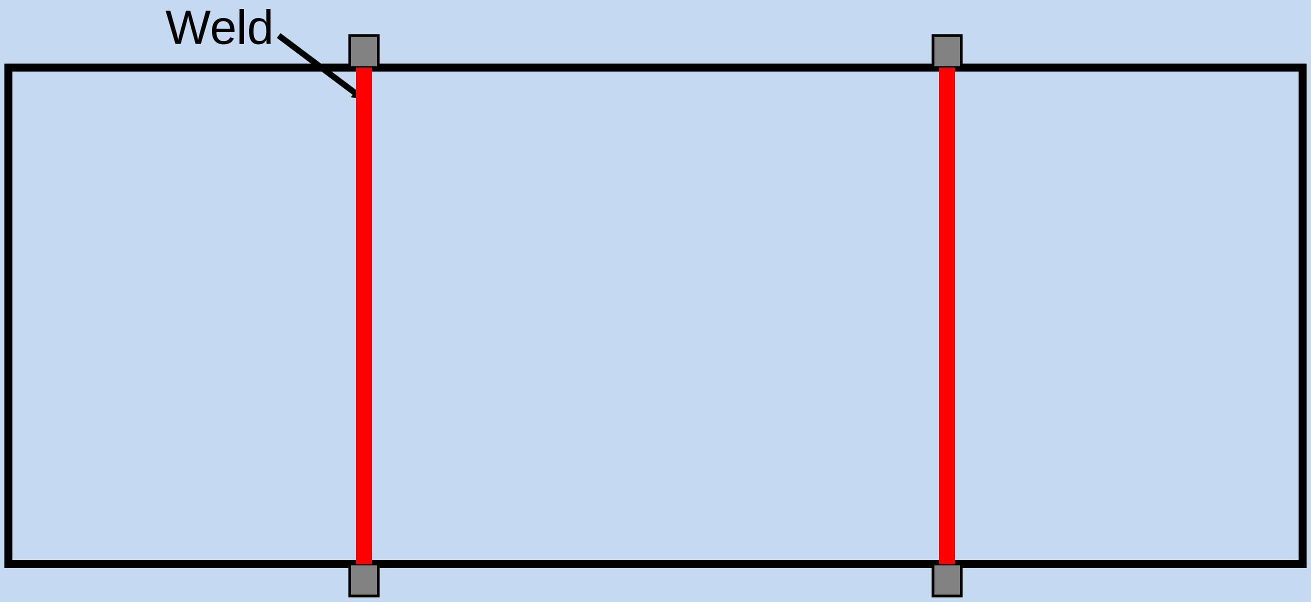
STEP 4: Weld and grind 2 splices

- Flange Sizing - change thickness



STEP 5: Turn over 1 piece

Flange Sizing - change thickness

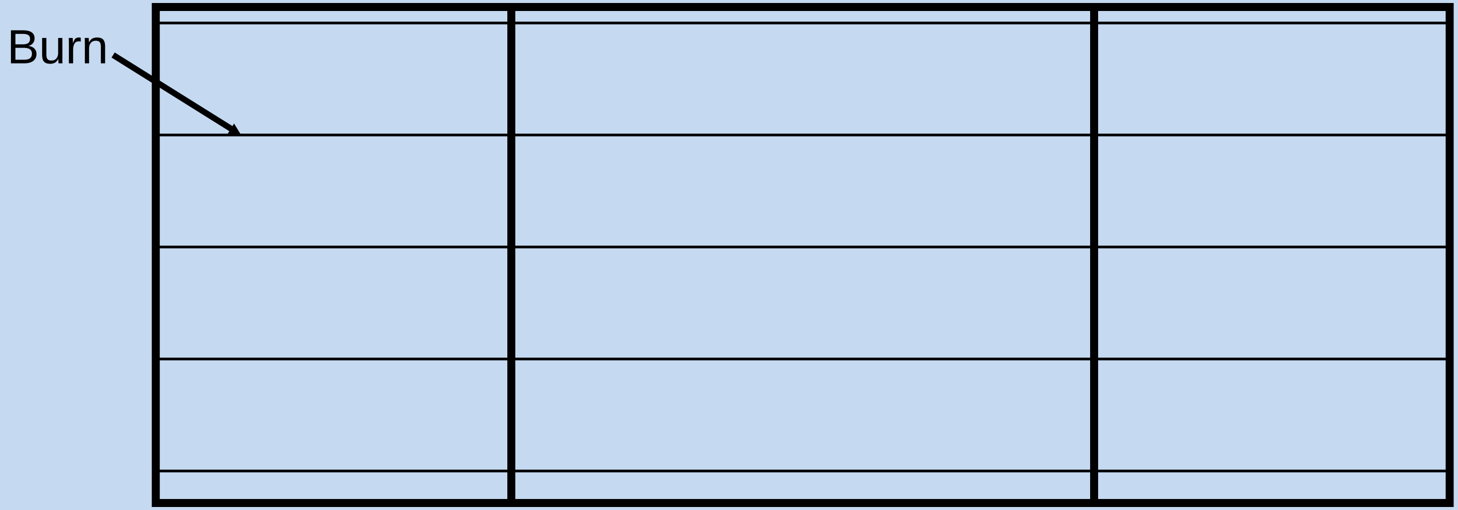


STEP 6: Back gouge, weld and grind 2 butt welds

Flange Sizing - change thickness

STEP 7: Remove and grind 4 run-off tabs

Flange Sizing - change thickness



STEP 8: Burn 4 flanges from 1 assembly

Flange Sizing - change thickness

STEP 8: Burn 4 flanges from 1 assembly

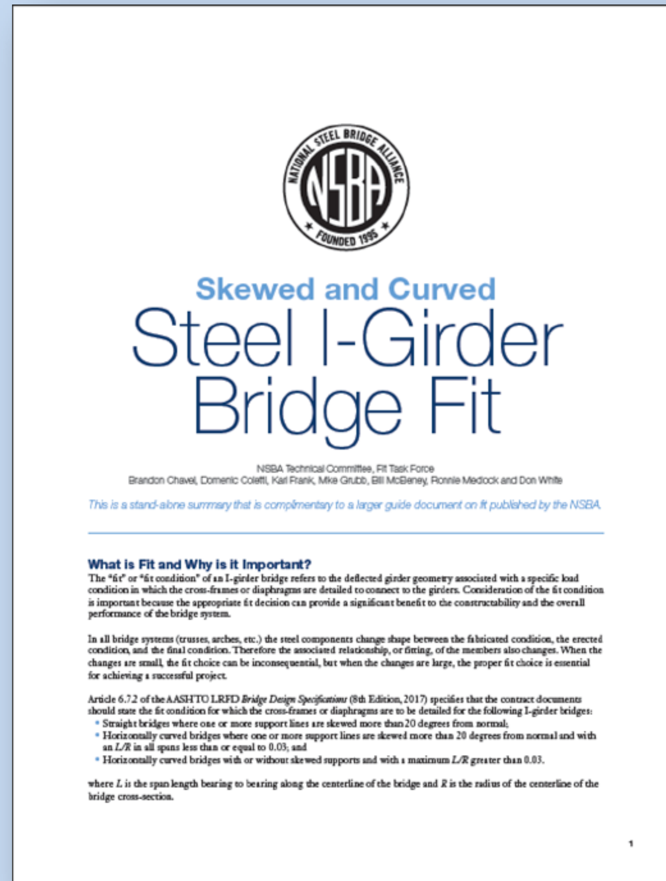
Plate Girders

- Flange Sizing
  - Width transitions increase <u>labor</u> for flange assemblies up to 35%
  - If you must change flange width, do so at bolted field splice (do not clip corners of top flanges)
  - Allow fabricators to eliminate splices within a shipping piece by carrying thicker material through to next designed splice location

Bridge Girder Fit

Skewed and Curved I-Girder Fit Guide

- What is Fit?
- Common Fit Conditions
- Customary Practice
- Recommended Fit Conditions
- Special Considerations
- Design and Analysis
- Conclusion



Skewed and Curved

Steel I-Girder Bridge Fit

NSBA Technical Committee, Fit Task Force
Brandon Chavel, Domenic Coletti, Karl Frank, Mike Grubb, Bill McEleney, Ronnie Medlock and Don White

This is a stand-alone summary that is complimentary to a larger guide document on fit published by the NSBA.

What is Fit and Why is it Important?

The "fit" or "fit condition" of an I-girder bridge refers to the deflected girder geometry associated with a specific load condition in which the cross-frames or diaphragms are detailed to connect to the girders. Consideration of the fit condition is important because the appropriate fit decision can provide a significant benefit to the constructability and the overall performance of the bridge system.

In all bridge systems (trusses, arches, etc.) the steel components change shape between the fabricated condition, the erected condition, and the final condition. Therefore the associated relationship, or fitting, of the members also changes. When the changes are small, the fit choice can be inconsequential, but when the changes are large, the proper fit choice is essential for achieving a successful project.

Article 6.7.2 of the AASHTO LRFD *Bridge Design Specifications* (8th Edition, 2017) specifies that the contract documents should state the fit condition for which the cross-frames or diaphragms are to be detailed for the following I-girder bridges:

- Straight bridges where one or more support lines are skewed more than 20 degrees from normal;
- Horizontally curved bridges where one or more support lines are skewed more than 20 degrees from normal and with an L/R in all spans less than or equal to 0.03; and
- Horizontally curved bridges with or without skewed supports and with a maximum L/R greater than 0.03.

where L is the span length bearing to bearing along the centerline of the bridge and R is the radius of the centerline of the bridge cross-section.

1

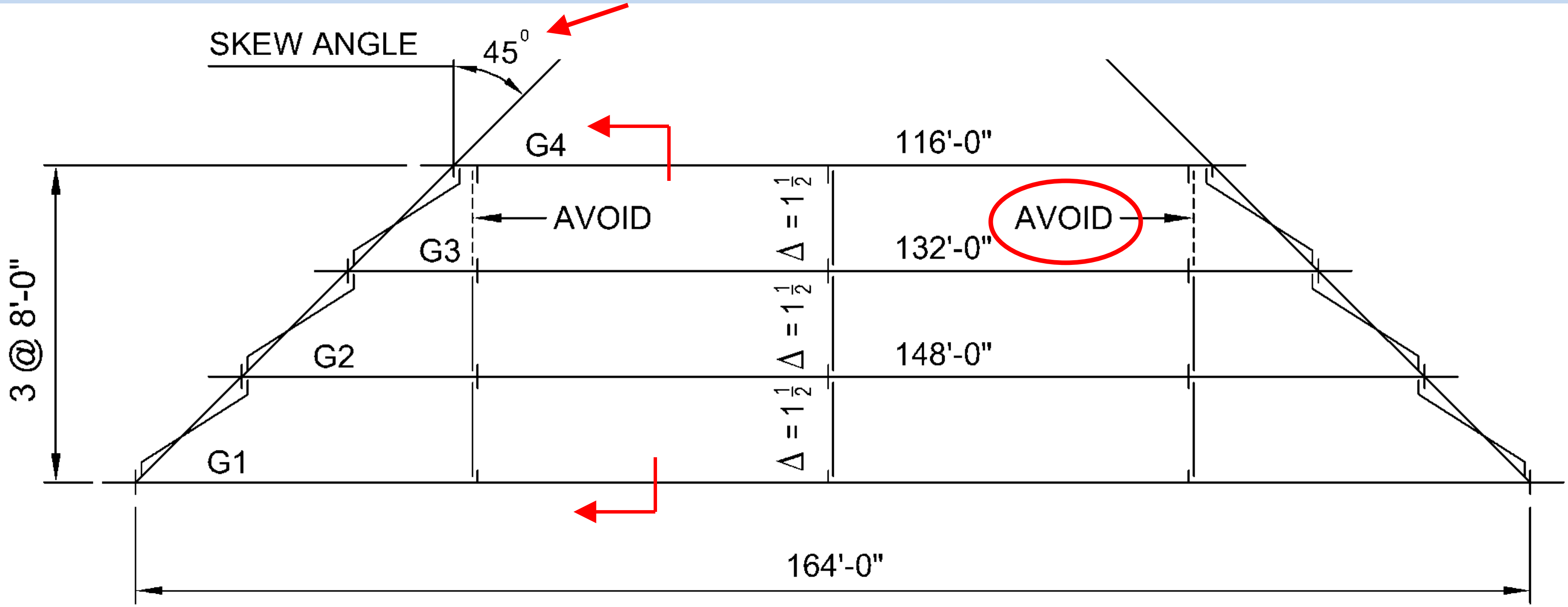
Girder Fit

- The "Fit Decision"
  - Affects design decisions regarding rotation demands on the bearings.
  - Affects internal force effects for which the cross-frames and girders must be designed.
  - Allows Fabricator/Detailer complete shop drawings and successfully fabricate the bridge components.
  - Allows Erector/Contractor assemble the steel and achieve the desired geometry in the field.

Design

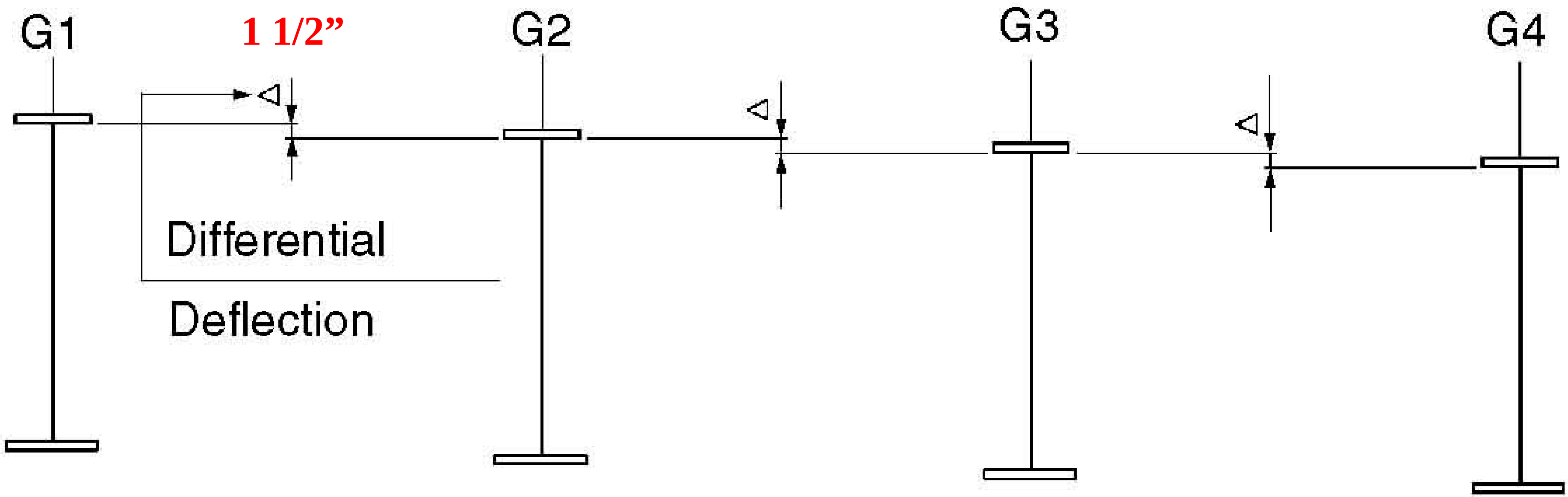
- Differential Dead Load Deflections
  - Skewed girder example
  - Phased construction
    - omit crossframes between phases, if possible
    - otherwise, single angle top & bottom strut (w/ 1 bolt)

