

AASHTO / NSBA Steel Bridge Collaboration  
*G 12.1, Guidelines for Design for Constructability*

**...answers here...**

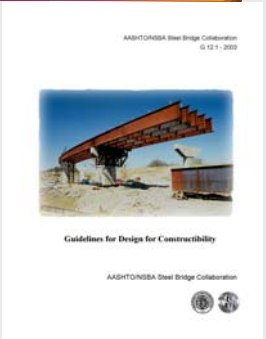
ASCE, Structural Group  
 Chicago, Illinois  
 January 20, 2010

William McEleney  
 NSBA, Director



*Brief Background*

- Consensus based
- AASHTO publication



*Chapters*

- Design
- Girder Design
- Boxes
- Bolts
- Corrosion Protection
- Other



*• Design*

- Rolled Beam vs. Plate Girder
- Girder Spacing
- Minimum Thicknesses
- Material Availability
- Flange Sizing
- Differential Deflections
- Bearings

*• Design*

- Rolled Beam vs. Plate Girder
  - Rolled beam generally more economical
  - Availability – rolling schedules, etc
  - Except with hard curve or camber
  - Allow plate girder alternate (show on bid documents)

*• Design*

- Girder Spacing
  - Wider is more economical
  - A reduced number of girders (fewer linear feet) to be detailed, fabricated, painted, transported, erected, inspected and maintained
  - Fewer diaphragms, x-frames, bearings
  - MAYBE more pounds, but FEWER dollars

**• Design**

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- Girder Spacing
  - Use 10' to 11' with spans less than 140'
  - Use 11' to 14' with spans greater than 140'
  - Cost of thicker deck to accommodate wider spacing
    - Thicker deck may increase life
    - More dead load per girder may reduce vibration
  - Consider future redecking operations during preliminary design

**• Design**

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• Girder Spacing



**• Design**

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- Minimum Thicknesses
  - Stiffeners, connection plates
    - 7/16" minimum, 1/2" preferred
  - Plate girder webs
    - 7/16" minimum, 1/2" preferred
  - Plate girder flanges
    - 3/4" minimum

**• Design**

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• Plate Availability



- Arcelor-Mittal Steel USA
  - to 4" thick, 195" wide
- Nucor Steel
  - to 3" thick, 120" wide
- SSAB-IPSCO Steel
  - to 2" thick, 120" wide
- EVRAZ Claymont Steel
  - to 4" thick, 155" wide

**• Design**

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- Plate size preferences



**• Design**

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- Wide Flange Beam Availability
  - NUCOR YAMATO - to 44" deep
  - Chaparral - to 36" deep
  - Steel Dynamics - to 36" deep
  - 120' long - max
  - ASTM A992; ASTM A709, Gr. 50S
    - Minimum Yield = 50 ksi
    - No HPS

• *Design*

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- Plate Girder Flange Sizing
  - Shop butt splices within a shipping piece – when to change area?
    - No more than 2 shop slices
    - Minimum change; 1/8" (to 2 1/2" thick), 1/4"
    - Maximum change; thinner piece at least 1/2 of thicker...
    - ONLY when material cost saved > labor cost spent

• Flange Sizing – when to change area?

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


• *Design*

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- Plate Girder Flange Sizing
  - Shop butt splices within a shipping piece – what to change, 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

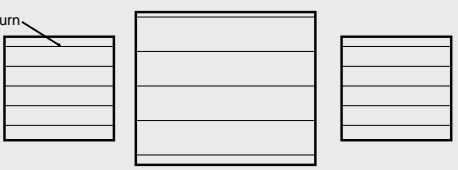
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**FABRICATE 4 FLANGE ASSEMBLIES**  
**STEP 1: Bevel (4) plate edges**

