Design for Constructibility Guidelines

AASHTO / NSBA
Steel Bridge Collaboration
G 12.1 - 2003

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NSBA, Regional Director

Brief Background

- Steel Bridge Collaboration
- Basis of Guidelines
- Consensus

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
    - Except with hard curve or camber
  - Availability – rolling schedules, etc
  - Allow plate girder alternate (show on bid documents)

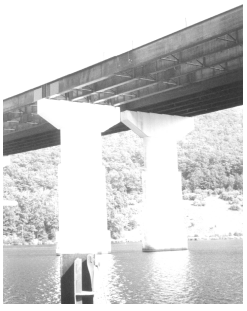
• *Design*

- 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*

- 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
  - 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*

- Plate Material Availability

• *Design*

- Wide Flange Beams Availability
  - NUCOR YAMATO – to 40" deep
  - Chaparral – to 36" deep
  - 120' long
  - ASTM A992; ASTM A709, Gr. 50S
    - Minimum Yield = 50 ksi
    - No HPS

• *Design*

- Flange Sizing – when to change area?
  - 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?

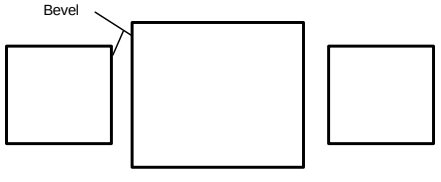
Multiply weight savings/inch x flange width (length of butt weld)							
Thinner Plate at Splice (inches)	Thicker Plate at Splice (inches)						
	1.0	1.5	2.0	2.5	3.0	3.5	4.0
1.0	70	70	70				
1.5		80	80	80	80		
2.0			90	90	90	70	70
2.5				100	100	80	80
3.0					110	90	90
3.5						110	110
4.0							130

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

- *Design*

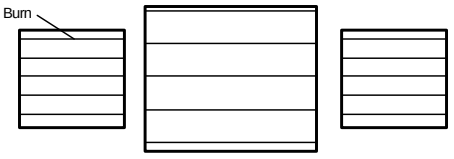
- Flange Sizing – how to change area?
  - Shop butt splices within a shipping piece – what to change, width or thickness?
    - Keep width constant (i.e., to change cross section area, change thickness)
    - WHY ?
    - compare changing width vs. changing thickness

- Flange Sizing - change width



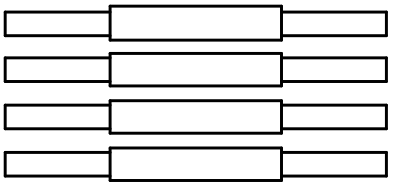
FABRICATE 4 FLANGE ASSEMBLIES
STEP 1: Bevel (4) plate edges

- Flange Sizing - change width



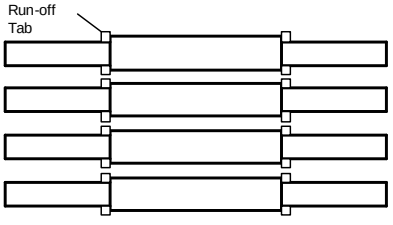
STEP 2: Burn 12 pieces from 3 plates

- Flange Sizing - change width



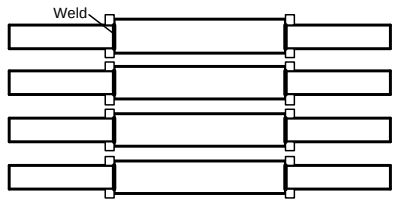
STEP 3: Fit up and tack weld 4 flange assemblies