Skewed Girders



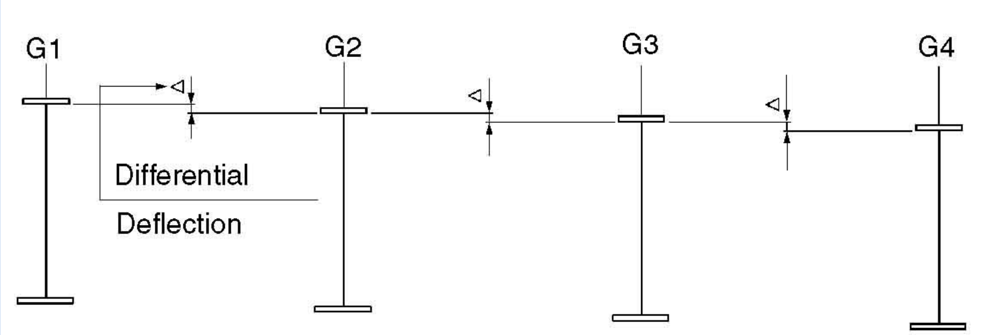
Δ = DIFFERENTIAL DEFLECTION

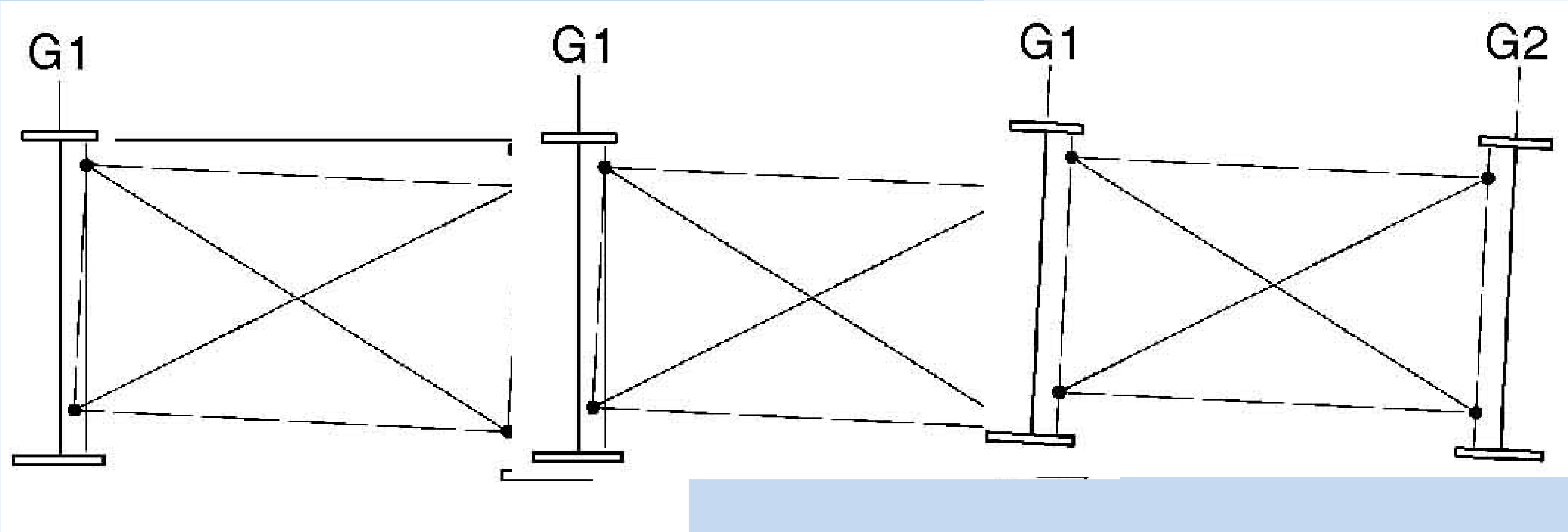
Skewed Girders



STAGE 1

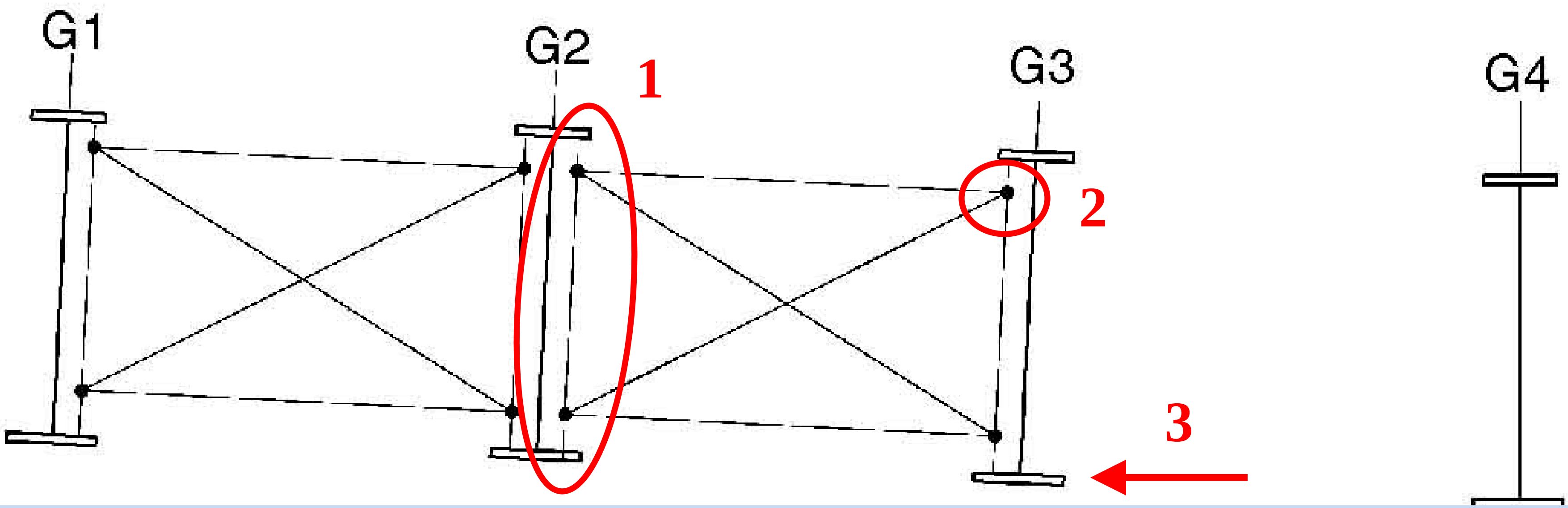
Skewed Girders





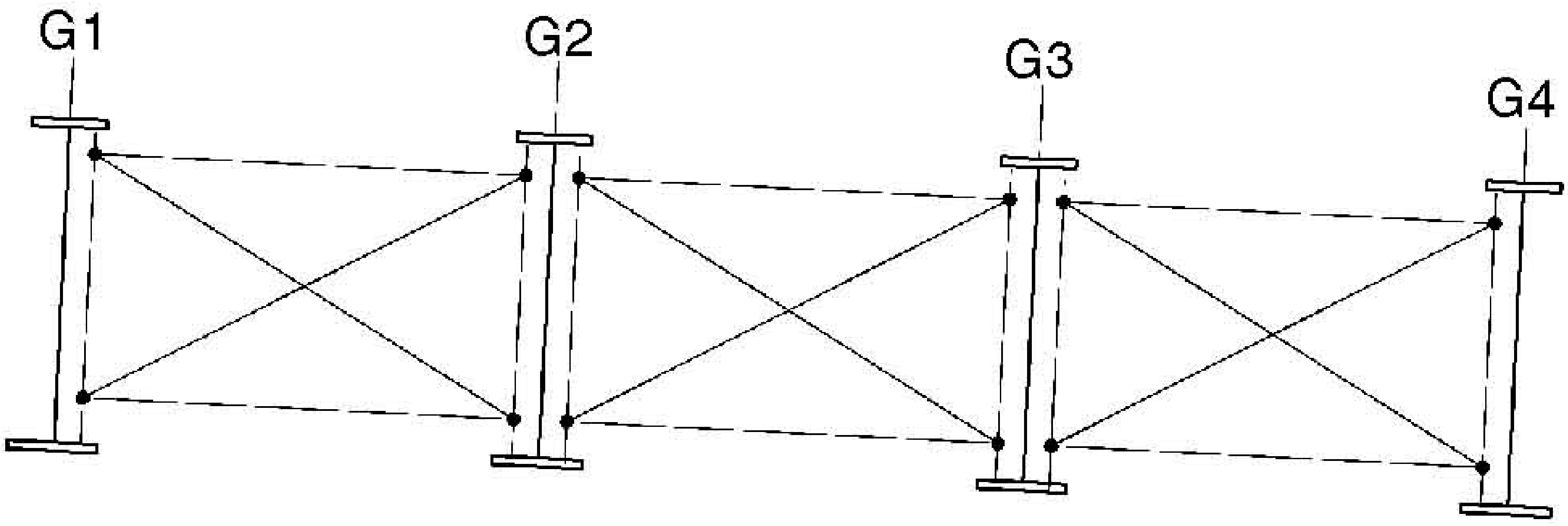
STAGE 2 STAGE 3 STAGE 4

Skewed Girders



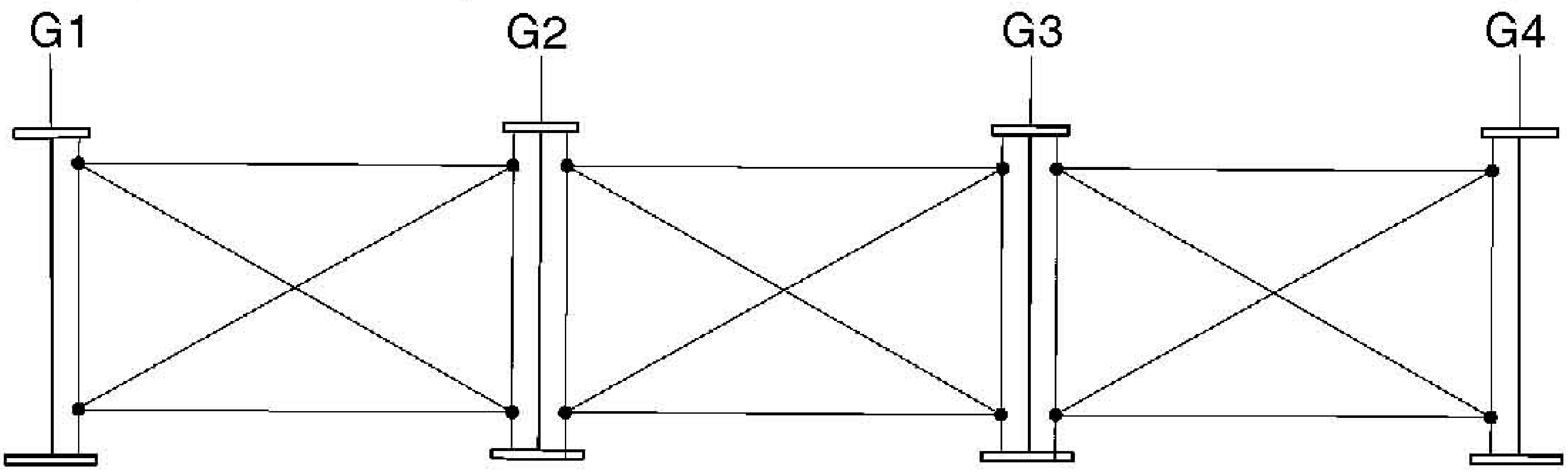
STAGE 5

Skewed Girders



STAGE 6

Skewed Girders



STAGE 7

Bridge Connection Details

Plate Girders

- Bearing Stiffeners/Diaphragms, Connection & Intermediate Stiffeners
- Welding
- General Details

Plate Girders

Bearing Stiffeners/Diaphragms, Connection & Intermediate Stiffeners

- Bearing stiffeners can be either fabricated normal to top flange or vertical (plumb) under full dead load (DL) – there is no clear benefit one way or the other
- Connection (and intermediate) stiffeners should be normal to top flange

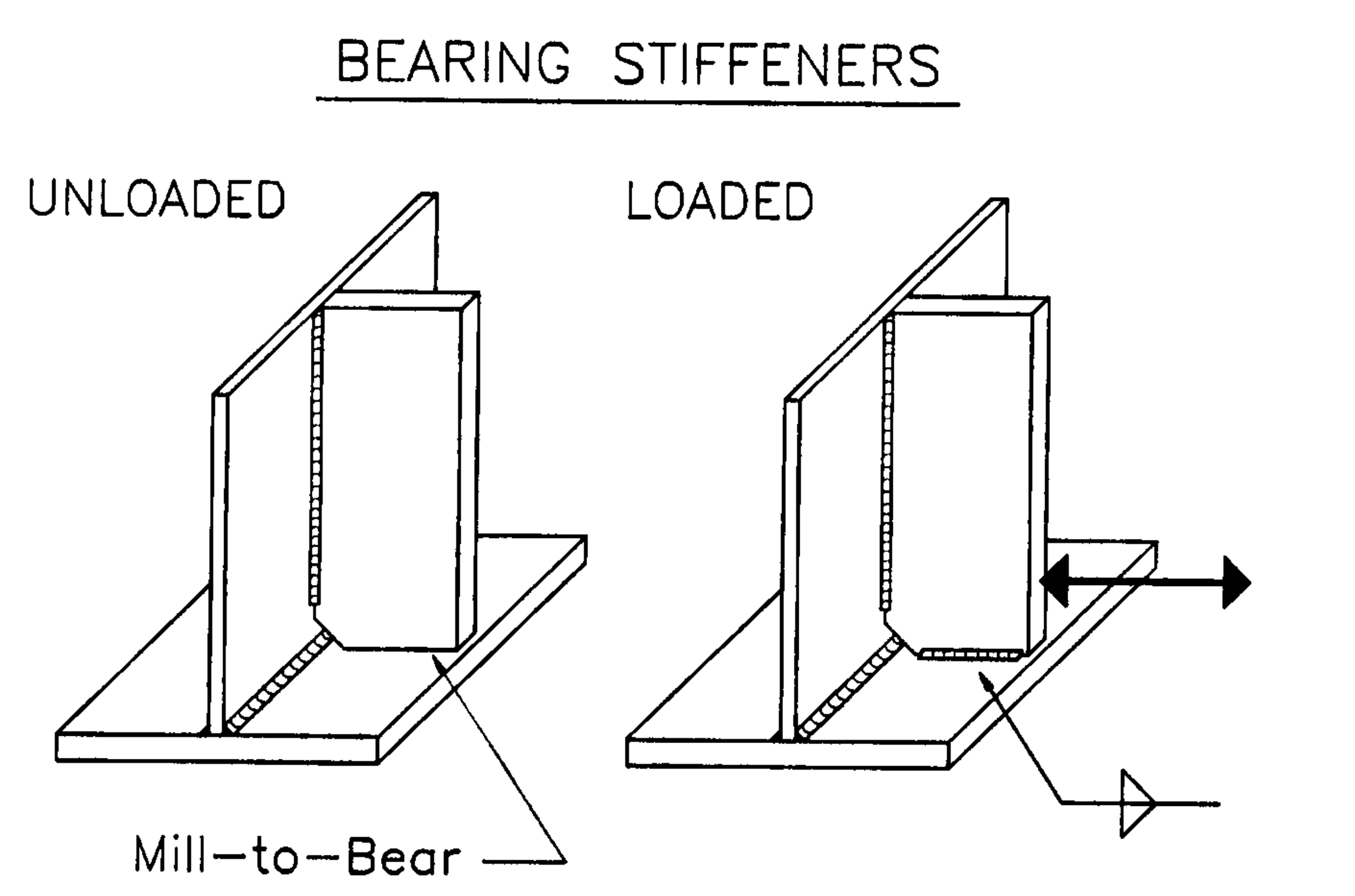
Bearing Stiffeners

Bearing Stiffener Attachment

– mill to bear fit on bottom flange
  - add a fillet weld (if transversely loaded)

- **NO** Complete joint penetration (CJP) weld
- AWS D1.5 tolerances for fit between underside of bottom flange and bearing sole plate (projected area of bearing stiffeners and web)

Bearing Stiffeners



Bearing Stiffeners

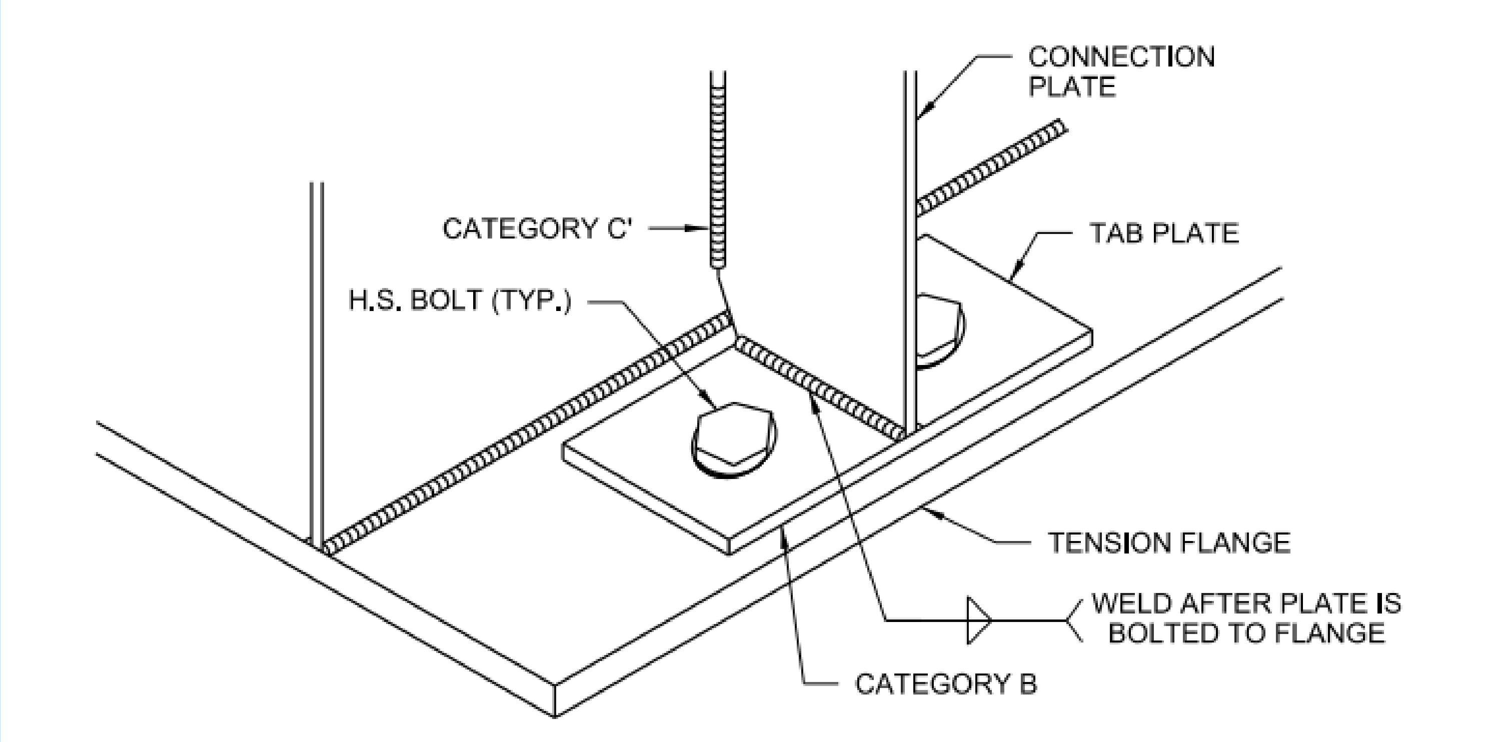
Pipe Option for Skewed Girders

Connection Stiffeners

Connection Stiffener Attachment

- attach to top and bottom flanges
- welds to tension flanges ARE ALLOWED as long as the live load stress range does not exceed the allowable fatigue stress
- if needed, use bolted tab plates ONLY at the specific location, not at all connection plates
- good placement of connection plates should eliminate need for any tab plates