• Flange Sizing - change width

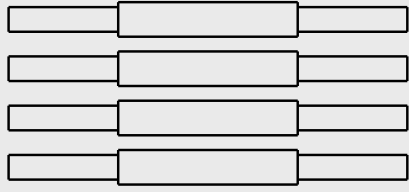
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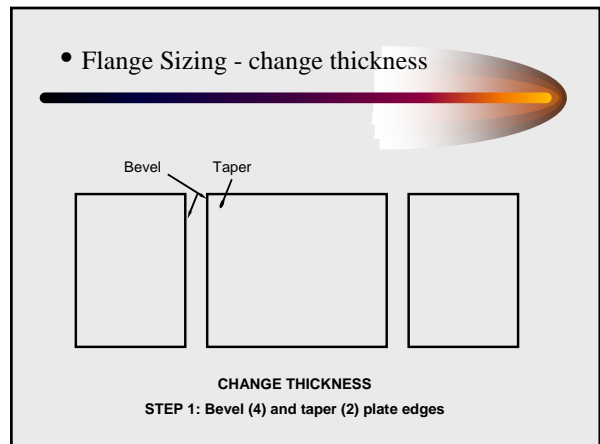
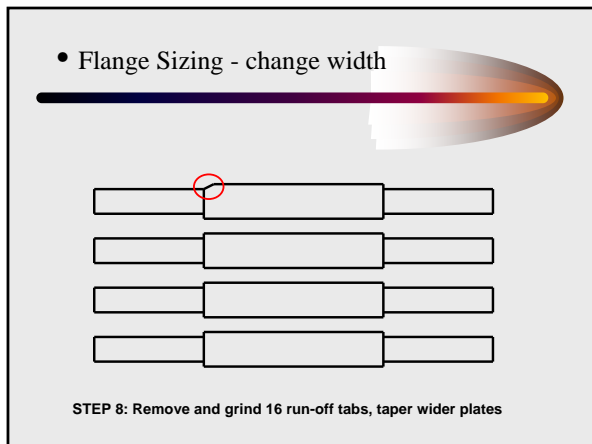