- Flange Sizing - change width



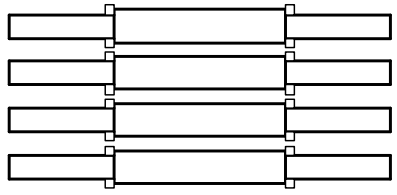
STEP 4: Attach 16 run-off tabs

- Flange Sizing - change width



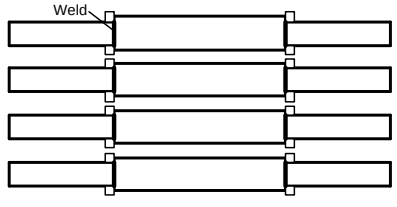
STEP 5: Weld and grind 8 splices

- Flange Sizing - change width



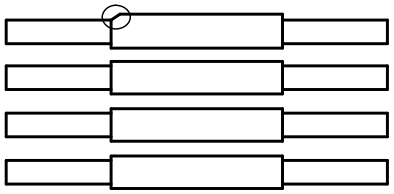
STEP 6: Turn over 4 flange assemblies

- Flange Sizing - change width



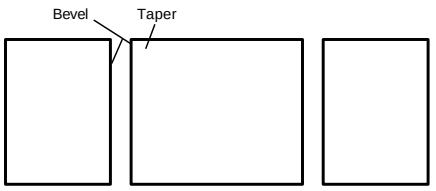
STEP 7: Back gouge, weld and grind 8 butt joints