Connection Stiffener Attachment

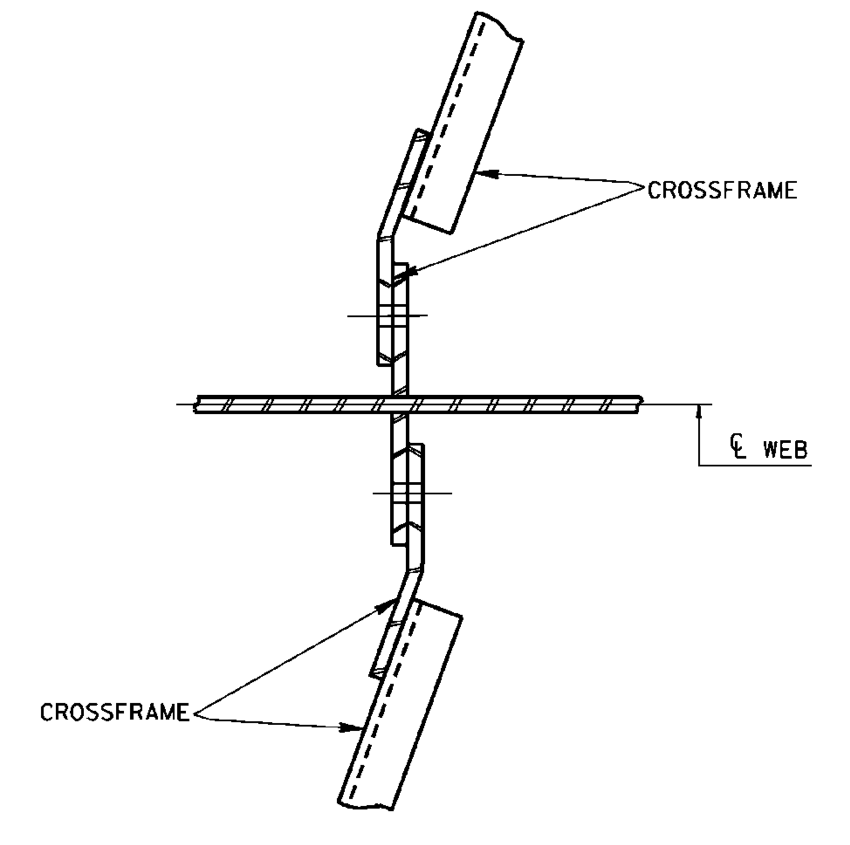


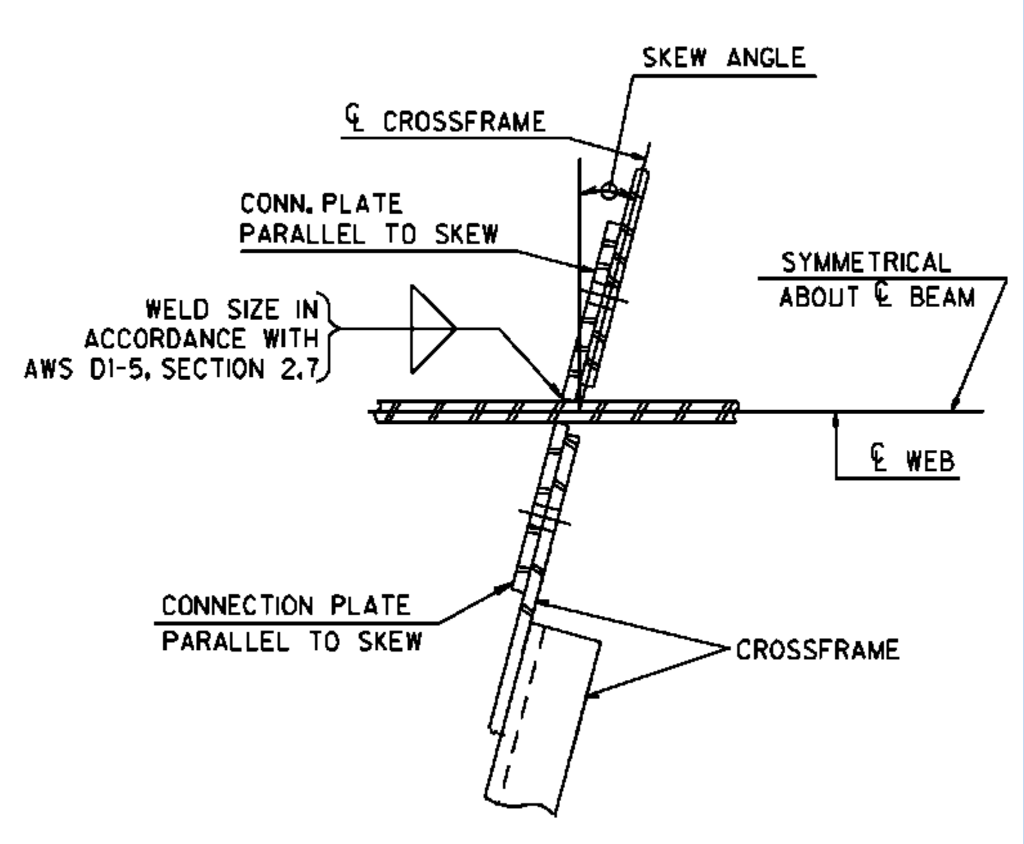
•Bolted Tab Plate

(NOT RECOMMENDED)

Skewed Cross Frame Connections

20° maximum skew





preferred (by fabricators)

Skewed Cross Frame Connections

Give the fabricator the option to use either a skewed connection or bent gusset plates.

Skewed Cross Frame Connections

Rolled beams

- Connection stiffener alternate for rolled beams
  - AASHTO requirements revised in 2011 to allow ‘bolted clip angle’ for intermediate diaphragms – see 6.6.1.3.1

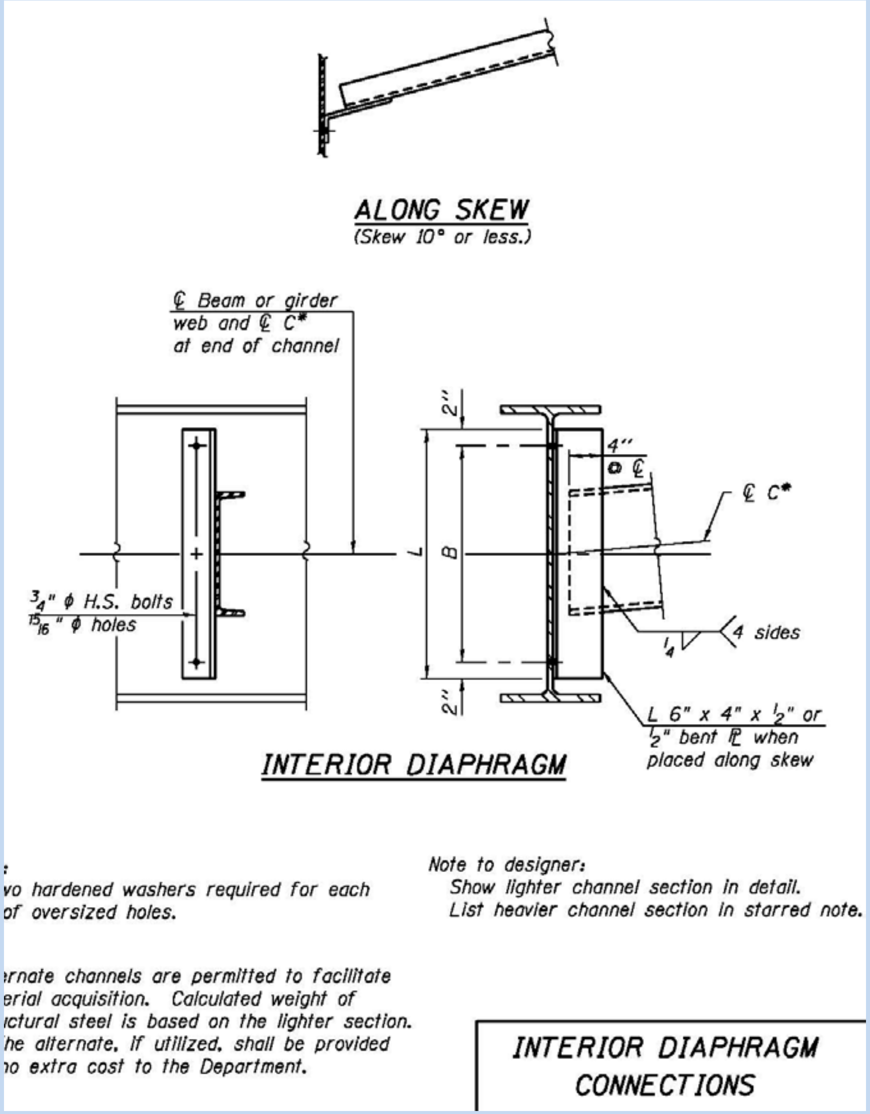


Plate Girders

- General Details
  - Intermediate Stiffeners – weld to compression flange, tight fit (per AWS D1.5) to tension flange (not required, but may help fabricator to control flange tilt)

Plate Girders

- General Details
  - Cross Frame design

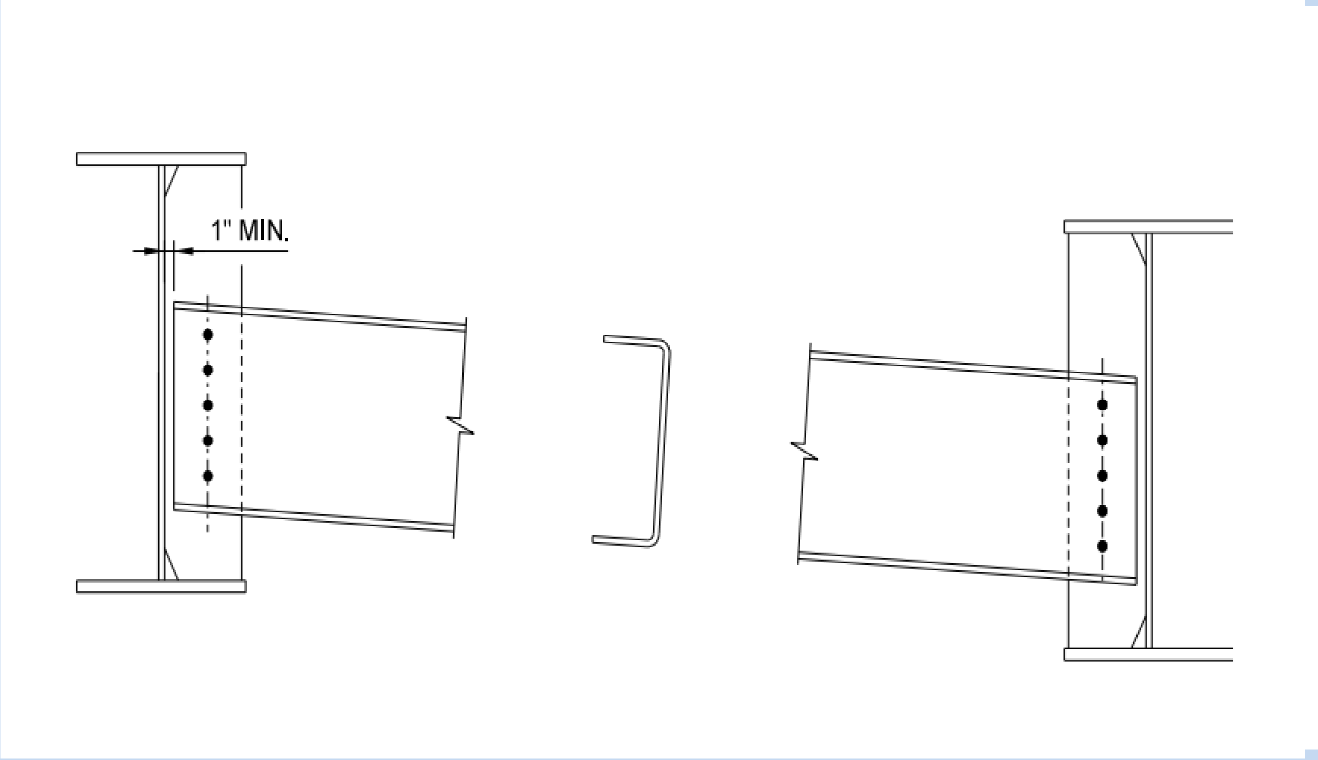


Plate Girders

- General Details
  - Curved Plate Girders
    - heat curve / cut curve
  - Rolled Beams
    - cold camber OK

Shipping/Fabrication Piece Limits

- To have the most competition:
  - Length < 80 feet
  - Weight < 40 tons
  - Height < 9 feet tall

- To ship by road, 'max'
  - Length < 175 feet
  - Weight < 90 tons
  - Height < 13.5 feet (on side), < 9.5 feet (upright)
  - Width < 16 feet

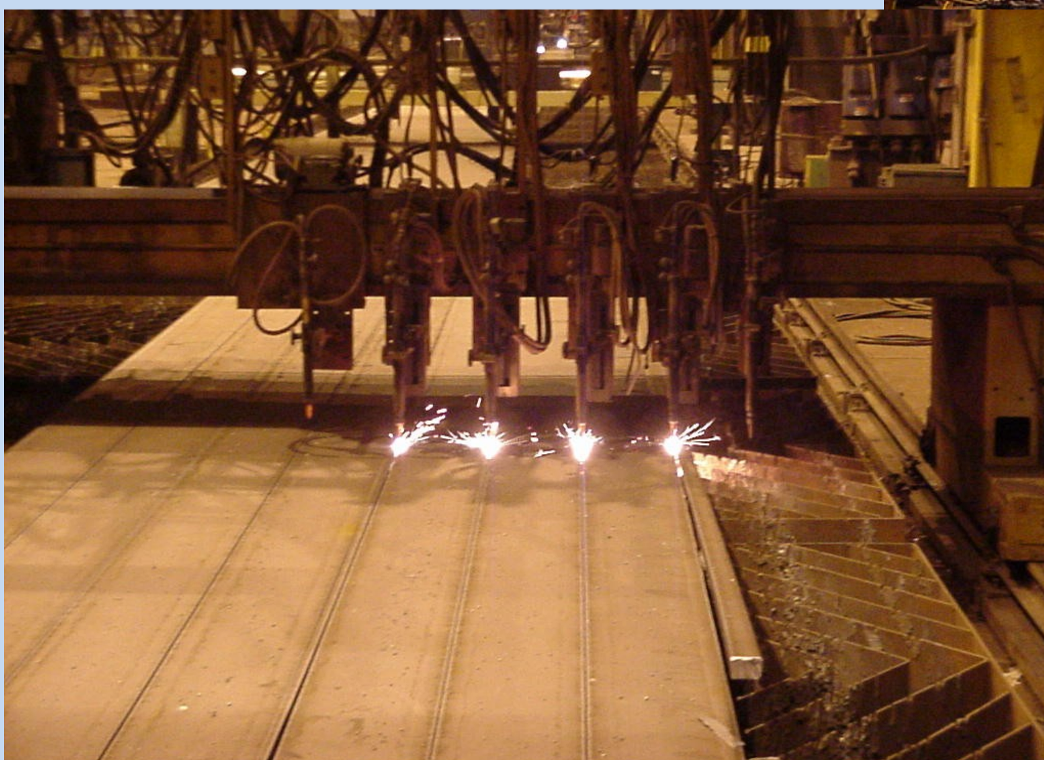
Steel Plate Girder Fabrication

Main Steps

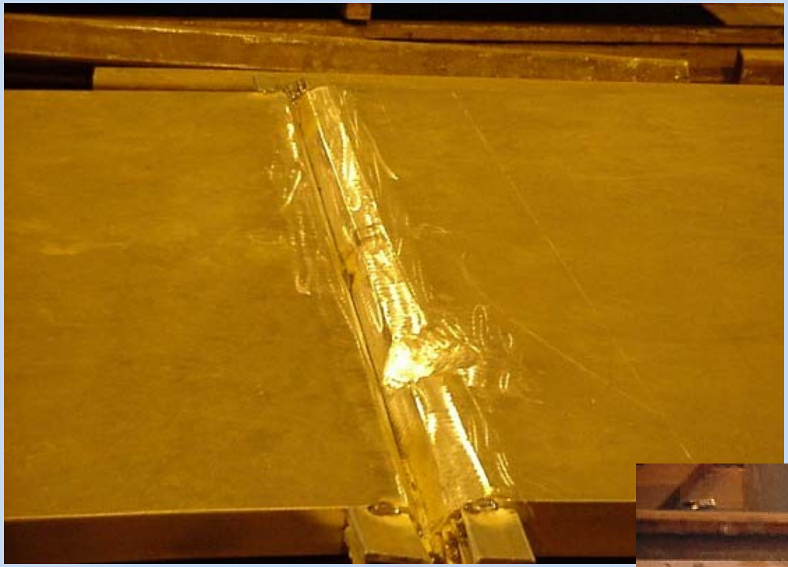
- Preparation
- Girder Assembly
- Fit & Weld Components
- Laydown
- Cleaning & Painting
- Final Inspection
- Shipping