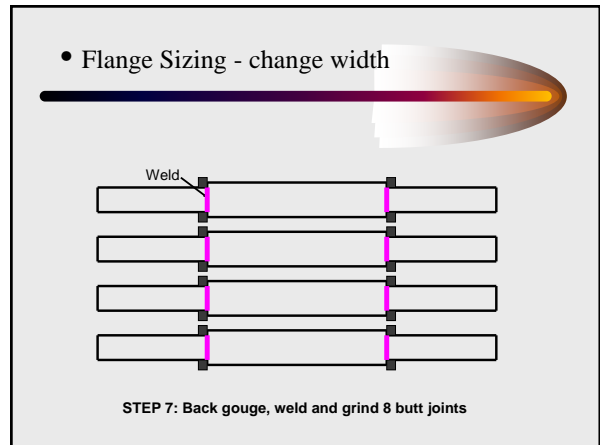
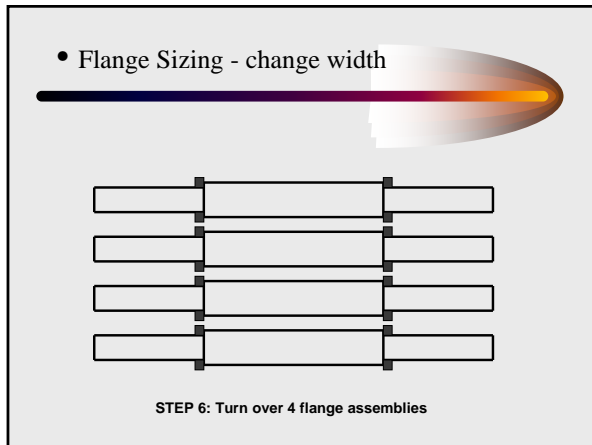
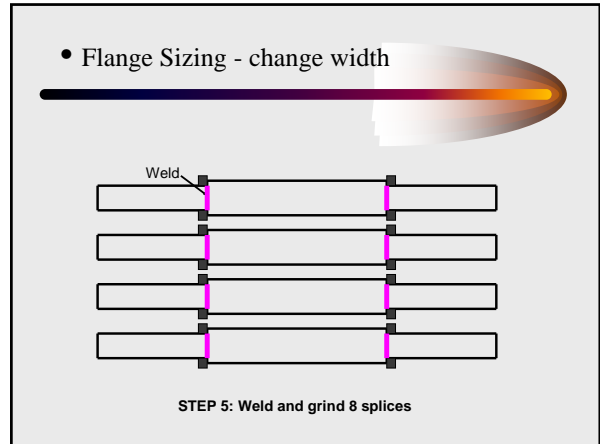
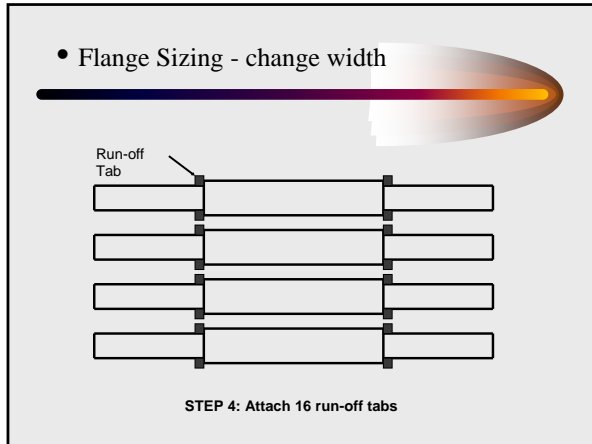
**STEP 2: Burn 12 pieces from 3 plates**

