AASHTO / NSBA Steel Bridge Collaboration
*Guidelines for Design for Constructability*

***answers here…***

*Indiana DOT*
*Indianapolis, IN*
*July 24, 2012*

William McEleney
NSBA, Director

## *Brief Background*

- Consensus based
- AASHTO publication

## *Chapters*

- Design
- Plate Girders
- Box Girders
- 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)

eSPAN140™
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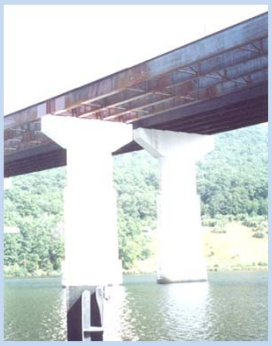
## • *Design*

- 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*

- 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

## • Girder Spacing



## • *Design*

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

## • *Design*

- Plate Availability
  - – Arcelor-Mittal Steel USA
    - to 4” thick, 195” wide
  - – Nucor Steel
    - to 3” thick, 120” wide
  - – SSAB-IPSCO Steel
    - To 3” thick, 120” wide
  - – EVRAZ Claymont Steel
    - to 4” thick, 155” wide

## • *Design*

- Plate size preferences - width

| | WIDTH | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 72" | 75" | 78" | 81" | 84" | 87" | 90" | 93" | 94" | 95" | 96" | 99" | 102" | 108" |
| ArcelorMittal | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Evraz | √ | | √ | | √ | | √ | | | | √ | | √ | √ |
| Nucor | √ | √ | √ | √ | √ | | √ | √ | √ | √ | √ | √ | √ | √ |
| SSAB | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |

*Modern Steel Construction*, Sept 2011

- Plate size preferences – thickness increments

## • *Design*

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

## *Availability*

- fabricator comments
  - rolled beam availability
  - rolled beam vs. plate girder
  - plate material availability
  - other

## • *Design*

- 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 ½” 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?

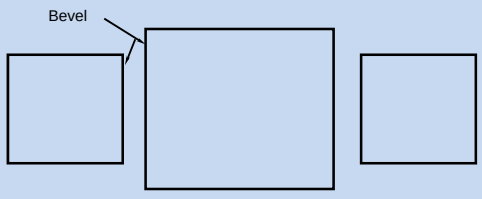
| Multiply weight savings/inch x flange width (length of butt weld) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Thinner Plate at Splice (inches) | Thicker Plate at Splice (inches) | | | | | | |
| | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 |
| 1.0 | 70 | 70 | 70 | | | | |
| 1.5 | | 80 | 80 | 80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