Raw Material

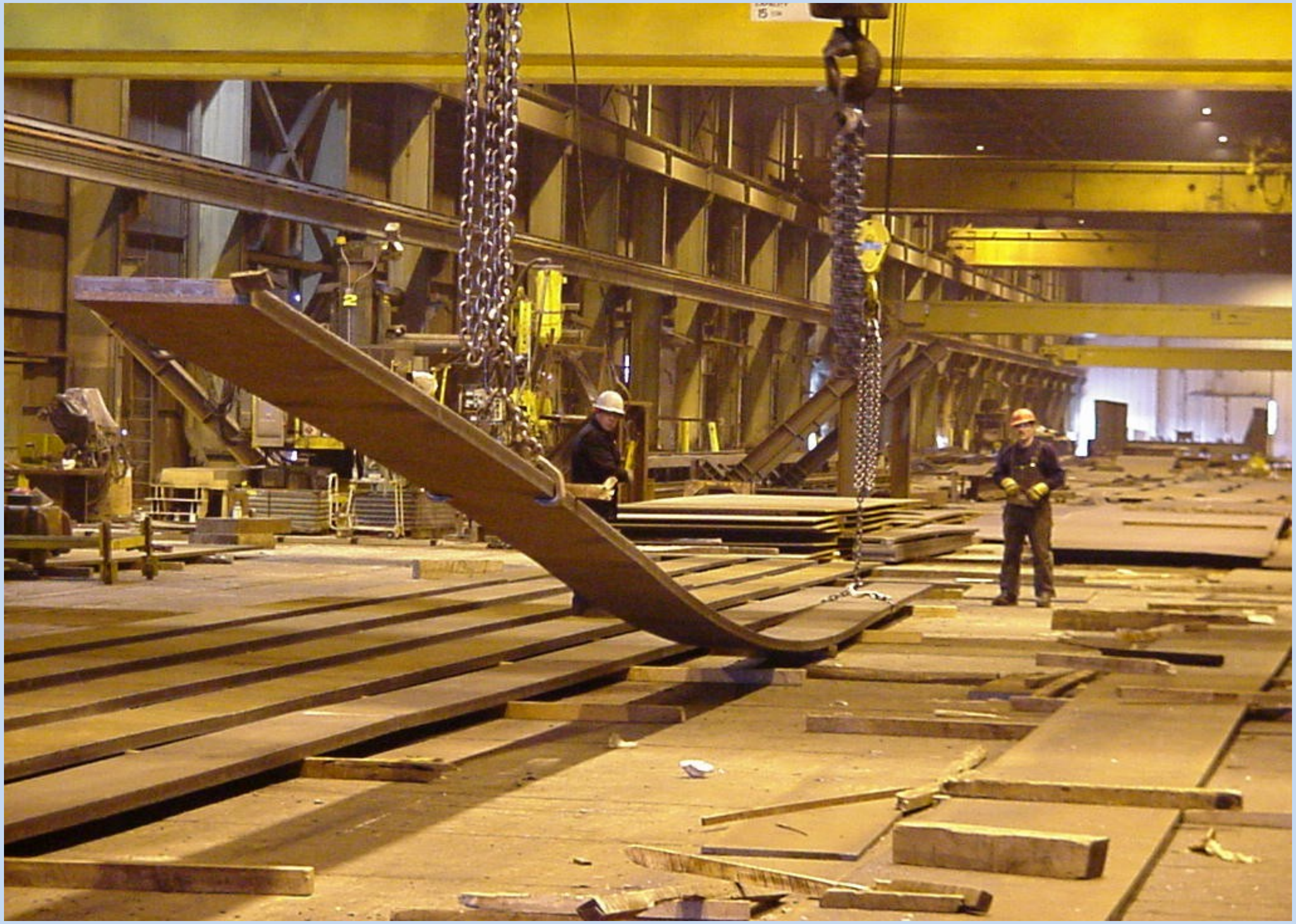
Burning



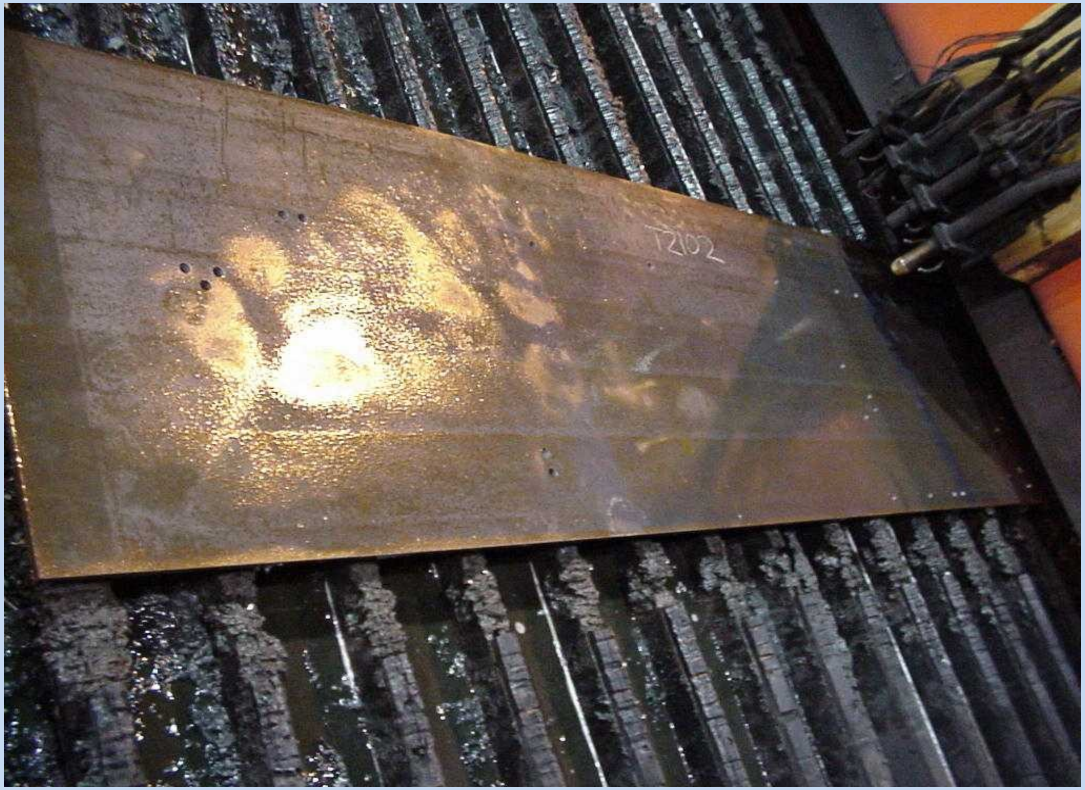
Shop Splicing (SAW)



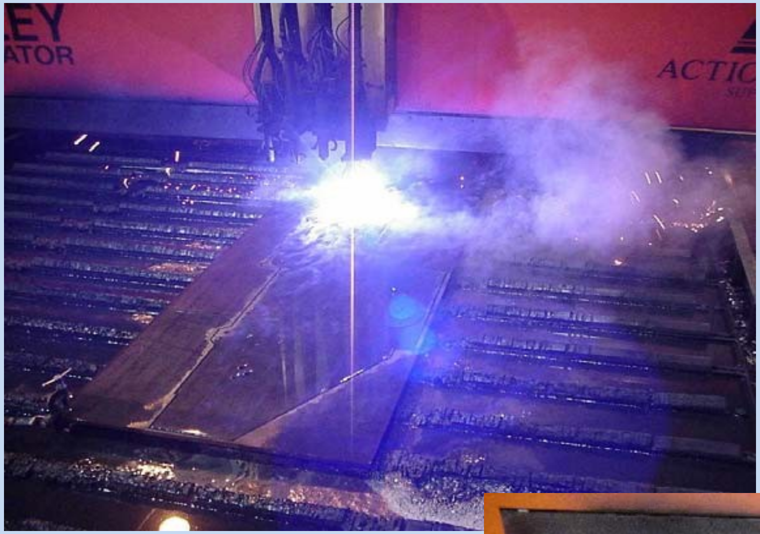
Material Handling



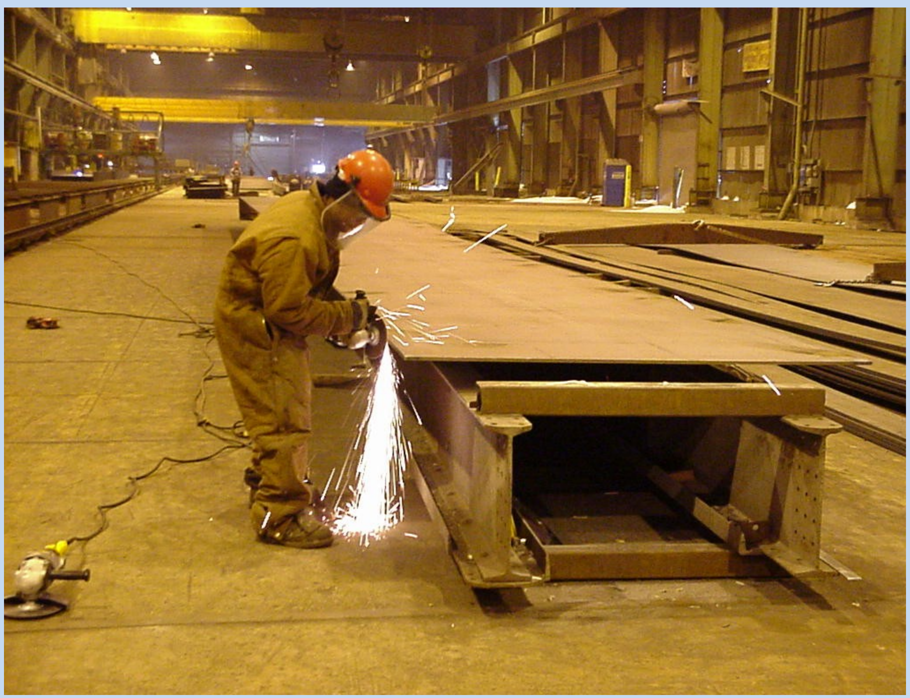
Plasma Burning



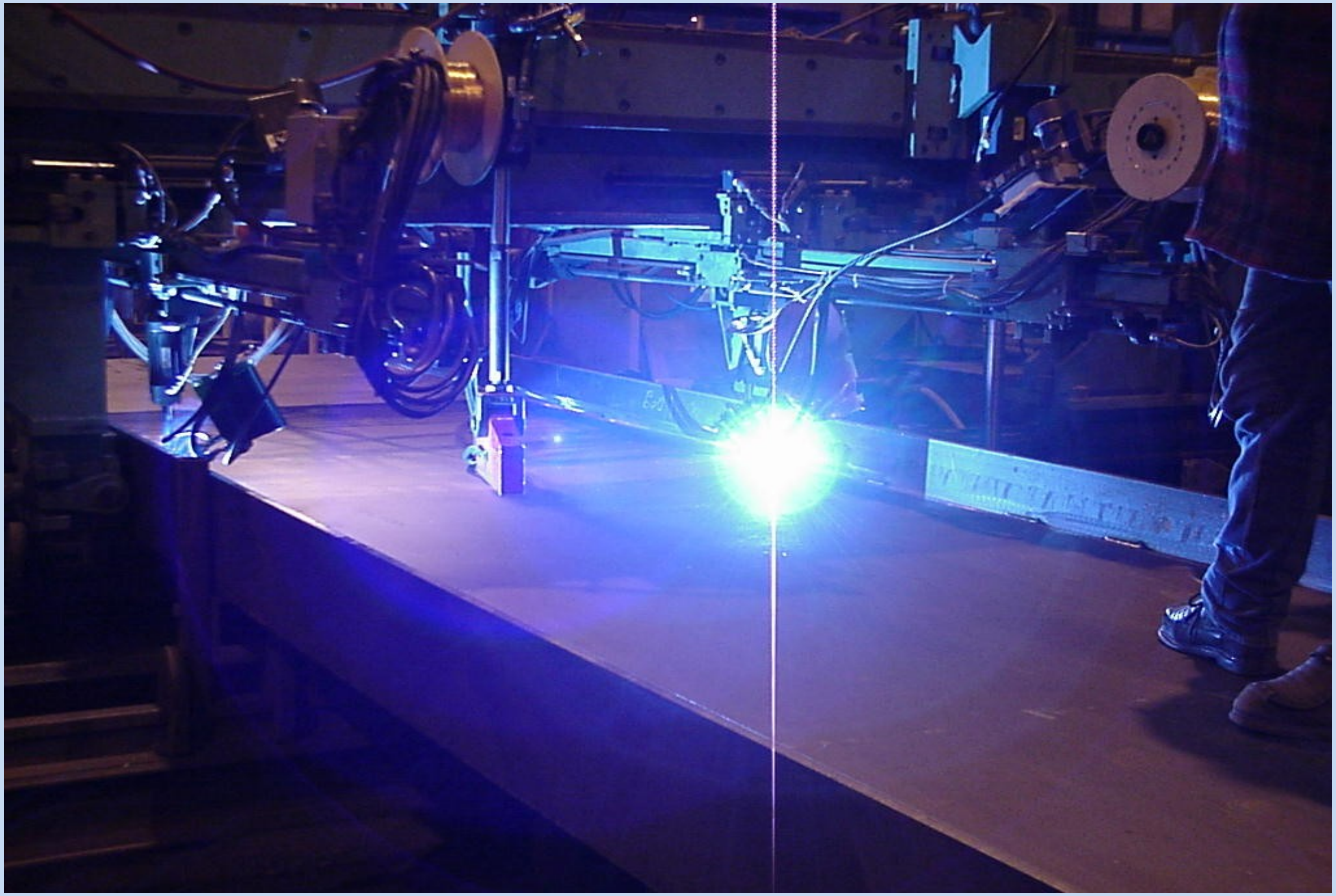
Plasma Burning



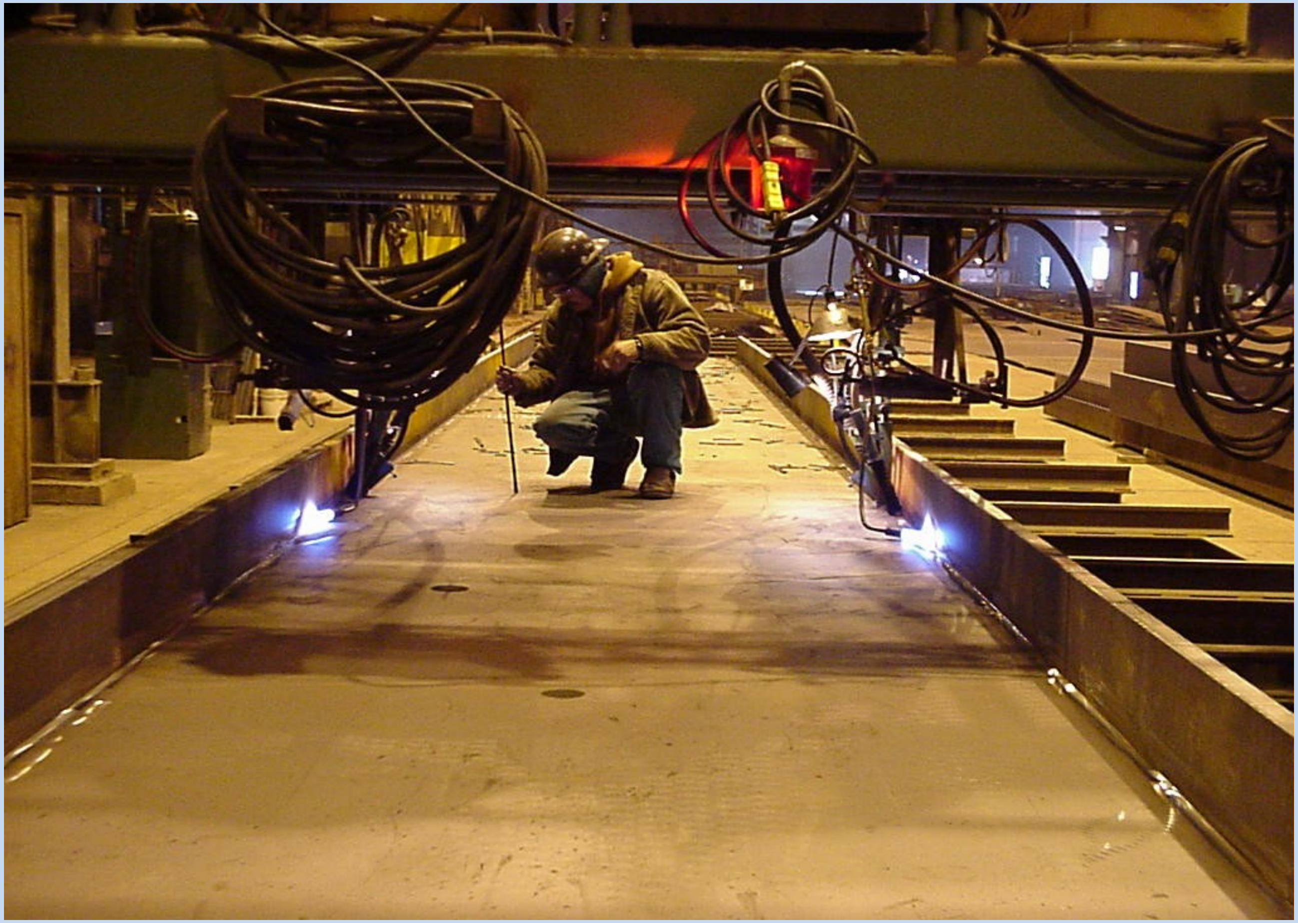
Girder Assembly



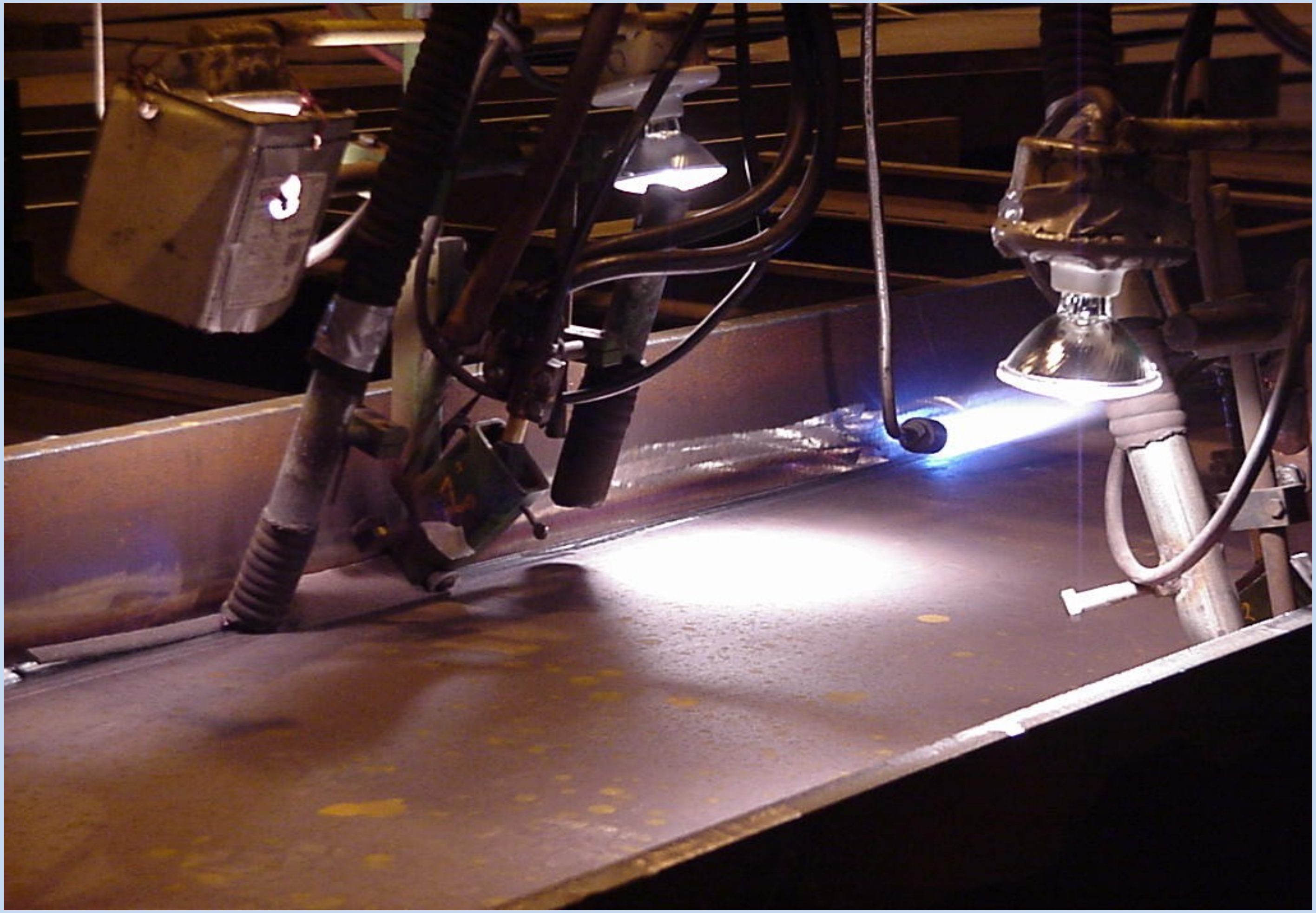
Clamp & Tack Web to Flange (GMAW)



