Design For Efficient Fabrication, Shipping & Erection

Practical Answers to Theoretical Questions

HIGH STEEL STRUCTURES, INC.

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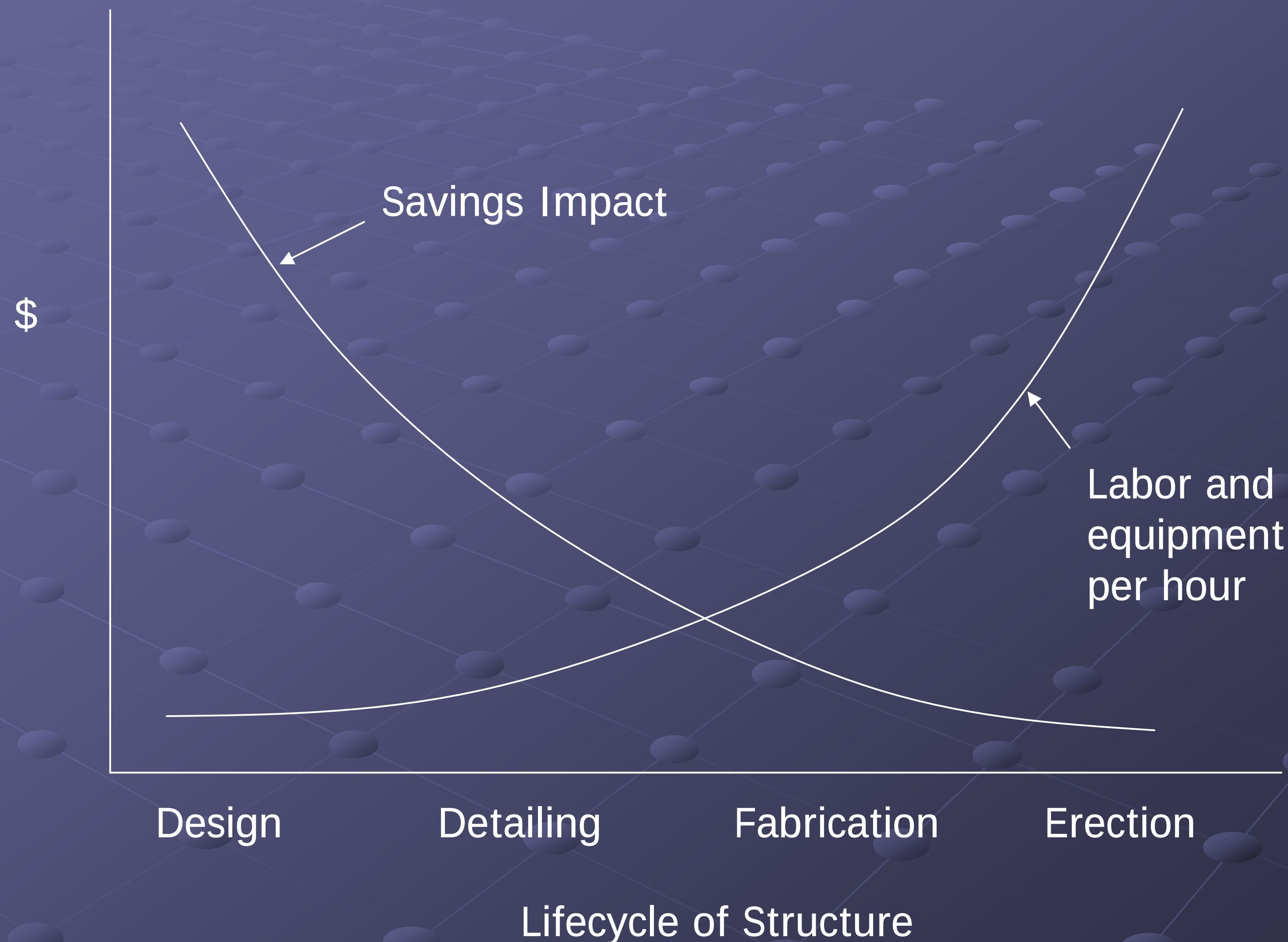
Topics

- General Information
  - G1.4, S2.1, S10.1, G12.1
- Fabrication
- Shipping
- Erection

General Information



Economic Fabrication

- Consistency / Repeatability
  - Materials
  - Details
- Learning Curve

Economic Fabrication

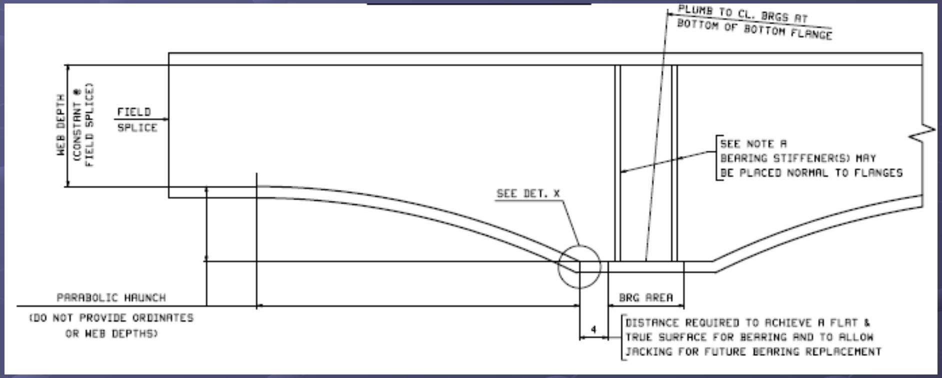
- Girder Spacing
  - Maximize girder spacing (11’-14’) to eliminate a girder line
    - Example: 4 girder lines instead of 5
      - 20% less girders
      - 25% less cross frames
  - Keep spacing constant for as much of the structure as possible