- Flange Sizing - change width



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

- Flange Sizing - change thickness

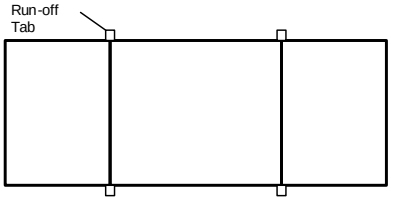


CHANGE THICKNESS
STEP 1: Bevel (4) and taper (2) plate edges

- Flange Sizing - change thickness

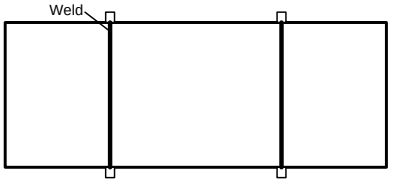
STEP 2: Fit up and tack weld 3 plates

- Flange Sizing - change thickness



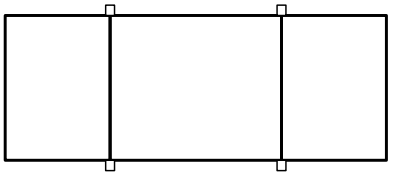
STEP 3: Attach 4 run-off tabs

- Flange Sizing - change thickness



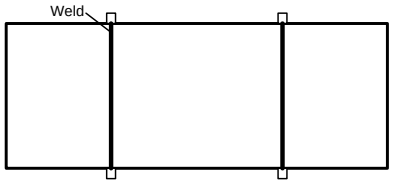
STEP 4: Weld and grind 2 splices

- Flange Sizing - change thickness



STEP 5: Turn over 1 piece

- Flange Sizing - change thickness

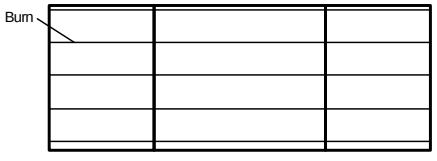


STEP 6: Back gouge, weld and grind 2 butt welds

- Flange Sizing - change thickness

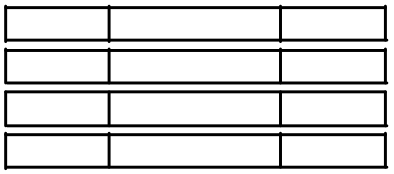
STEP 7: Remove and grind 4 run-off tabs

- Flange Sizing - change thickness



STEP 8: Burn 4 flanges from 1 assembly

- Flange Sizing - change thickness



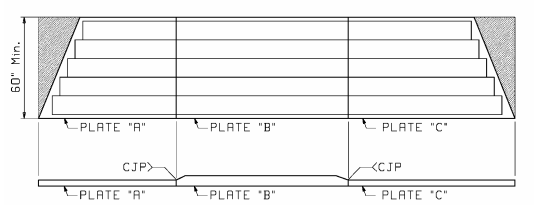
STEP 8: Burn 4 flanges from 1 assembly

- *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*

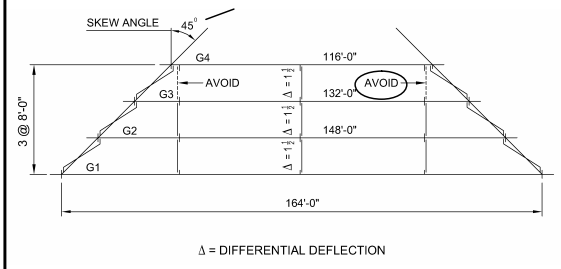
- Flange Sizing



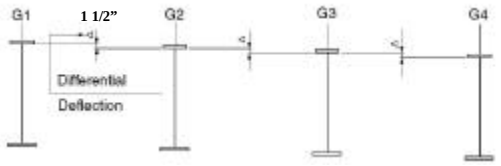
• *Design*

- Differential 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

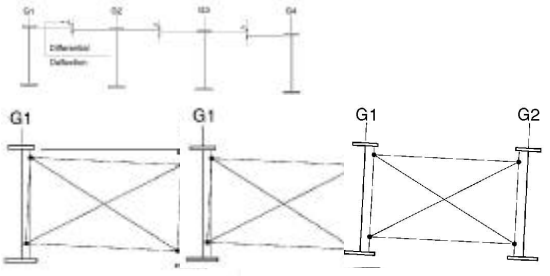


- Skewed Girders



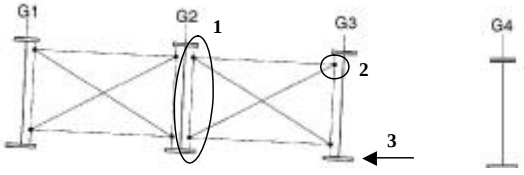
STAGE 1

- Skewed Girders



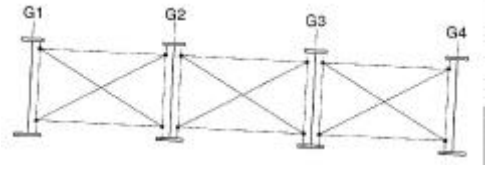
STAGE 2 STAGE 3 STAGE 4

- Skewed Girders



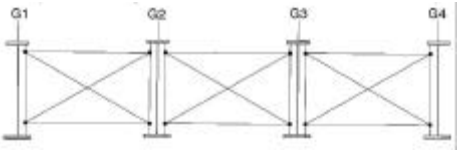
STAGE 5

- Skewed Girders



STAGE 6

- Skewed Girders



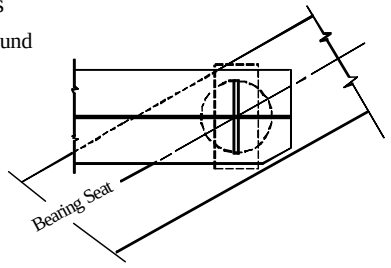
STAGE 7

• *Design*

- Bearings
  - Use elastomeric if possible
  - Use pot bearing next
  - See Collaboration *Steel Bridge Bearing Design and Detailing Guidelines*, AASHTO Ballot '04
  - See HSDH *Steel Bridge Bearing Selection and Design Guide*