Web to Flange Continuous Welding



Web to Flange Continuous Welding



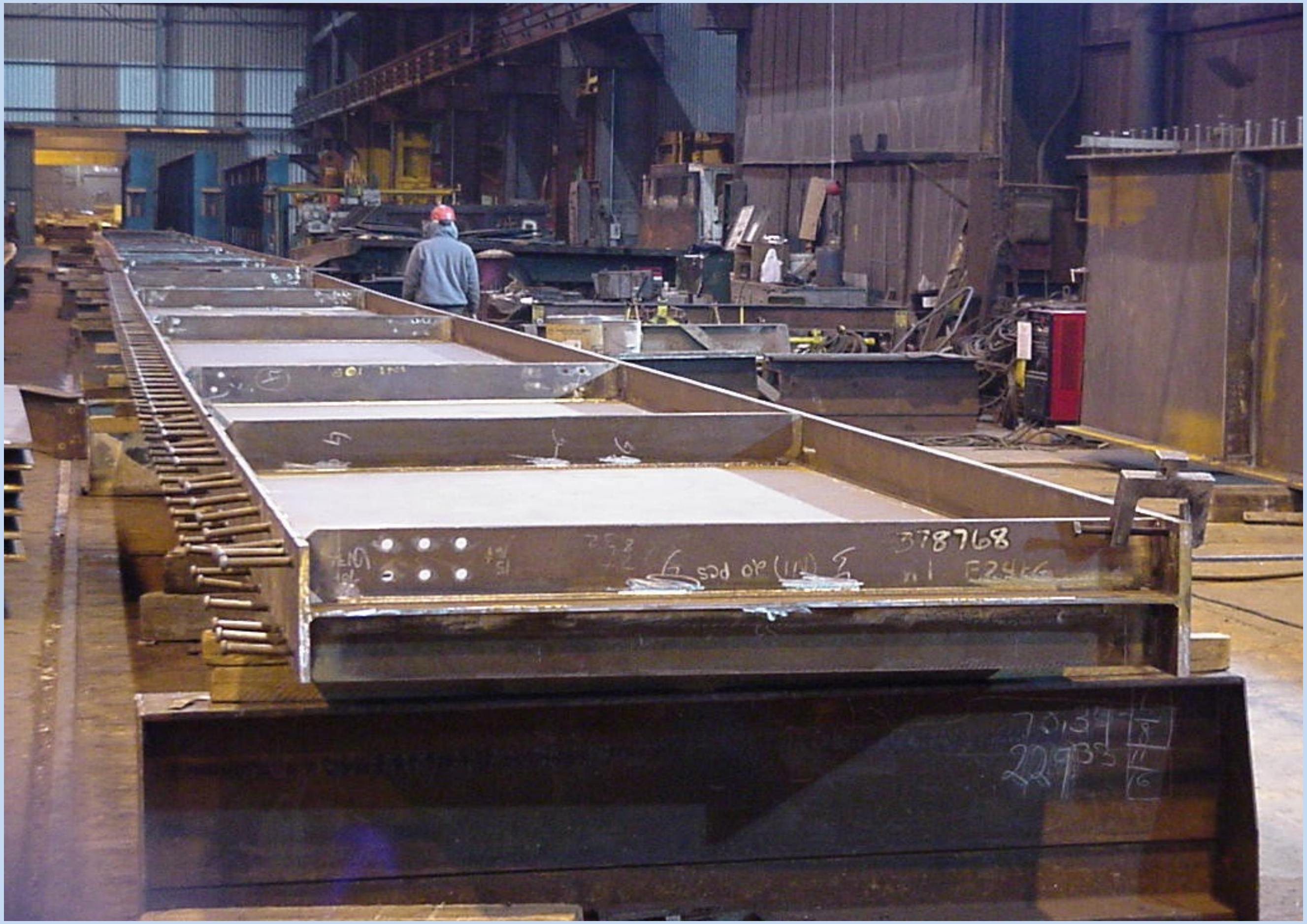
Fit & Weld Components

Inspection & Quality Control

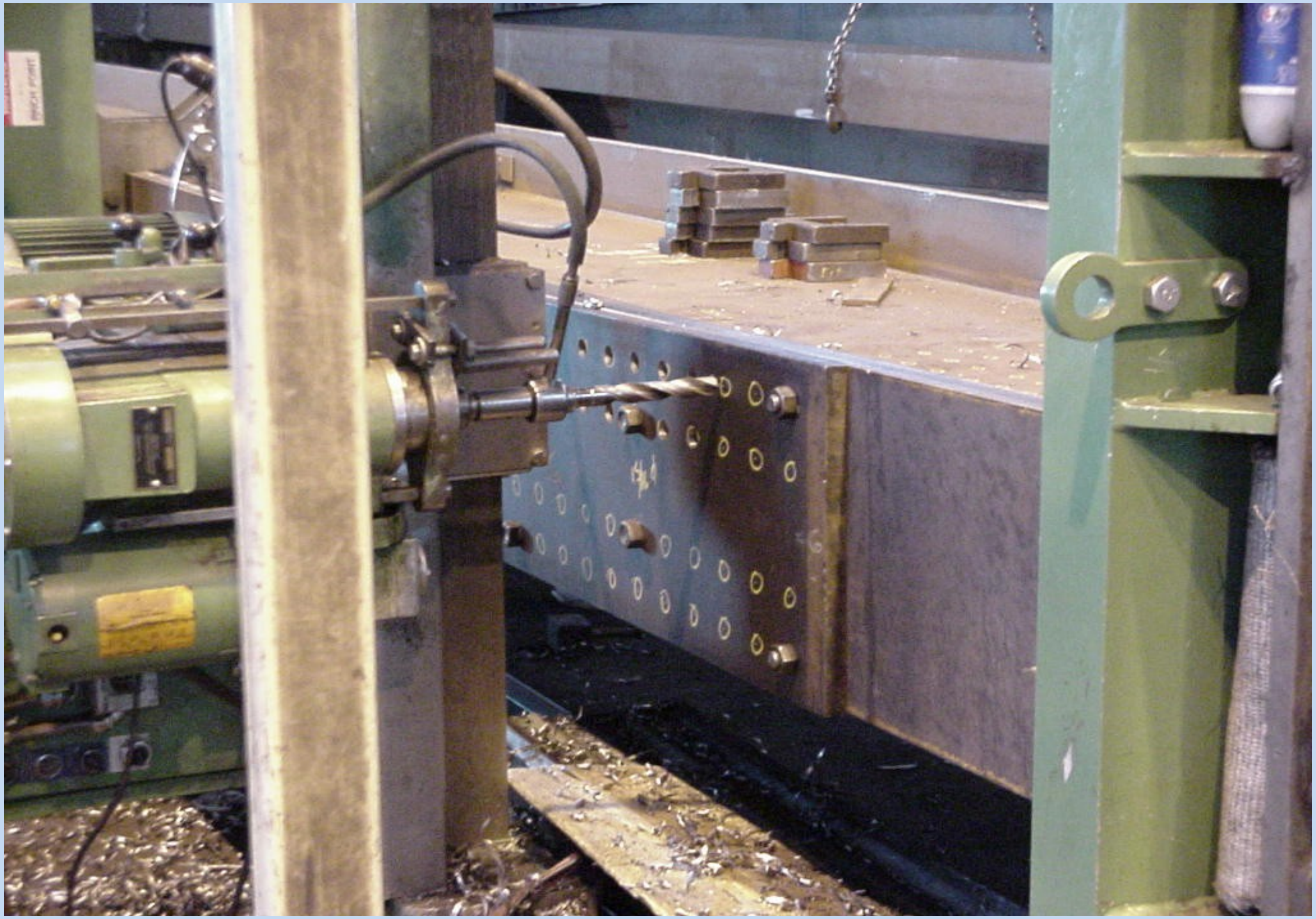
Fit & Weld Components

Laydown – Vertical Assembly

Laydown – Horizontal

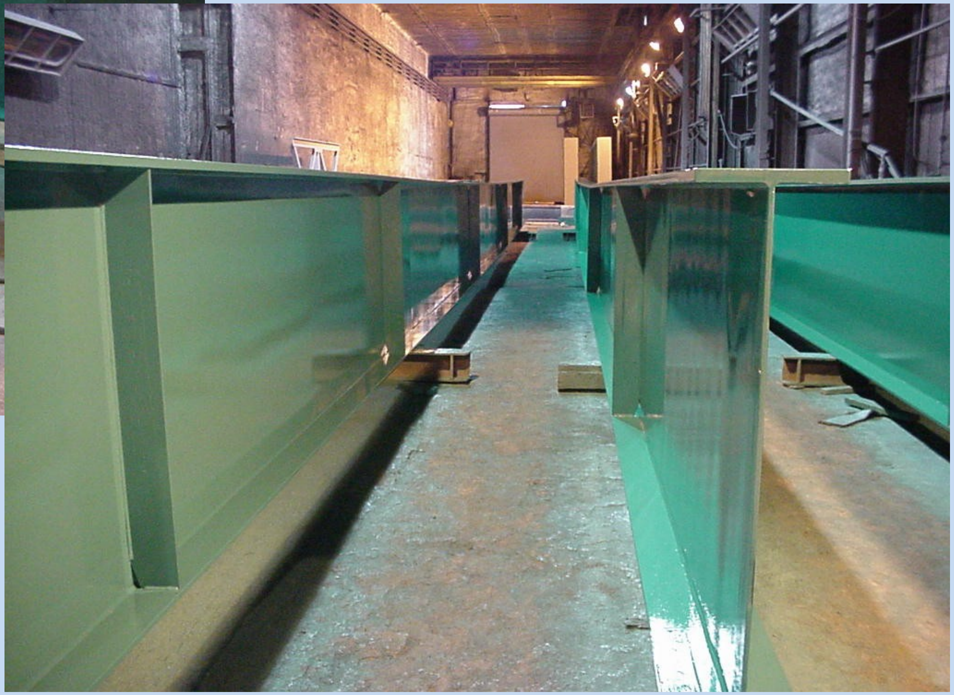


Laydown – Horizontal



Cleaning & Painting

Cleaning & Painting



Final Inspection

Shipping

Shipping

Shipping

Erection & Placement

Bolted Splice Design

Field Erection

•Note 2 rows of bolts each side of web and 16 bolts each flange

AASHTO LRFD Design Changes

1. New ASTM Bolt Specifications
2. Bolt Design
3. Standard Hole Sizes
4. Girder Field Splice Design

ASTM Specifications High Strength Bolts

- New Specification Combines 4 Specifications into 1 for both buildings and bridges-F3125
  - A325 Standard Hex Bolt
  - F1852 (A325 Tension Control)
  - A490 Standard Hex Bolt
  - F2280 (A490 Tension Control)
  - \+ Metric

  } F3125

- The old names become Grades

F3125 Significant Changes

1. Grade A325: F_u = 120 ksi for all diameters (results in an increase in shear capacity for bolts >= 1 in. and increase in required installation tension)
2. Annex A1- Table gives permitted coatings and over tapping required for nuts
   - No hot dip or mechanical galvanizing of Grade A490 bolts
   - F1136 and F2833 Zinc/Aluminum Allowed on **all** Grades Both A325 and A490

Slip Critical Connections

Class	Typical Surface	Slip Coefficient	
		Old Spec.	New Spec.
A	Mill Scale	0.33	0.30
B	Zinc-Rich Paint, Blasted, *Metalized	0.50	0.50
C	Galvanized	0.33	0.30
D	Organic Zinc- Rich Paint	-	0.45

*Unsealed metalized zinc or 85/15 zinc aluminum, sealed metalized coatings are not included.

Bolt Holes

- Hole diameter for bolts greater than or equal to 1″ in diameter is increased to the nominal diameter of the bolt plus 1/8″. This eliminates the need to field ream holes to fit large-diameter hot forged bolts, which have a longitudinal forging seam that interferes with holes 1/16″ larger than the bolt diameter.
- Miss drilled holes- fill with fully tensioned high strength bolt (Category B fatigue strength).

Bolted Field Splices of Flexural Members

Remove applicability of the 75 percent and average rules in Article 6.13.1 to the design of bolted and welded splices for flexural members.

Revise general article on design of bolted splices for flexural members implementing new simplified bolted splice design procedure.

Removal of check for slip of bolts during erection of steel.

Simplified design procedure produces more economical field splice designs.

.

Splice Design Procedure

Design Flange Connection to Develop the Smallest Design Yield Resistance of the Connected Flanges.

$$P_{fy} = F_{yf} A_e$$

Design Web Connection to Develop the Smallest Factored Shear Resistance of the Connected Webs.

$$V_r = \phi_v V_n$$

Two Rows of bolts minimum on each side of splice.

Typical Girder Field Splice

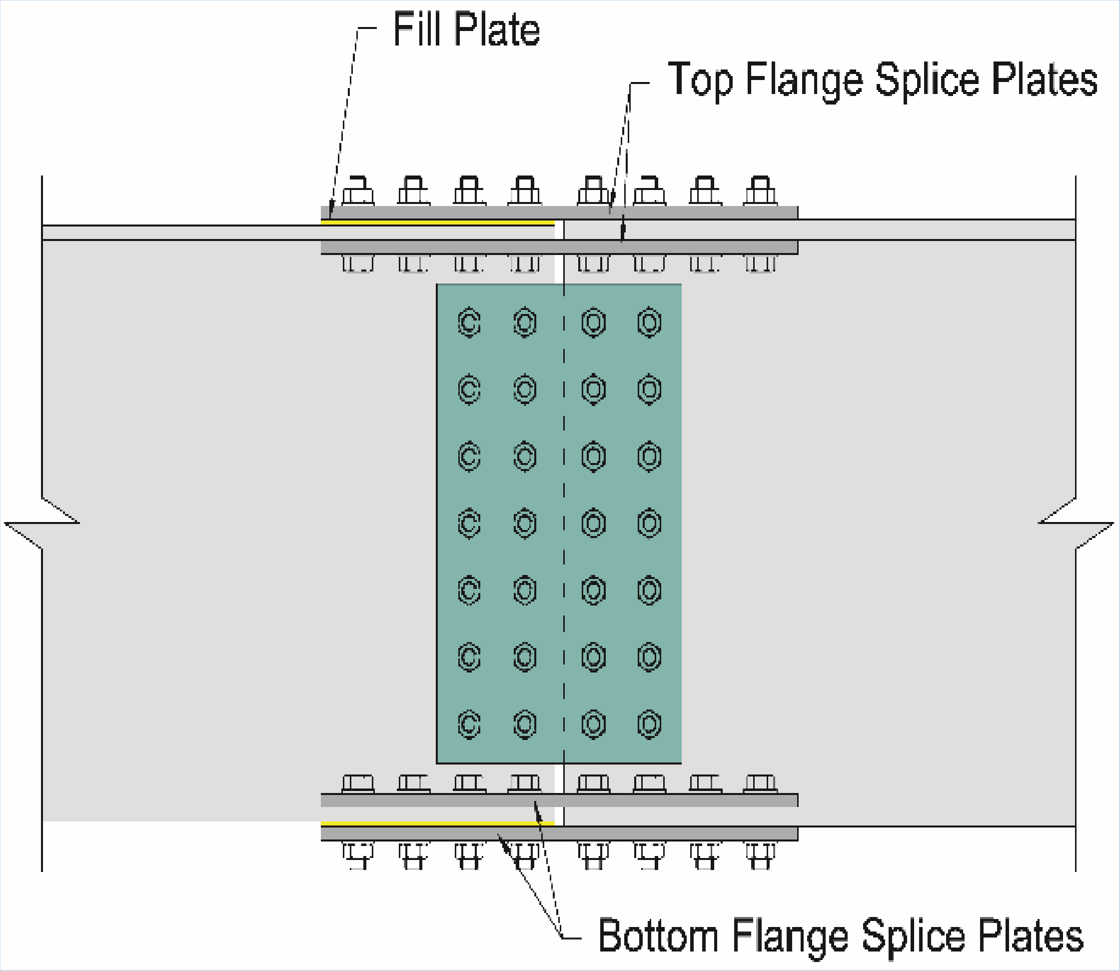


Plate Girder Field Splice

- Field Splice
- 92 bolts in each web
- 32 bolts each flange

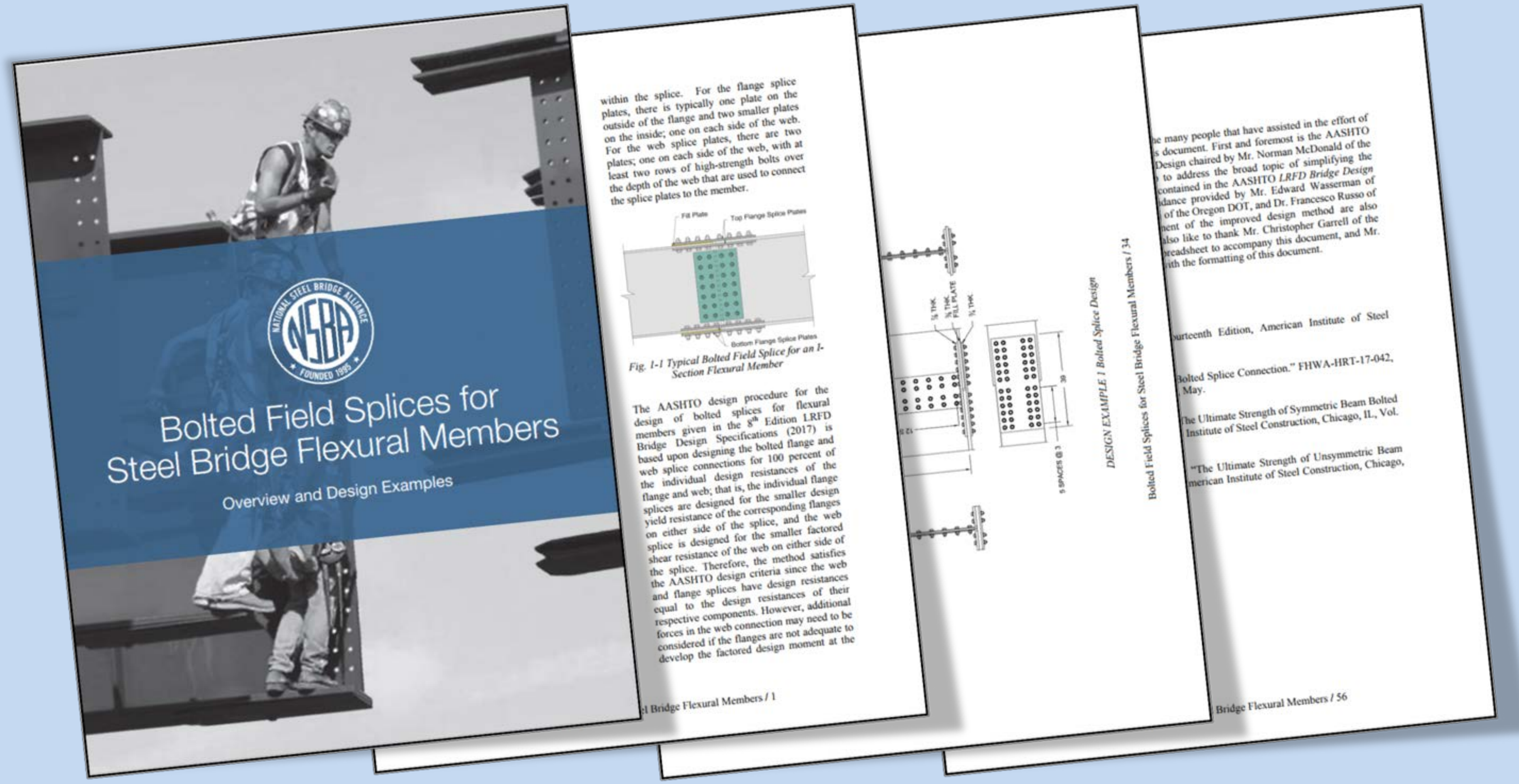
- Bolts: 312x$20= $6,240
- Labor: 312x10 min= 52 field hours each splice