## • *Design*

- 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

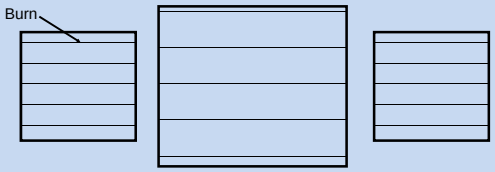
## • Flange Sizing - change width



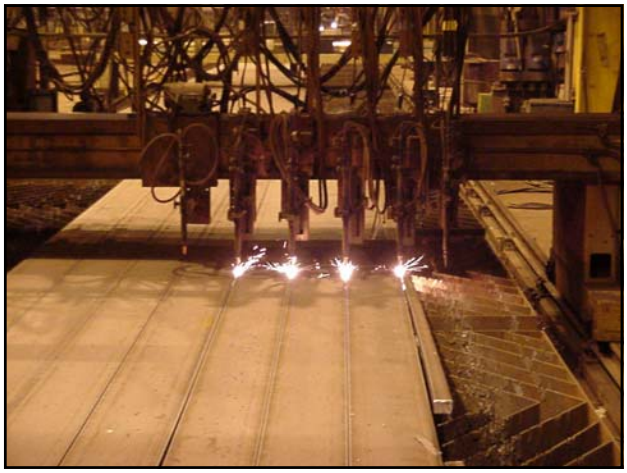

**FABRICATE 4 FLANGE ASSEMBLIES**

**STEP 1: Bevel (4) plate edges**

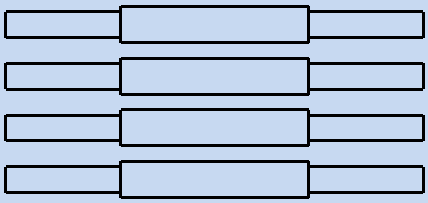
- Flange Sizing - change width




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

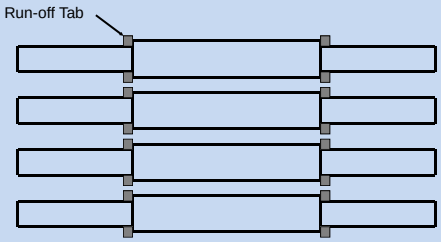


- Flange Sizing - change width



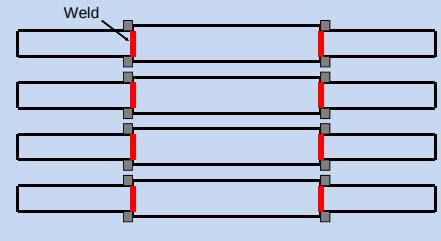
**STEP 3: Fit up and tack weld 4 flange assemblies**

- Flange Sizing - change width



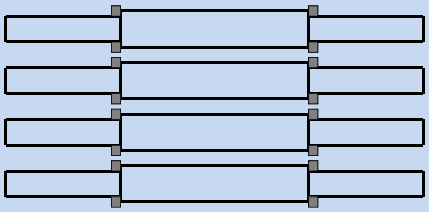

**STEP 4: Attach 16 run-off tabs**

- Flange Sizing - change width



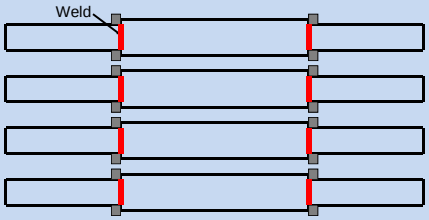

**STEP 5: Weld and grind 8 splices**

- Flange Sizing - change width



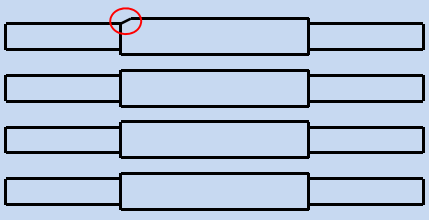
STEP 6: Turn over 4 flange assemblies

- Flange Sizing - change width



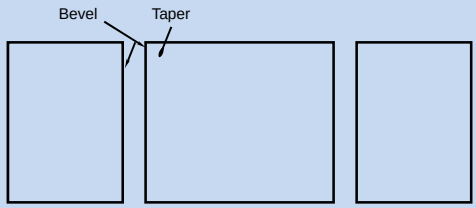

STEP 7: Back gouge, weld and grind 8 butt joints

- Flange Sizing - change width



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

- Flange Sizing - change thickness



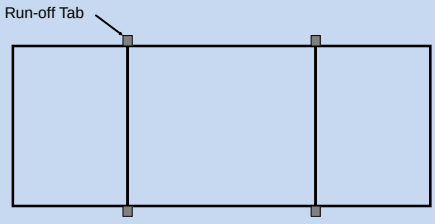

**CHANGE THICKNESS**

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

- Flange Sizing - change thickness

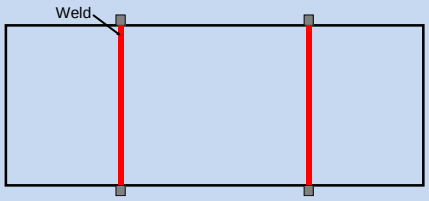
**STEP 2: Fit up and tack weld 3 plates**