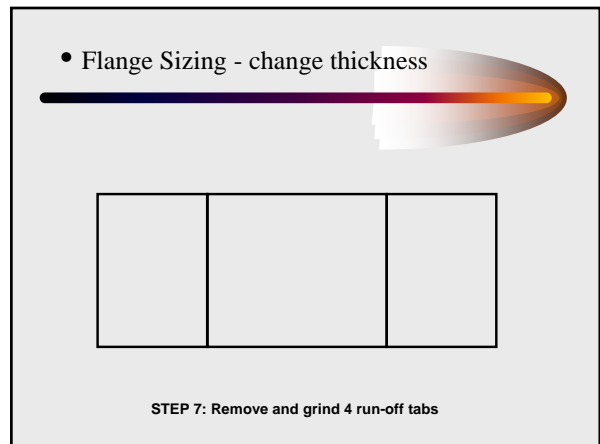
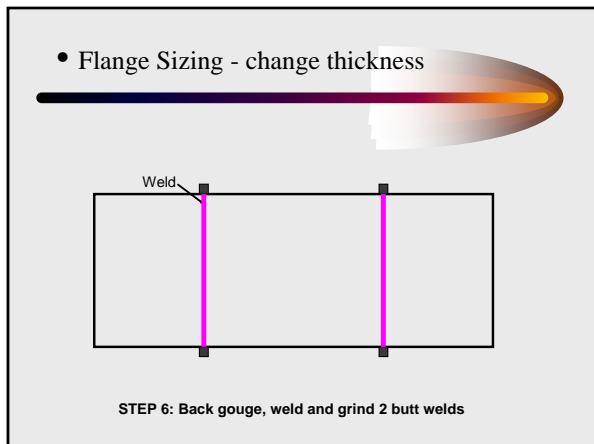
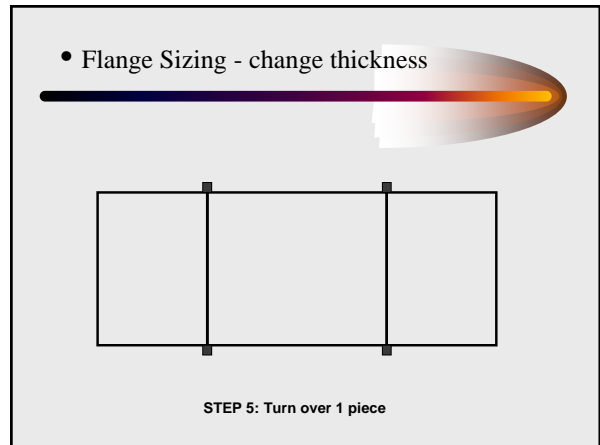
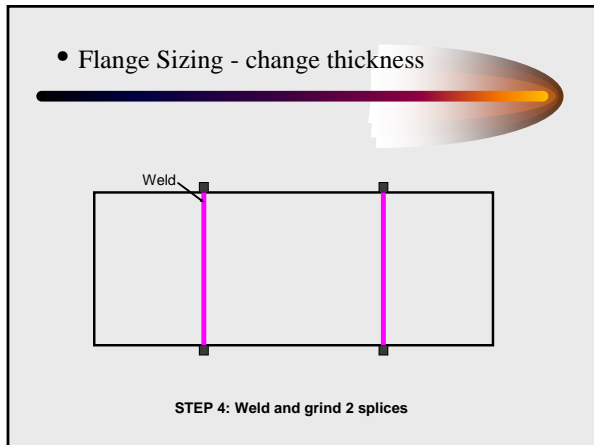
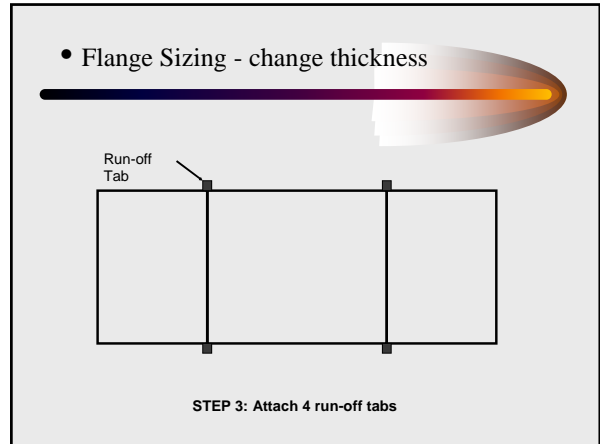
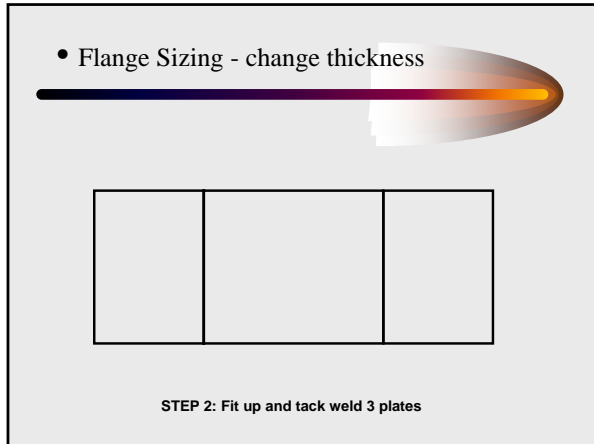
• Flange Sizing - change width