Tub Girder Splice

- Field Splice
- 36 bolts each top flange
- 80 bolts in each web
- 85 bolts bottom flange
- 634 bolts
- 1,902 holes

- Bolts: 634x$20= $12,680
- Labor: 634x10 min= 106 field hours each splice

Overview & Design Examples



NSBA Splice Spreadsheet - Input

NSBA Bolted Splice Designer - Plate Girder

Cell Fill Color
- User Input Field
- Spreadsheet Status Field
- Spreadsheet Calculated Field

Design Input

Unfactored Loads - Splice Centerline

	Moment (kip-ft)	Shear (kip)
Noncomposite Dead Load (DC_1)	248.00	-82.00
Superimposed Composite Dead Load (DC_2)	50.00	-12.00
Future Wearing Surface (DW)	52.00	-11.00
Positive Live Load plus Impact (LL^+ + I)	2469.00	19.00
Negative Live Load plus Impact (LL^- + I)	-1754.00	-112.00
Deck Casting	1300.00	-82.00

Girder Properties

	Left	Right
Top Flange Material	Grade 50W	HPS Grade 70W
Top Flange Thickness (in)	1	1
Top Flange Width (in)	16	18
Web Material	Grade 50W	Grade 50W
Web Thickness (in)	1/2	9/16
Web Depth (in)	69	

Bolt Properties

Bolt Type	A325	
Bolt Diameter (in)	7/8	
Web Threads	Included	
Flange Threads	Excluded	
Surface Condition Factor (K_s)	B	
Hole Size Factor (K_h)	Standard	
Top Flange Rows	4	OK
Web Rows	2	OK
Bottom Flange Rows	4	OK

Concrete Deck Properties

Composite	Composite
Thickness (in)	9
Haunch (in)	0

Spacing and Clearance Values

EULA | Input | Figures | Design Result Summary | Design Check Summary | Flange Splice Design | Web Splice Design

Flange Splice Calculations

NSBA Bolted Splice Designer - Plate Girder

NOTICE: DO NOT MODIFY THIS SHEET

Flange Calculations

Load Combinations - Factored Moment

	Moment (kip-ft)						
	Noncomposite Dead Load (DC1)	Superimposed Composite Dead Load (DC2)	Future Wearing Surface (DW)	Positive Live Load plus Impact (LL+ + I)	Negative Live Load plus Impact (LL- + I)	Deck Casting	
Load Combination	248.00	50.00	52.00	2469.00	-1754.00	1300.00	Factored (kip-ft)
Deck Casting	0.00	0.00	0.00	0.00	0.00	1.40	1,820.00
Strength I - Positive	1.25	1.25	1.50	1.75	0.00	0.00	4,771.25
Strength I - Negative	0.90	0.90	0.65	0.00	1.75	0.00	-2,767.50
Service II - Positive	1.00	1.00	1.00	1.30	0.00	0.00	3,559.70
Service II - Negative	1.00	1.00	1.00	0.00	1.30	0.00	-1,930.20

Bolt Factored Shear Resistance

Location	Bolt Type	Bolt Area (sq-in)	K_h	ϕ_s	F_u (ksi)	P_t (kip)	R_r - Single Shear (kip)	R_r - D
Flange	A325 - Excluded	0.6013	Standard	0.80	120	39.00	32.33	

Bolt Nominal Slip Resistance

Surface Condition Factor (K_s)	Hole Size Factor (K_h)	P_t (kip)	R_n - Double Shear (kip)
0.50	1.00	39.00	39.00

Strength Limit State Design

Location	F_y (ksi)	F_u (ksi)	0.84 (F_u/F_y)	Width (in)	Thickness (in)	Filler Plate Thickness (in)

EULA | Input | Figures | Design Result Summary | Design Check Summary | Flange Splice Design | Web Splice Design

Web Splice Calculations

NSBA Bolted Splice Designer - Plate Girder

NOTICE: DO NOT MODIFY THIS SHEET

Web Calculations

Load Combinations - Factored Shear

	Shear (kip)						
	Noncomposite Dead Load (DC1)	Superimposed Composite Dead Load (DC2)	Future Wearing Surface (DW)	Positive Live Load plus Impact (LL+ + I)	Negative Live Load plus Impact (LL- + I)	Deck Casting	
Load Combination	-82.00	-12.00	-11.00	19.00	-112.00	-82.00	Factored Shear (kip)
Deck Casting	0.00	0.00	0.00	0.00	0.00	1.40	-114.80
Service II - Positive	1.00	1.00	1.00	1.30	0.00	0.00	-80.30
Service II - Negative	1.00	1.00	1.00	0.00	1.30	0.00	-250.60

Bolt Factored Shear Resistance

Location	Bolt Type	Bolt Area (sq-in)	K_h	ϕ_s	F_u (ksi)	P_t (kip)	R_r - Single Shear (kip)	R
Web	A325 - Included	0.6013	Standard	0.80	120	39.00	25.98	

Bolt Nominal Slip Resistance

Faying Surface Class (K_s)	Hole Size Factor (K_h)	P_t (kip)	Slip Capacity - Double (kip)
0.50	1.00	39.00	39.00

Flange Design Results

Flange Moment Resistance Check Results

	H_w (kip)	Controlling
Positive	DNA	
Negative	DNA	

EULA | Input | Figures | Design Result Summary | Design Check Summary | Flange Splice Design | Web Splice Design

Design Result Summary

NSBA Bolted Splice Designer - Plate Girder

Design Result Summary

Cell Fill Color

- User Input Field
- Spreadsheet Status Field
- Spreadsheet Calculated Field

NOTICE: DO NOT MODIFY THIS SHEET

Bolts Arrangement

	Bolt Rows (Per Side)	Total Bolts (Per Side)
Top Flange	4	12
Web	2	26
Bottom Flange	4	24

	Gage - Bolts (in)	Edge Distance (in)	Pitch - Bolts (in)	End Distance (in)	Gage - Bolt Groups (in)	Pitch - Bolt Groups (in)
Top Flange	3	2	3	1 1/2	6	3 3/4
Web	3	2	5 1/8	1 1/2	4 3/4	DNA
Bottom Flange	4	2	3	1 1/2	6	3 3/4

Splice Plate Dimensions

	Thickness (in)	Width (in)	Length (in)
Top Flange - Outer	5/8	16	18 3/4
Top Flange - Inner (Each)	11/16	7	
Top Filler	0	0	0
Web	3/8	14 3/4	64 1/2
Web Filler	0	0	0
Bottom Flange - Inner (Each)	7/8	8	

EULA | Input | Figures | Design Result Summary | Design Check Summary | Flange Splice Design | Web Splice Design

Steel Bridge Suite

- NSBA Splice
  - 8th Edition AASHTO LRFD
  - Plate Girder Bolted Splice Design Tool

NSBA Overview

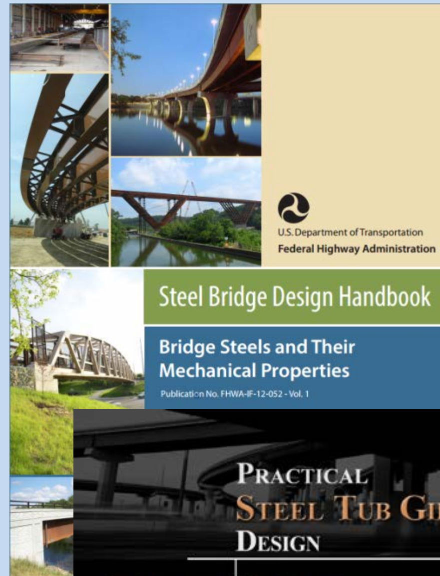
What We Do

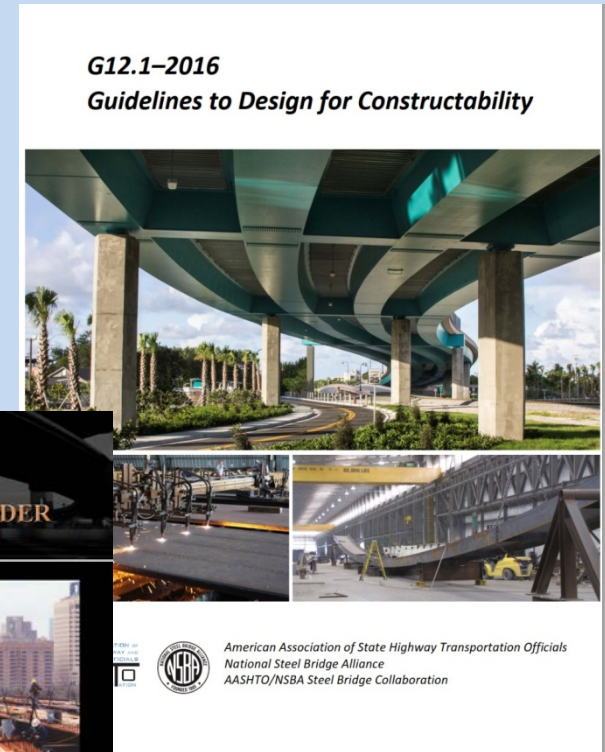
- We're out in the Industry
- Bridge Forums
- AASHTO Collaboration Meetings
- Industry Meetings and Trade Shows
- Office/Site visits

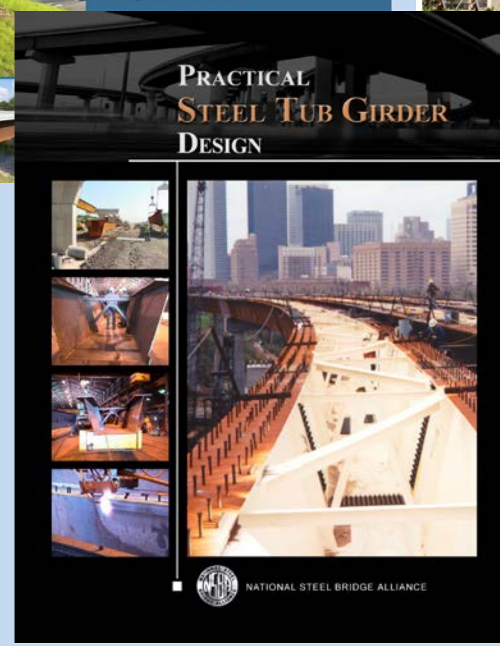
•We work in close collaboration with the FHWA and AASHTO.

- Coauthor with AASHTO on the AASHTO/NSBA Collaboration documents.
- Major contributor to the FHWA's *Steel Bridge Design Handbook.*

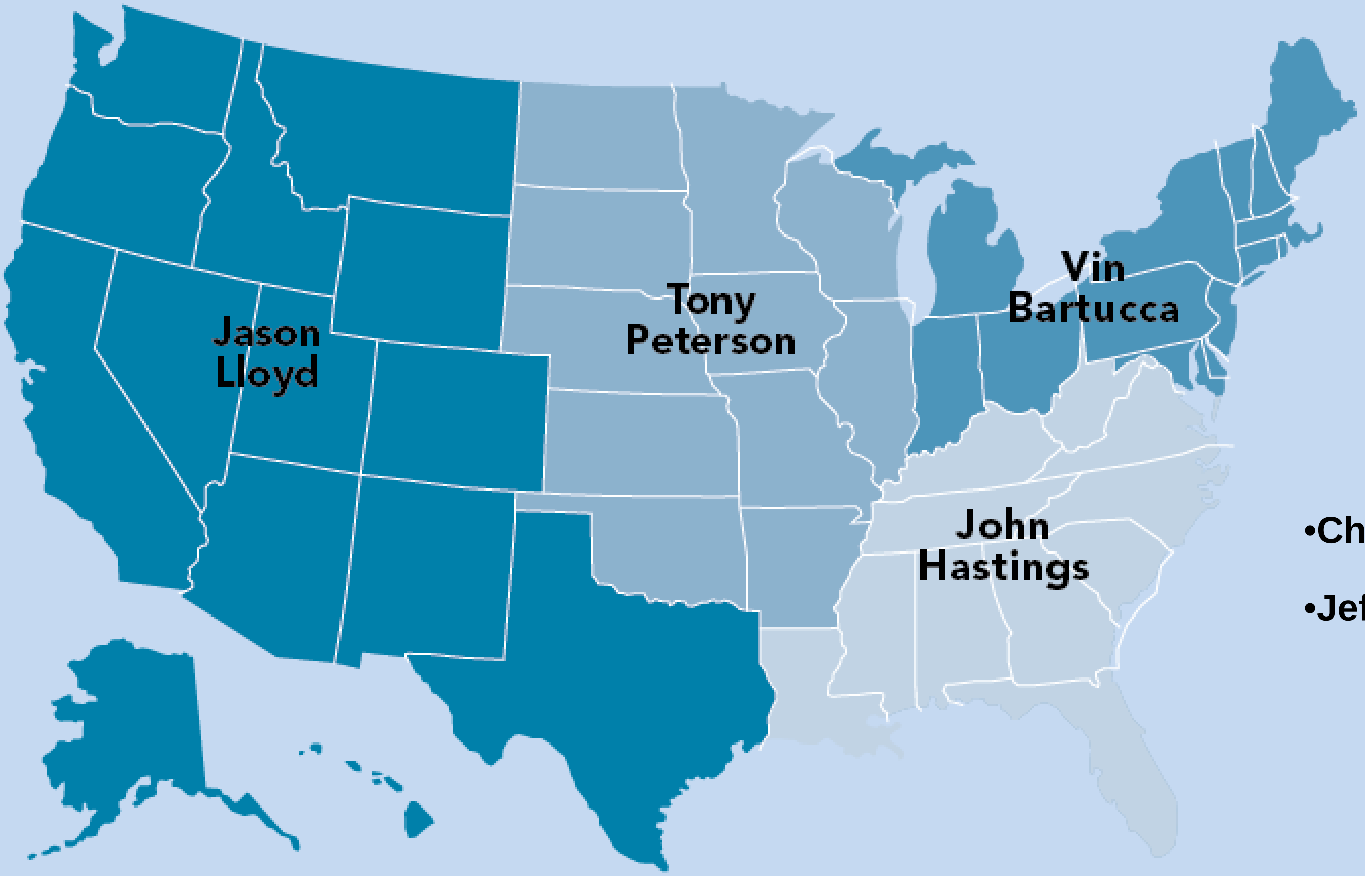
•We maintain an ever expanding library of publications and white papers.







Market Coverage



- Chris Garrell
- Jeff Carlson

Resources for Designers

Resources for Engineers

Engineer

- Type Selection
- Framing and Transverse Section Development
- Design and Analysis
- Details Design
- Drawing Production and Review
- Construction

What We Provide

- The NSBA maintains a growing list of

•technical resources to aid in making steel bridges more economical and constructible.