- Flange Sizing - change thickness



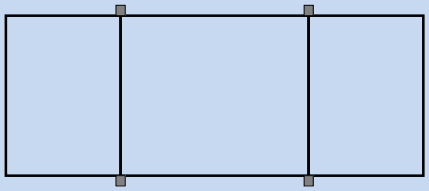

**STEP 3: Attach 4 run-off tabs**

- Flange Sizing - change thickness



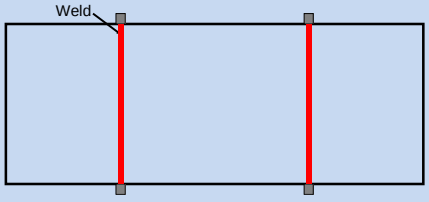

**STEP 4: Weld and grind 2 splices**

- Flange Sizing - change thickness



**STEP 5: Turn over 1 piece**

- Flange Sizing - change thickness

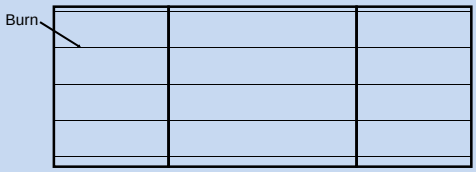



**STEP 6: Back gouge, weld and grind 2 butt welds**

- 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

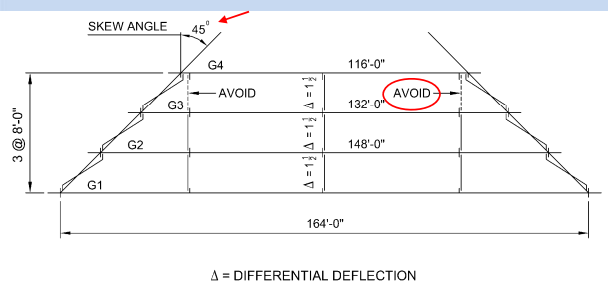
## • *Design*

- 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

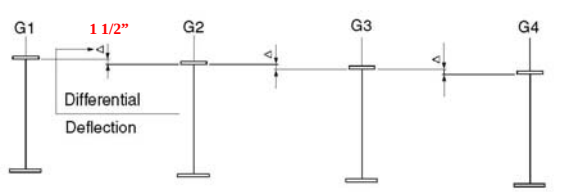
## • *Design*

- 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

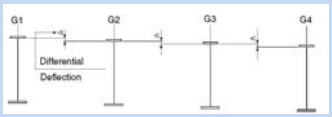


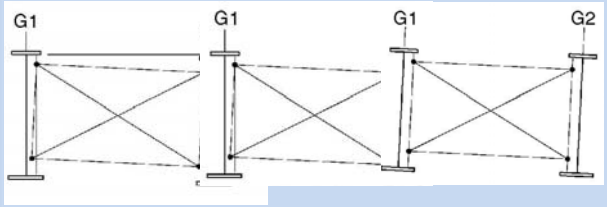
- Skewed Girders




STAGE 1

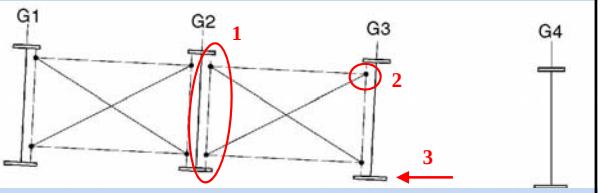
- Skewed Girders



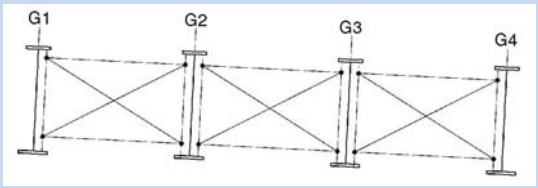

STAGE 2 STAGE 3 STAGE 4

- Skewed Girders



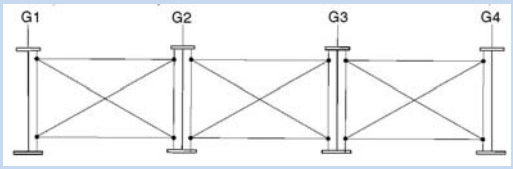

STAGE 5

- Skewed Girders




STAGE 6

- Skewed Girders



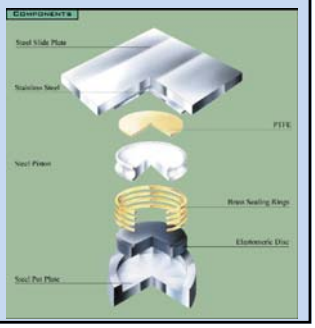

STAGE 7

- *Design*

- Bearings
  - Use elastomeric if possible
    - 800 kips, 4” lateral, .04 radians rotation

## • *Design*

- Bearings
  - Use pot bearing next




## • *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*

## • *Plate Girders*

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

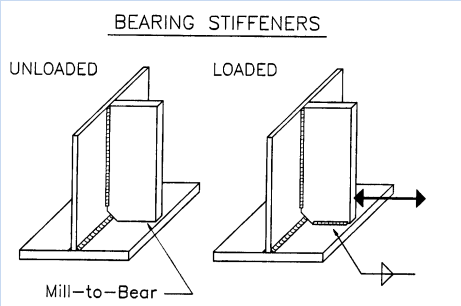
## • *Plate Girders*

- Bearing Stiffeners/Diaphragms, Connection & Intermediate Stiffeners
  - – Bearing stiffeners can be either fabricated normal to top flange or vertical (plumb) under full dead load (DL) - 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

## • *Plate Girders*

- 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)