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**STEP 3: Fit up and tack weld 4 flange assemblies**





- Flange Sizing - change thickness

STEP 8: Burn 4 flanges from 1 assembly

- Flange Sizing - change thickness

STEP 8: Burn 4 flanges from 1 assembly

- Design

- Flange Sizing
  - Width transitions increase labor 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

- Design

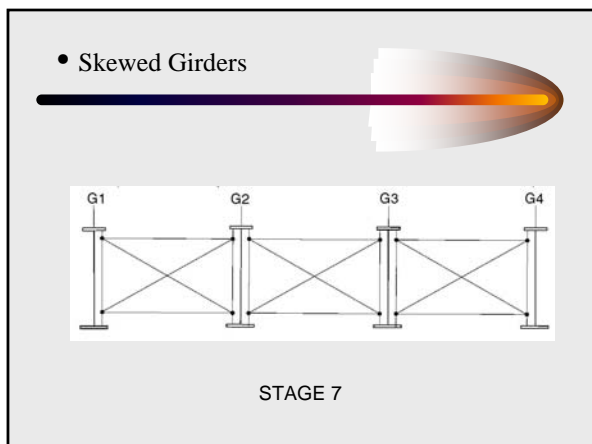
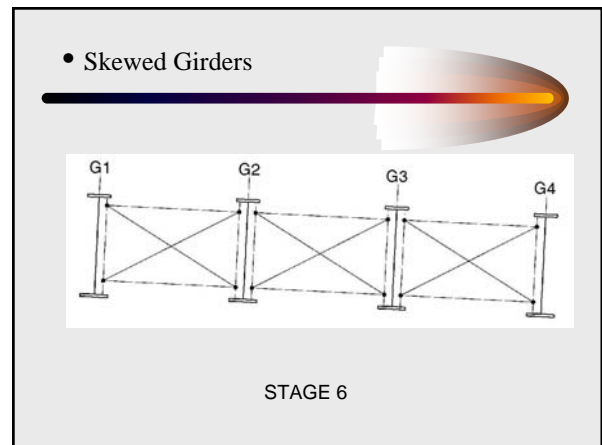
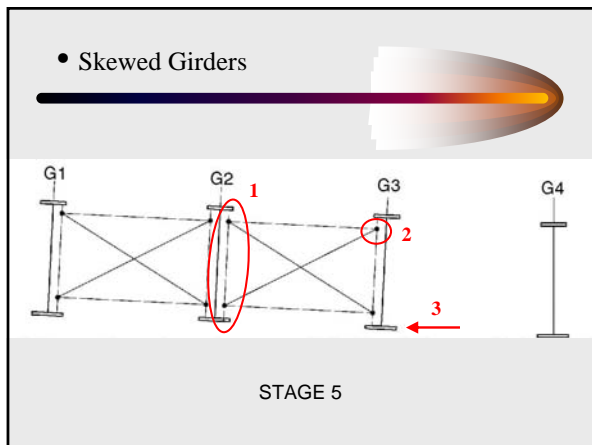
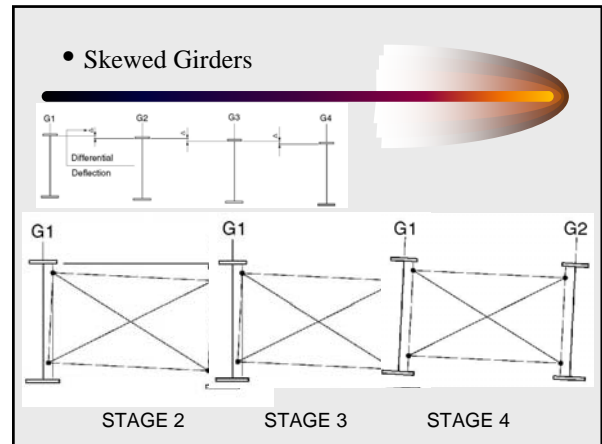
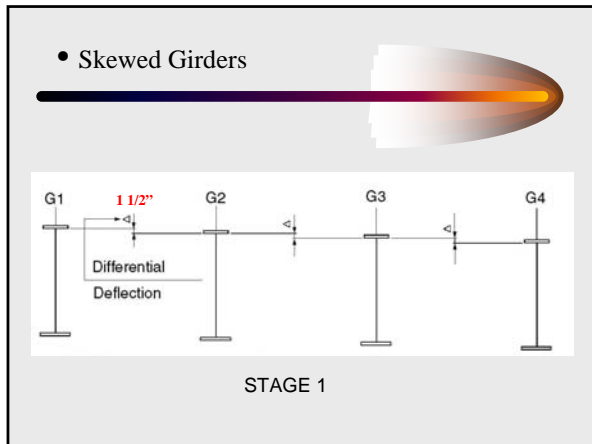
- Flange Sizing