- Design support strategies
- Free software
- Design Handbook, AASHTO/NSBA collaboration documents
- Technical white papers
- Modern Steel Construction Articles
- New steel bridge technology in the marketplace
- Material availability
- Existing conceptual study library
- Basic raw material price info

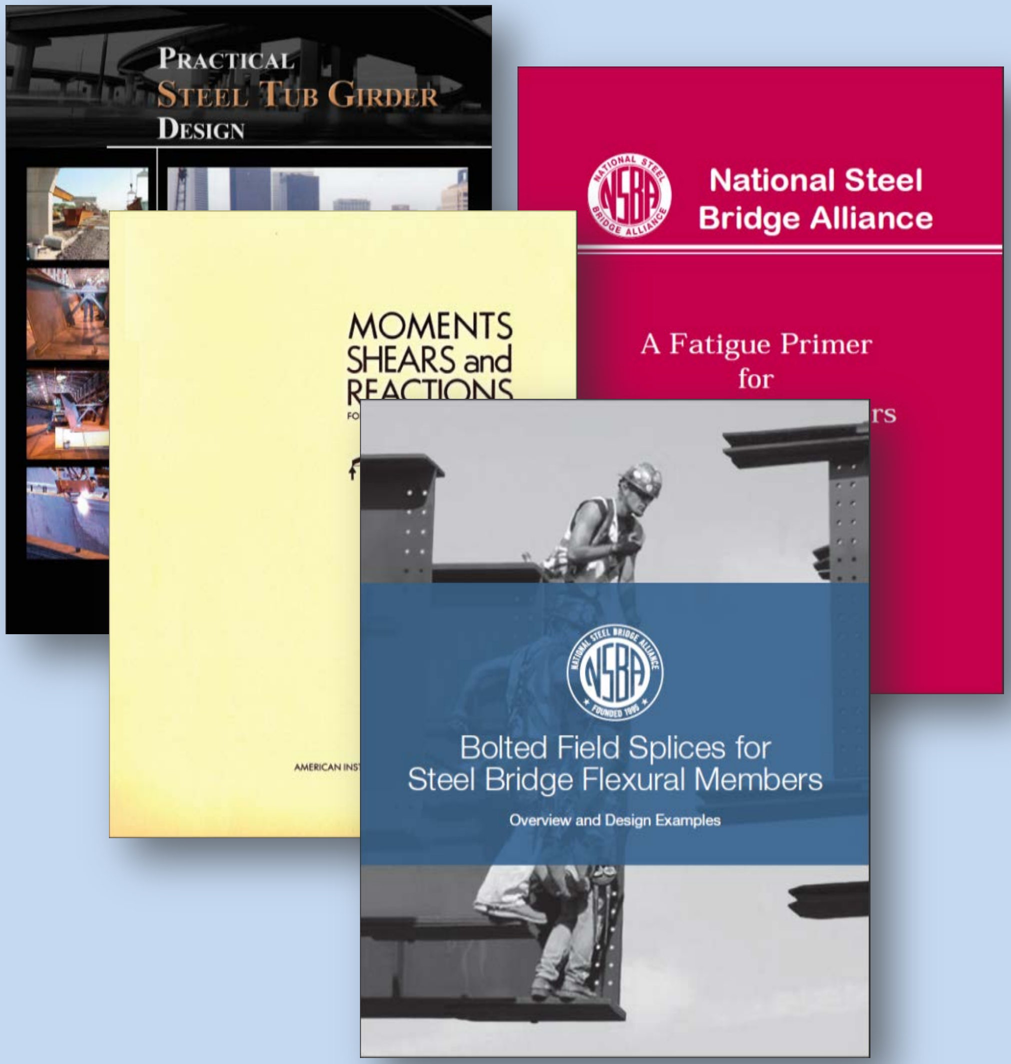
LRFD SIMON
SOFTWARE SOLUTION FOR PRELIMINARY BRIDGE DESIGN

•Both updated to AASHTO 8th Edition

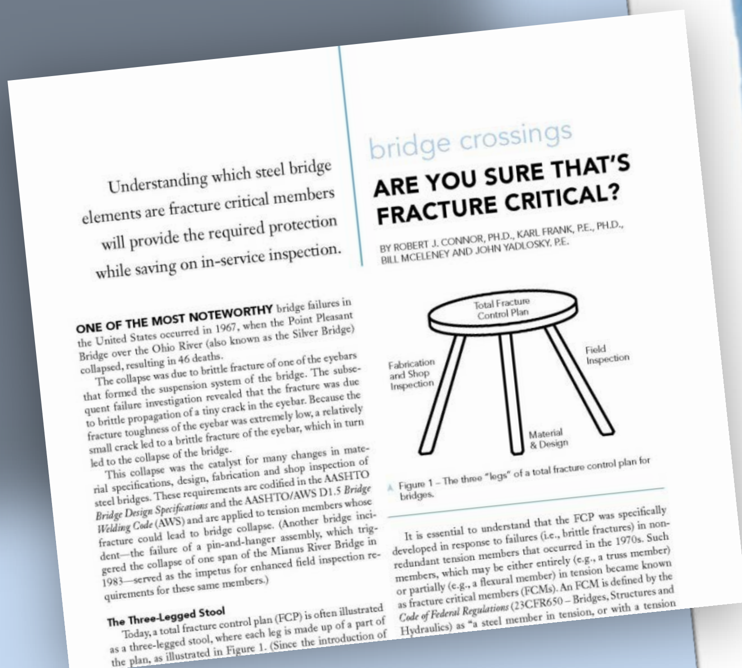
NSBASPLICE
SOFTWARE SOLUTION FOR SPLICE DESIGN

NSBA/AISC Technical Resources

- Practical Steel Tub Girder Design
- A Fatigue Primer for Structural Engineers
- Moments, Shears, and Reactions
- Bolted Field Splices



Steel Bridge Design Support



Understanding which steel bridge elements are fracture critical members will provide the required protection while saving on in-service inspection.

bridge crossings

ARE YOU SURE THAT'S FRACTURE CRITICAL?

BY ROBERT J. CONNOR, PH.D., KARL FRANK, P.E., PH.D., BILL MCELENEY AND JOHN YADLOSKY, P.E.

ONE OF THE MOST NOTEWORTHY bridge failures in the United States occurred in 1967, when the Point Pleasant Bridge over the Ohio River (also known as the Silver Bridge) collapsed, resulting in 46 deaths.

The collapse was due to brittle fracture of one of the eyebars that formed the suspension system of the bridge. The subsequent failure investigation revealed that the fracture was due to brittle propagation of a tiny crack in the eyebar. Because the fracture toughness of the eyebar was extremely low, a relatively small crack led to a brittle fracture of the eyebar, which in turn led to the collapse of the bridge.

This collapse was the catalyst for many changes in material specifications, design, fabrication and shop inspection of steel bridges. These requirements are codified in the AASHTO steel bridges. These requirements are codified in the AASHTO/AWS D1.5 *Bridge Bridge Design Specifications* and the AASHTO/AWS D1.5 *Bridge Welding Code* (AWS) and are applied to tension members whose fracture could lead to bridge collapse. (Another bridge incident—the failure of a pin-and-hanger assembly, which triggered the collapse of one span of the Mianus River Bridge in 1983—served as the impetus for enhanced field inspection requirements for these same members.)

The Three-Legged Stool

Today, a total fracture control plan (FCP) is often illustrated as a three-legged stool, where each leg is made up of a part of the plan, as illustrated in Figure 1. (Since the introduction of

Figure 1 – The three "legs" of a total fracture control plan for bridges.

It is essential to understand that the FCP was specifically developed in response to failures (i.e., brittle fractures) in non-redundant tension members that occurred in the 1970s. Such members, which may be either entirely (e.g., a truss member) or partially (e.g., a flexural member) in tension became known as fracture critical members (FCMs). An FCM is defined by the *Code of Federal Regulations* (23CFR650 – Bridges, Structures and Hydraulics) as "a steel member in tension, or with a tension

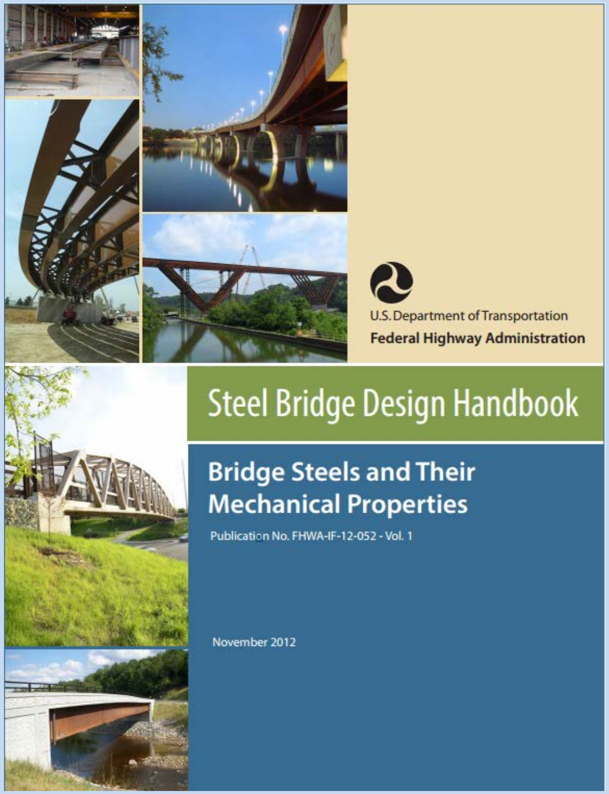
AASHTO/NSBA Steel Bridge Collaboration
G 12.1 - 2003

Guidelines for Design for Constructibility

AASHTO/NSBA Steel Bridge Collaboration

Steel Bridge Design Handbook

1. Bridge Steels and their Mechanical Properties
2. Steel Bridge Fabrication
3. Steel Bridge Shop Drawings
4. Structural Behavior of Steel
5. Selecting the Right Bridge Type
6. Stringer Bridges: Making the Right Choices
7. Loads and Load Combinations
8. Structural Analysis
9. Redundancy



Steel Bridge Design Handbook

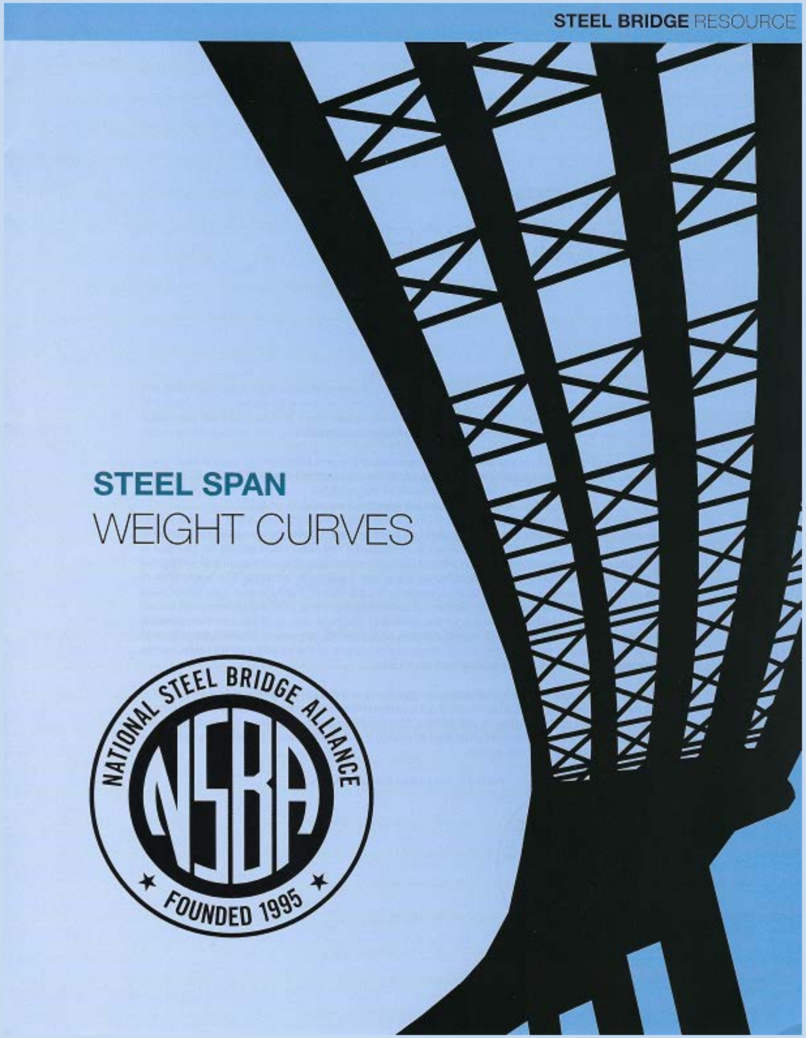
10. Limit States
11. Design for Constructability
12. Design for Fatigue
13. Bracing System Design
14. Field Splice Design
15. Bearing Design
16. Substructure Design
17. Bridge Deck Design
18. Load Rating of Steel Bridges
19. Corrosion Protection of Steel Bridges

Steel Bridge Design Handbook

20. 3-span Straight Steel I-Girder Bridge
21. 2-span Straight Steel I-Girder Bridge
22. 2-span Straight Steel Wide-Flange Beam Bridge
23. 3-span Straight Steel Tub-Girder Bridge
24. 3-span Curved Steel I-Girder Bridge
25. 3-span Curved Steel Tub-Girder Bridge