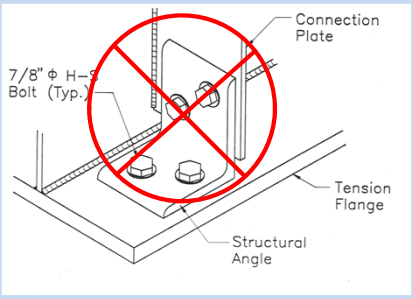
## • Bearing Stiffeners



## • *Plate Girders*

- 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

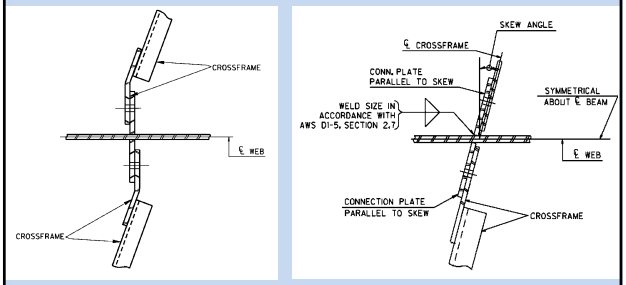



## • *Plate Girders*

- Connection Stiffener for Skewed Girders
  - Prefer bent connection plate vs. skewed connection plate for skewed cross frames

## • Skewed Cross Frame Connections

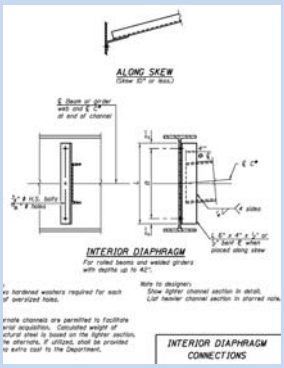
20º maximum skew




preferred (by fabricators)

## • *Plate Girders (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*

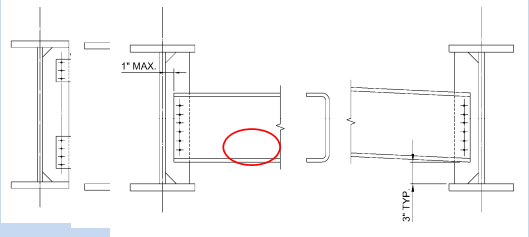
- General Details
  - Shop Assembly Requirements
  - Haunched Flange Transition
    - Bent or welded
    - Straight or curved haunch

## • *Plate Girders*

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

## • *Plate Girders*

- General Details
  - Cross Frame design




## • *Box Girders*

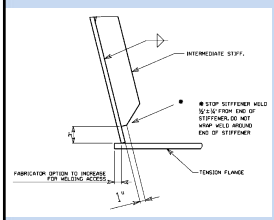
- Closed Box Details
- Trapezoidal Tub Girder Details
  - Stiffener detail at (near) bottom flange
  - Stiffening of bottom flange (compression zone)
  - External cross frames

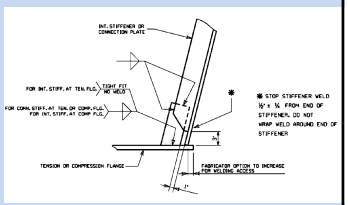
## • *Box Girders*

- Closed Box Configuration - Corner Welds
  - Try to arrange to use fillet welds or partial pen
- 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)

## • *Box Girders*

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




## • *Box Girders*

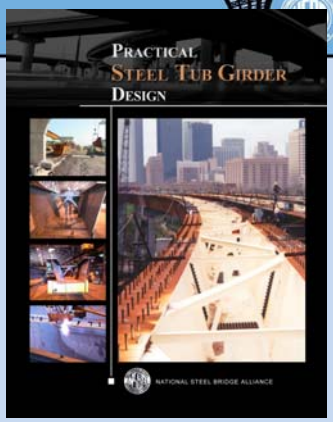
- Stiffening of Bottom Flange (Compression Zone)
  - Use WTs (versus bars)
  - Stop short of field splice (splice plates should adequately stiffen the flange)

## • *Box Girders*

- 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



## *Shipping/Fabrication Piece Limits*

- 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*

NSBA website
- www.steelbridges.org

AASHTO bookstore
- www.transportation.org

## *SIMON*

- Updating to 5th Edition AASHTO LRFD
- Enhanced with Graphic User Interface
- Distributed at WSBS in April
  - general distribution August 1
- www.steelbridges.org\softwareregistration

LRFD SIMON
SOFTWARE SOLUTION FOR PRELIMINARY BRIDGE DESIGN

## *NSBASplice*

- Updated from AISI product (10 years ago) to 5th Edition AASHTO LRFD
- general distribution August 1
- www.steelbridges.org\softwareregistration

## Contact Information…

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