- Design

- Differential Dead Load Deflections
  - Phased construction
    - omit crossframes between phases, if possible
    - otherwise, single angle top & bottom strut (w/ 1 bolt)
  - Curved girders
    - 'beyond the scope'
  - Skewed girders

- Skewed Girders

Δ = DIFFERENTIAL DEFLECTION



• *Design*

• Bearings

- Use elastomeric if possible
  - 800 kips, 4" lateral, .04 radians rotation
- Use pot bearing next
- See Collaboration G9.1, *Steel Bridge Bearing Design and Detailing Guidelines*

**• Design**

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- Bearings
  - Spherical Bearing - approximately \$1200 ea
  - Pot Bearing - approximately \$800 ea
  - Bronze Rocker - approximately \$600 ea
  - Elastomeric - approximately \$225 ea
  - Built-Up Rocker - used mostly in RR structures
    - approximately \$1.50/lb

**• Girder Design**

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- Bearing Stiffeners, Box Girder Bearing Diaphragms, Connection & Intermediate Stiffeners
- Welding
- General Details
- Longitudinal Web Field Splices

**• Girder Design**

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- Bearing Stiffeners, Box Girder Bearing Diaphragms, Connection & Intermediate Stiffeners
  - Bearing stiffeners can be either fabricated normal to top flange or vertical (plumb) under full dead load (DL) - effect on design is minimal
  - Box girder bearing diaphragms can be either normal to top flange or vertical under DL
  - Connection (and intermediate) stiffeners should be normal to top flange

**• Girder Design**

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- Bearing Stiffener Attachment
  - mill to bear fit on bottom flange
    - add a fillet weld (if transversely loaded)
  - **NO** full penetration 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**

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**BEARING STIFFENERS**

UNLOADED      LOADED

Mill-to-Bear

**• Girder Design**

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- Minimum Spacing between Stiffeners
  - 8" or 1 1/2 times stiffener plate width

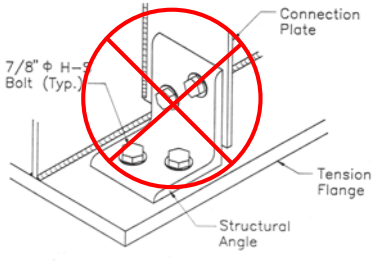
**• Girder Design**

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- Connection Stiffener Attachment
  - attach to top and bottom flanges
  - welds to tension flanges ARE ALLOWED as long as the stress in the flange does not exceed the allowable fatigue stress for the type of weld
  - good placement of connection plates should eliminate need for any tab plates
  - if needed, use tab plates only at the specific location, not at all connection plates

**• Connection Stiffener Attachment**

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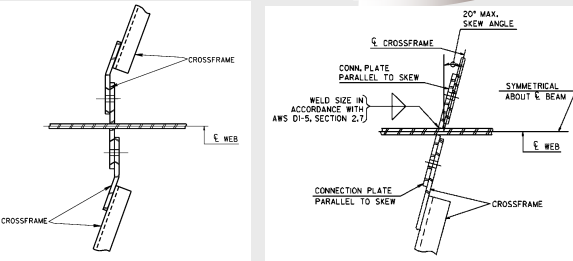
**• Girder Design**

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- 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)
  - Compression Joints - open joint w/ 100% bolts (vs. milled joint w/ 50% bolts)
  - Prefer bent connection plate vs. skewed connection plate for skewed cross frames

**• Skewed Cross Frame Connections**

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preferred (by fabricators)                      20° maximum skew



**• Girder Design**


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- General Details
  - Shop Assembly Requirements
  - Haunched Flange Transition
    - Bent or welded
    - Straight or curved haunch
  - Curved Girders - heat curve or cut curve
    - Allow either