• *Design*

- Bearings
  - Use round



• *Design*

- 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*

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

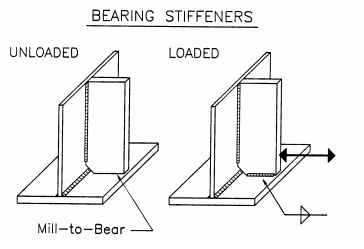
• *Girder Design*

- 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*

- 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



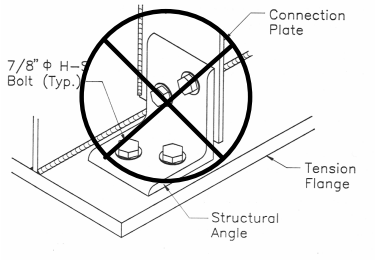
• *Girder Design*

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

• *Girder Design*

- 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

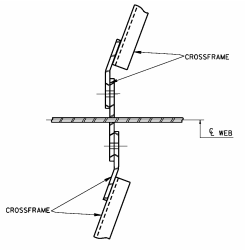
- Connection Stiffener Attachment



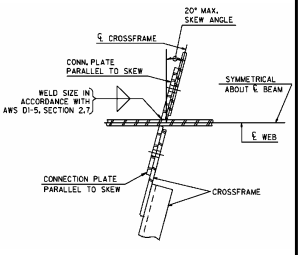
• *Girder Design*

- 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



preferred (by fabricators)



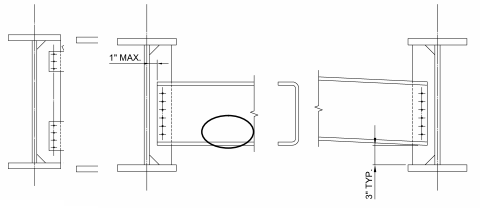
20º maximum skew

• *Girder Design*

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

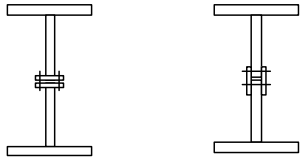
• *Girder Design*

- General Details
  - Cross Frame design



• *Girder Design*

- Longitudinal Web Field Splices (deep girders)



- use side plates

• *Boxes*

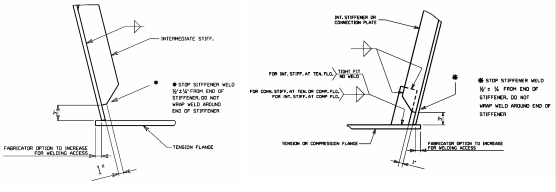
- Closed Box Configuration - Corner Welds
- Closed Box Diaphragm Attachment
- Closed Box Interior Diaphragm Minimum Access Hole Size
- Stiffener Detail at (near) Bottom Flange of Tub Girders
- Stiffening of Bottom Flange (Compression Zone)
- Interior Coating
- Relative Costs of Closed Boxes and Tub Girders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

• *Boxes*

- 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*

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



• *Boxes*

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

• *Boxes*

- 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

• *Bolts*

- Metric vs. Customary Units
  - Customary bolts (and holes)
- Mechanically or Hot-Dip Galvanize
  - Mechanically (except on weathering steel)
- Shop Bolts – Black vs. Galvanized
  - Mechanically galvanized

• *Corrosion Protection*

- 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

• *Other*

- Bid Lump Sum
  - Except for emergency or repair
- Partial Payment for Materials and Fabrication
  - Pay for mill material received (per mill invoice)
  - Pay at completion of fabriation (70% of contract)
  - Pay at delivery to site or storage (90% ")
- Contract Direct w/ Fabricator
  - Can expedite delivery of fabricated steel

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

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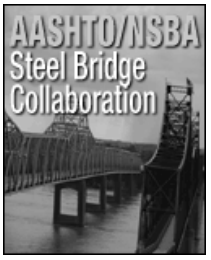

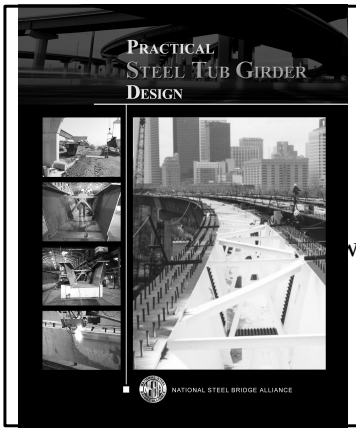

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