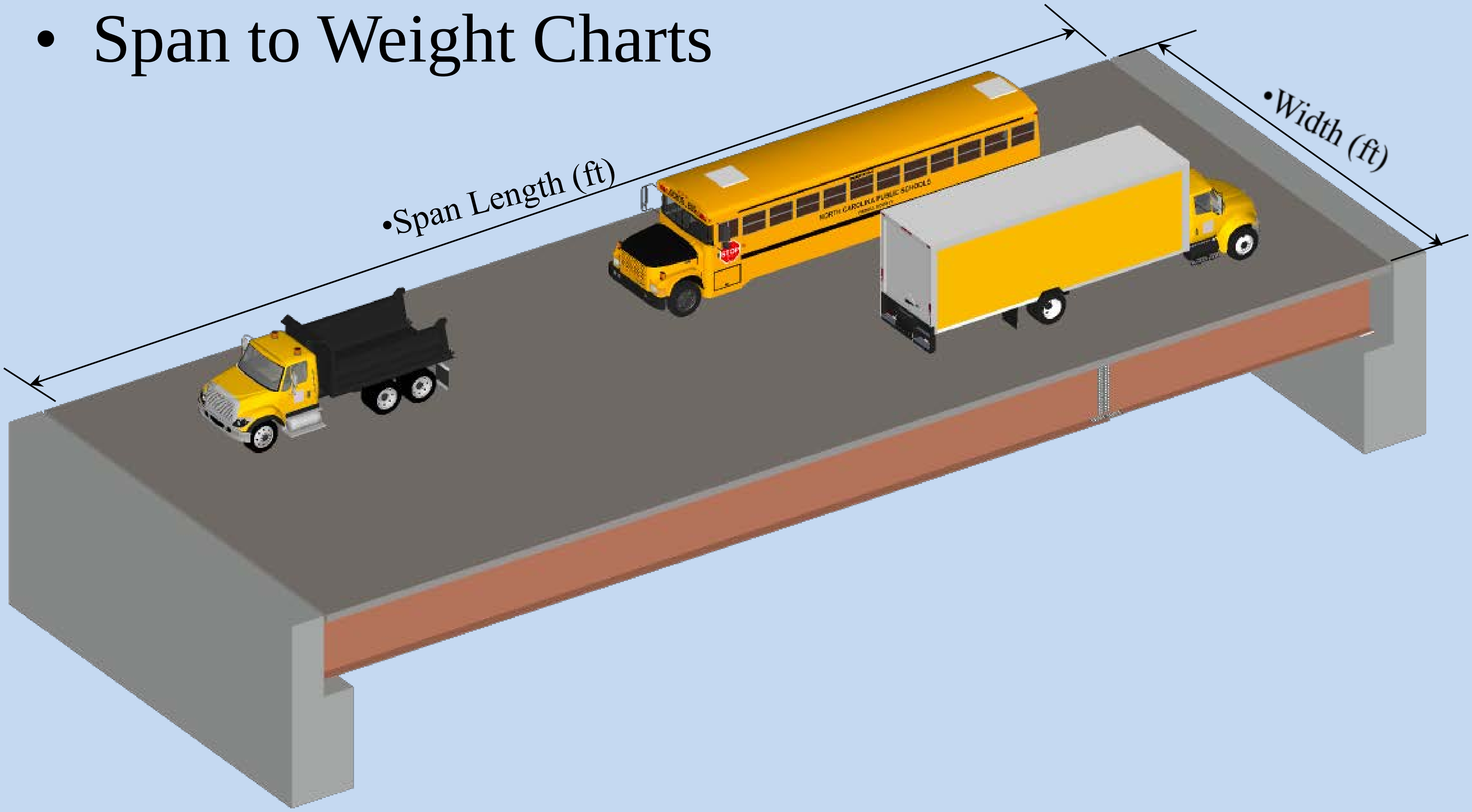
- http://www.fhwa.dot.gov/bridge/

Steel Bridge Design Resources



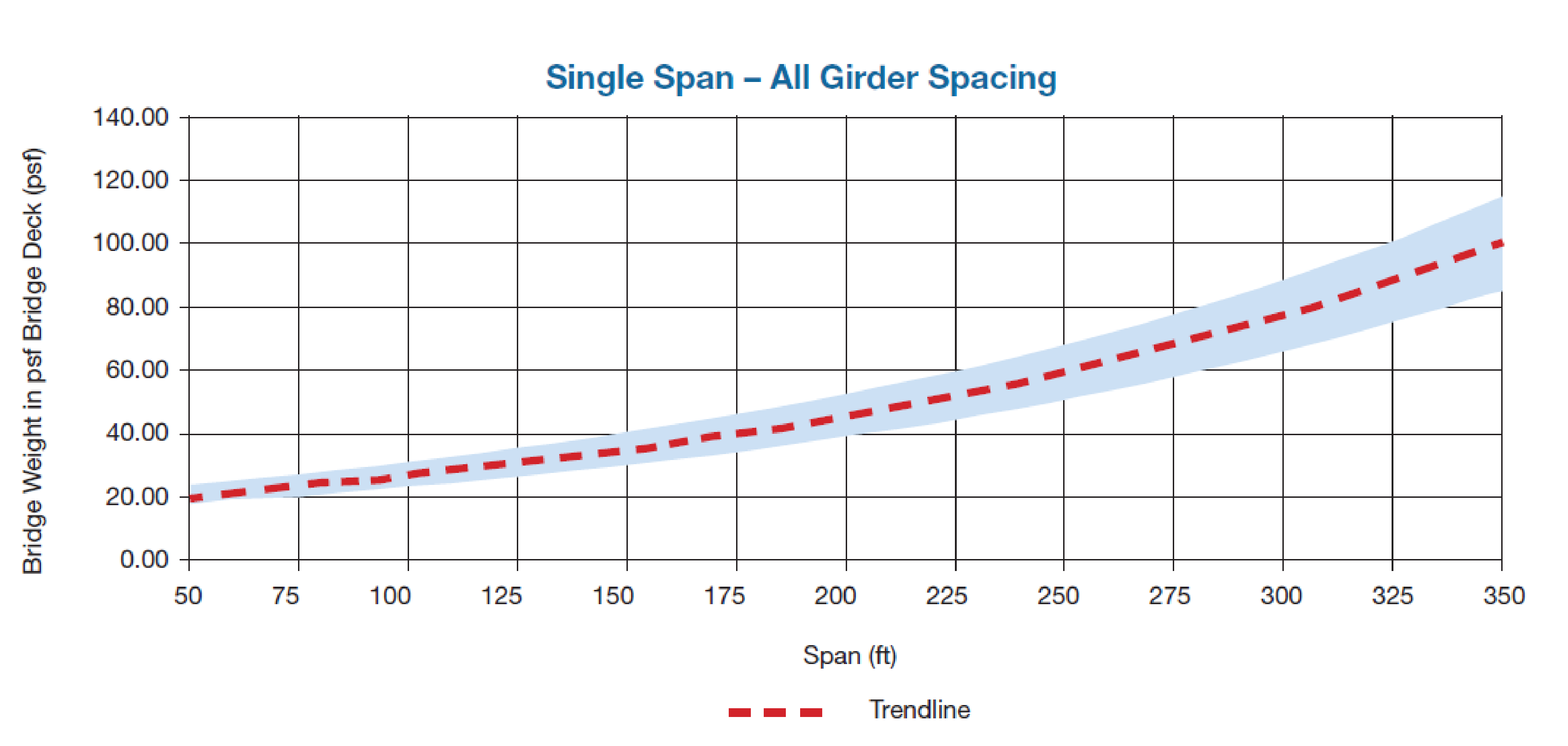
Steel Bridge Design Resources

- Span to Weight Charts



Steel Bridge Design Resources

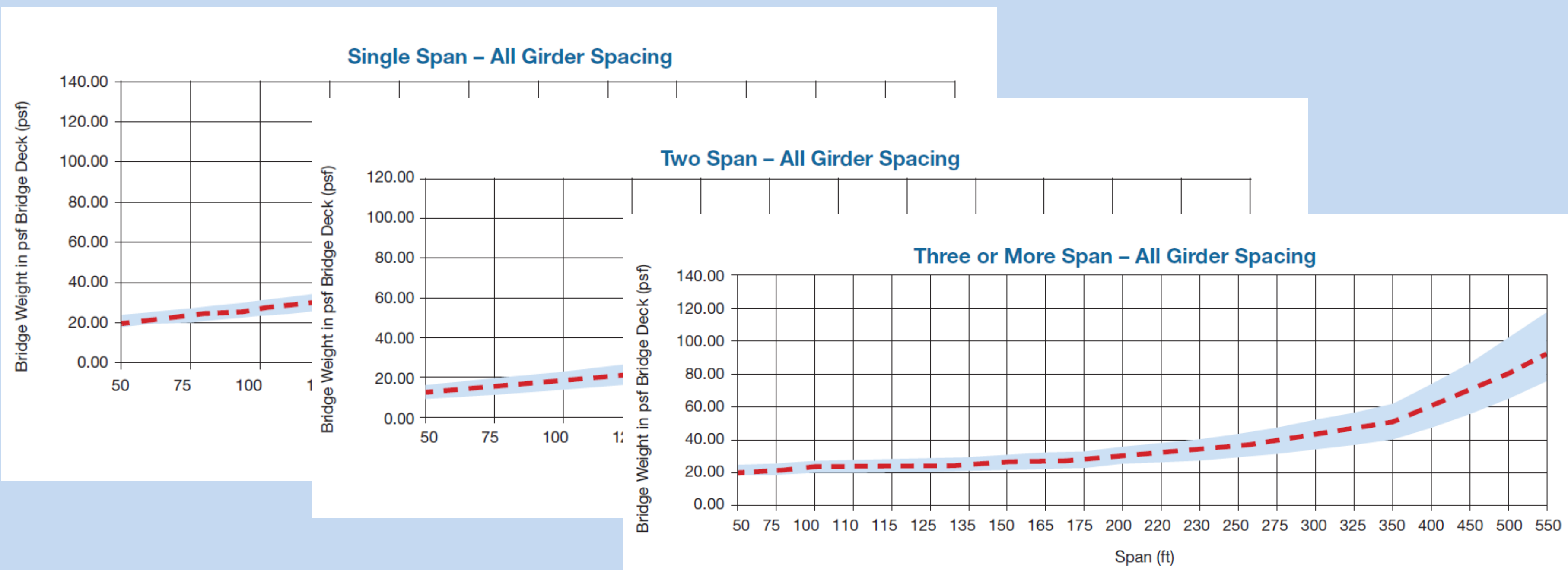
- Span to Weight Charts



•Bridge Weight (psf) x Bridge Area (sq-ft) x Historical Cost

Steel Bridge Design Resources

- Span to Weight Charts
  - Used during preliminary design phase.
  - Evaluation alternative structures.
  - Quickly determine relative costs.



Steel Bridge Design Resources

Steel Bridge Design Resources

- Continuous Span Standards
  - Center Span: 150 ft – 300 ft (15 foot increments).
  - End Spans: 78% of center span.
  - Girder Spacing: 7’– 6 through 12’ – 0.
  - Homogeneous and hybrid solutions.
  - Web depth to suit material efficiency.

- 88 Unique Steel Solutions.

Continuous Span Standards

- Assist engineers during the TS&L phase
  - Flange plate sizes and lengths
  - Web plate sizes and lengths
  - Diaphragm spacing
  - Stiffener locations
  - Girder weights
  - Shear connector spacing
  - Steel DL and Total DL camber tables

NSBA/AASHTO Collaboration Groups

- Includes participation from DOT's, consultants, owners, fabricators, contractors and inspectors.
- Meet several times during the year.

Task Groups

TG 1 - Detailing

TG 2 - Fabrication Specification

TG 4 - QA/QC

TG 8 - Coatings

TG 10 - Erection

TG 11 - Steel Bridge Design Handbook

TG 12 - Design for Economy and Constructability

TG 13 - Analysis of Steel Bridges

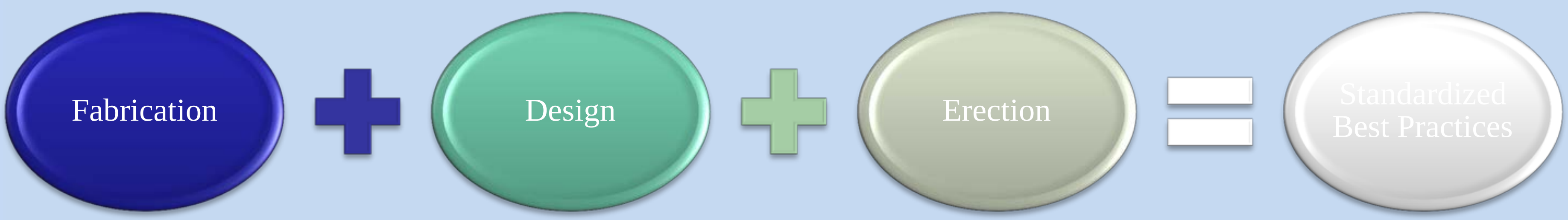
TG 15 - Data Modeling for Interoperability

TG 16 - Orthotropic Deck Panels

NSBA/AASHTO Collaboration Groups

Mission:

… provide a forum where professionals can work together to improve and achieve the quality and value of steel bridges through standardization of design, fabrication and erection.



AASHTO/NSBA Steel Bridge Collaboration

- Specifications and Guidelines
  - Specifications:
    - Written in “spec language”
    - Can be adopted as a contract document
  - Guidelines:
    - Written as a reference
    - Consensus of the steel industry

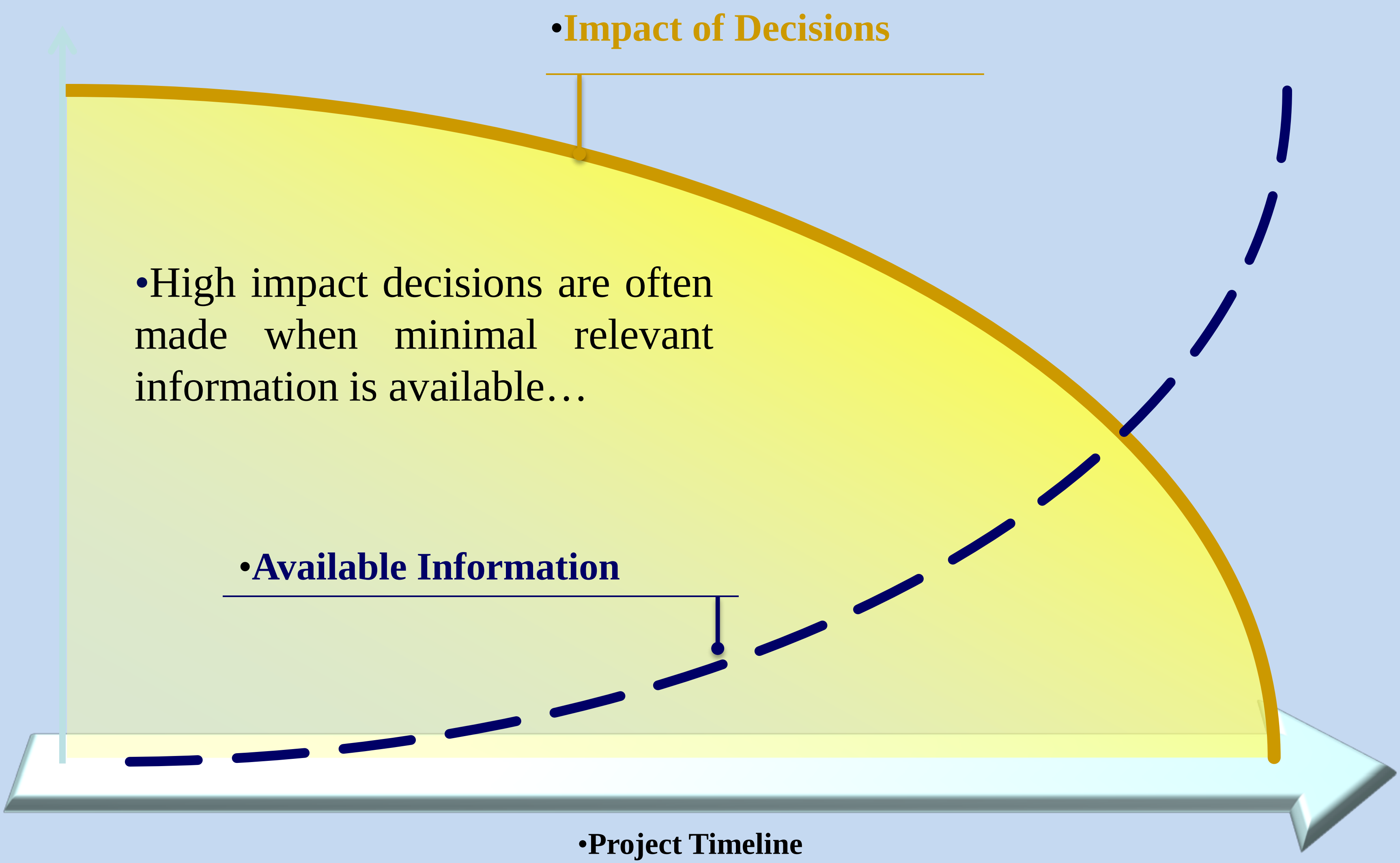
AASHTO/NSBA
COLLABORATION
CELEBRATING 20 YEARS

NSBA/AASHTO Collaboration Groups

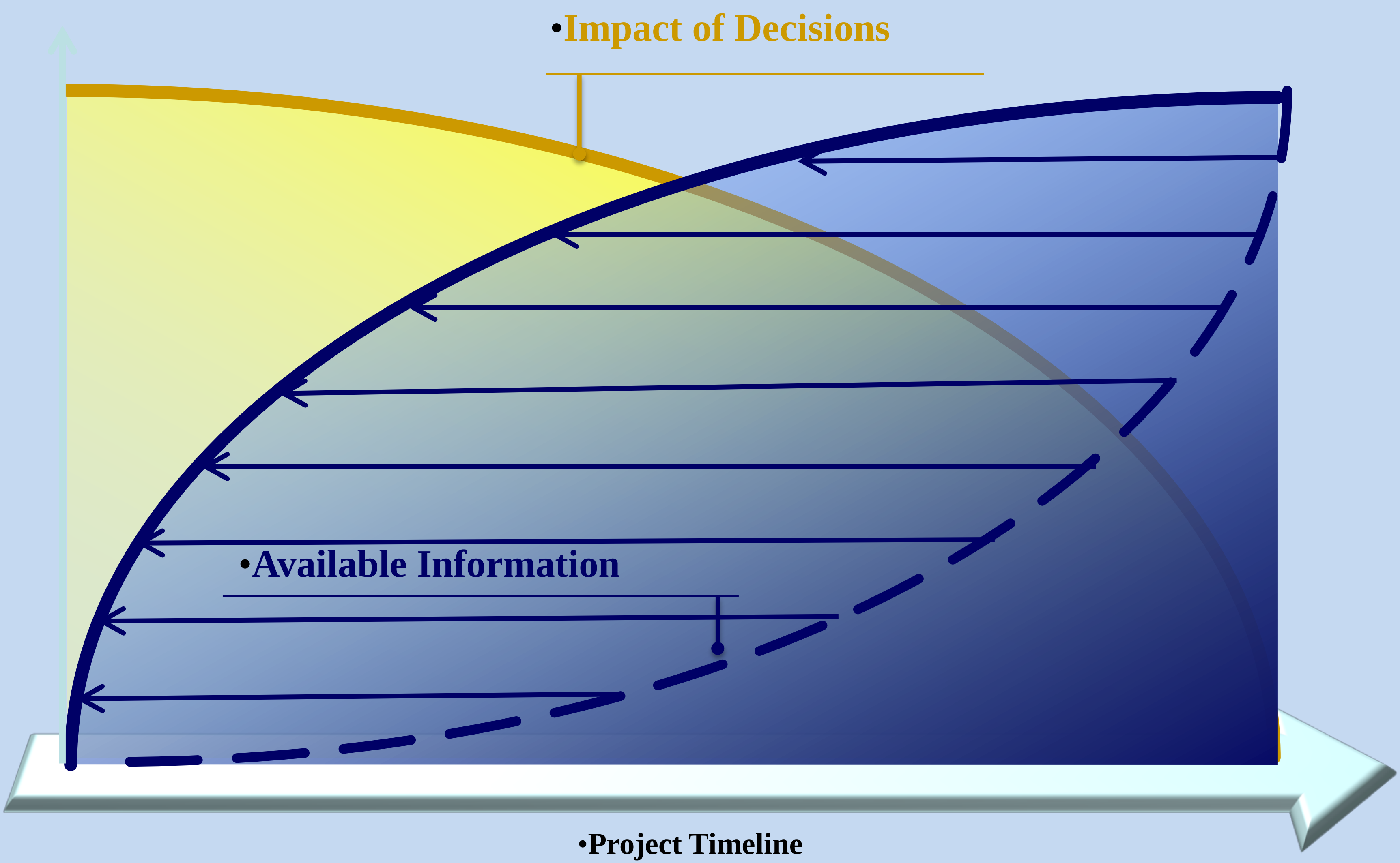
Documents

- Shop Drawing Approval Review/Approval Guidelines (G1.1-2000)
- Guidelines for Design Details (G1.4-2006)
- Guidelines for Resolution of Steel Bridge Fab. Errors (G2.2-2016)
- Steel Bridge Bearing Design and Detailing Guidelines (G9.1-2004)
- Guidelines for Design for Constructability (G12.1-2016)
- Guidelines for Steel Girder Bridge Analysis (G13.1-2014)
- Specification for Application of Thermal Spray Coatings (S8.2-2017)
- Steel Bridge Fabrication Guide Specification (S2.1-2018)

Right Information at the Right Time



Right Information at the Right Time

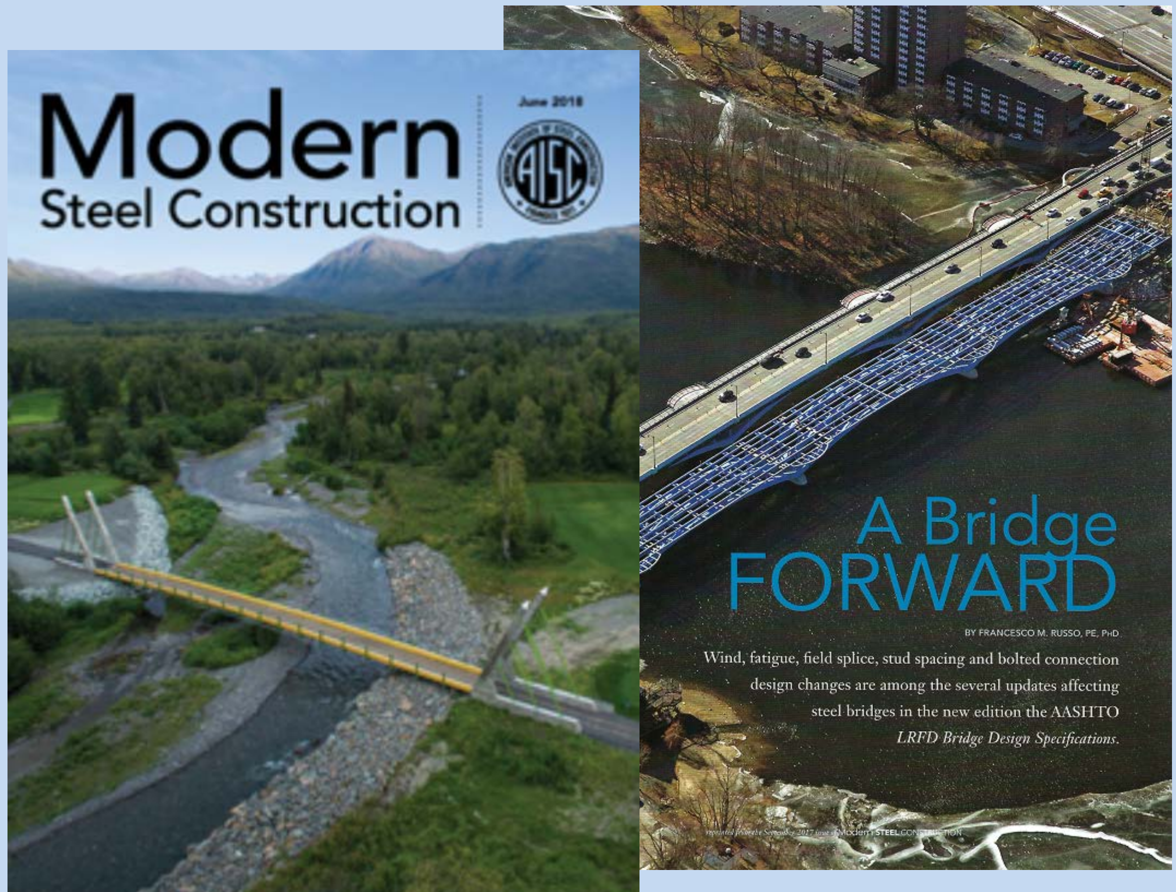


Modern Steel Construction

– Monthly publication for steel construction in the US
– Generally at least one bridge article each month
– Submit it to: www.aisc.org/bridgeideas

<u>Circulation = 60,000</u>

68% Engineers
15% Architects
8% Fabricators



NASCC The Steel Conference

Thank you

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