**• Girder Design**

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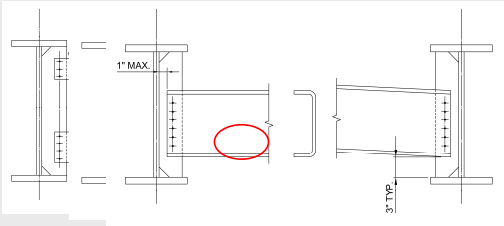
- General Details
  - Heat curve



**• Girder Design**

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- General Details
  - Cross Frame design



**• Girder Design**

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- Longitudinal Web Field Splices (deep girders)



- use side plates

**• Boxes**

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- Closed Box Configuration - Corner Welds
- Closed Box Diaphragm Attachment
- Closed Box Interior Diaphragm Minimum Access Hole Size
- Stiffener Detail at (near) Bottom Flange of Tub Girders
- Stiffening of Bottom Flange (Compression Zone)
- Interior Coating
- Relative Costs of Closed Boxes and Tub Girders
- External Cross Frames

**• Boxes**

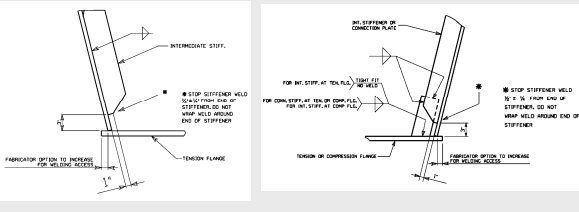
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- Closed Box Configuration - Corner Welds
  - Try to arrange to use fillet welds
- Closed Box Diaphragm Attachment
  - Weld 3 sides, tight fit at tension flange
- Closed Box Interior Diaphragm Access Hole
  - 32 x 36 inches preferred (18 x 24 inches min)

**• Boxes**

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- Stiffener Detail at (near) Bottom Flange of Tub Girders



**• Boxes**

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- Stiffening of Bottom Flange (Compression Zone)
  - Use WTs (versus bars)
  - Stop short of field splice (splice plates should adequately stiffen the flange)

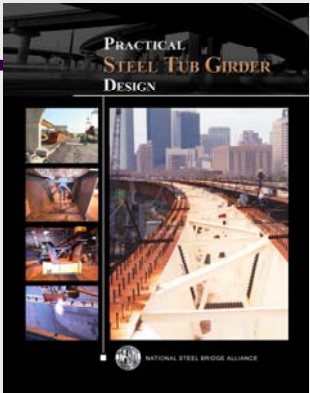
**• Boxes**

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- Interior Coating
  - For inspection; single coat, light color
- Relative Costs of Closed Boxes and Tub Girders
  - No recommendation (box may be 20-30% more)
- External Cross Frames
  - At supports; for curved

NSBA website

- [www.steelbridges.org](http://www.steelbridges.org)



PRactical STEEL TUB GIRDER DESIGN

NATIONAL STEEL BRIDGE ALLIANCE

**• Bolts**

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- Mechanically or Hot-Dip Galvanize
  - Mechanically (except on weathering steel)
- Shop Bolts – Black vs. Galvanized
  - Mechanically galvanized

**• Corrosion Protection**

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- Recommended Systems
  - Uncoated weathering steel
  - Shop primer w/ field top coats
  - All shop applied
- Bolt Faying Surfaces
  - Painted girders – use Class B, if coating is so rated
  - Weathering steel – blast and use Class B

**Shipping/Fabrication Piece Limits**

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- To have the most competition:
  - Length < 125 feet
  - Weight < 35 tons
  - Height < 9 feet tall
- To ship, by road, max. fabricated segments:
  - Length < 175 feet (varies by state)
  - Weight < 80 tons (varies by state)
  - Height < 13.5 feet (on side) 9.5 feet (upright)

*Collaboration Documents*

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NSBA website

- [www.steelbridges.org](http://www.steelbridges.org)

AASHTO bookstore

- [www.transportation.org](http://www.transportation.org)



Contact Information...

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