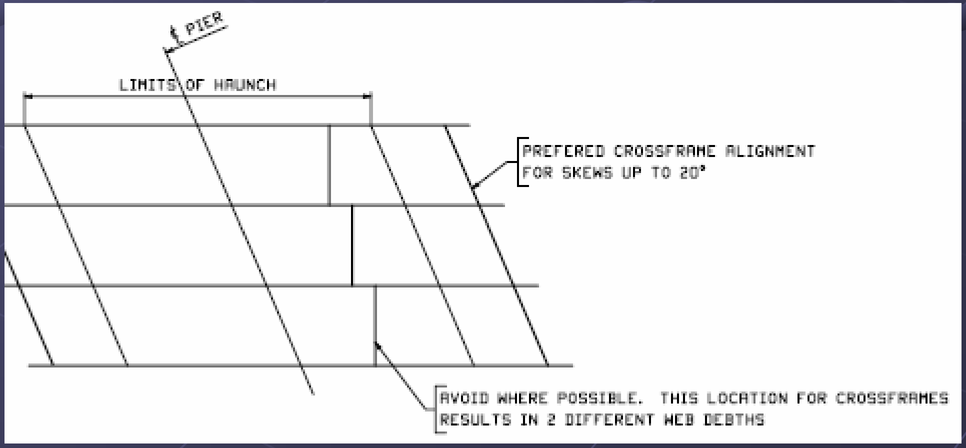
Economic Fabrication

- Girder Depths
  - Keep constant depth across structure
    - Minimizes diaphragm and stiffener variation
    - Simplifies detailing and fabrication
  - Exception: If girder weights vary dramatically (+/- 15 tons) from inside girder to outside girder, consider varying depth to keep erection costs down

Economic Fabrication

- Haunched girder
  - Avoid steep transitions (45' +/-)
    - Allow radius at bearing area to enable bending of flange – at a minimum, allow substitution of bending or welding (fabricator's option)
  - If bridge is skewed, keep diaphragm lines parallel to bearing lines (similar depths)



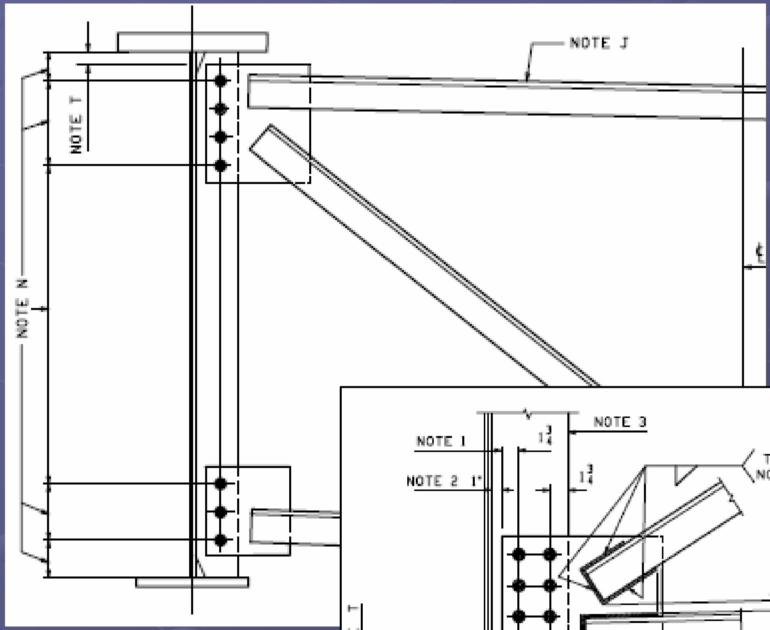


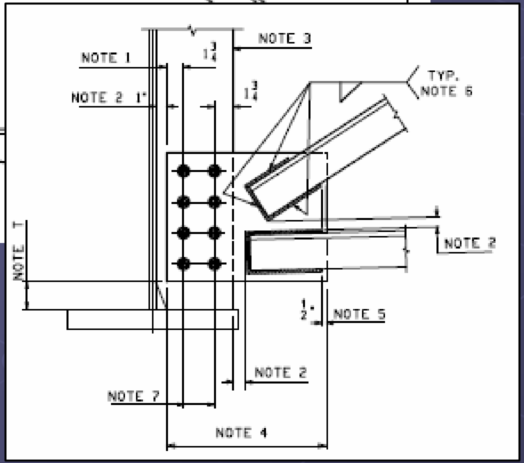
Economic Fabrication

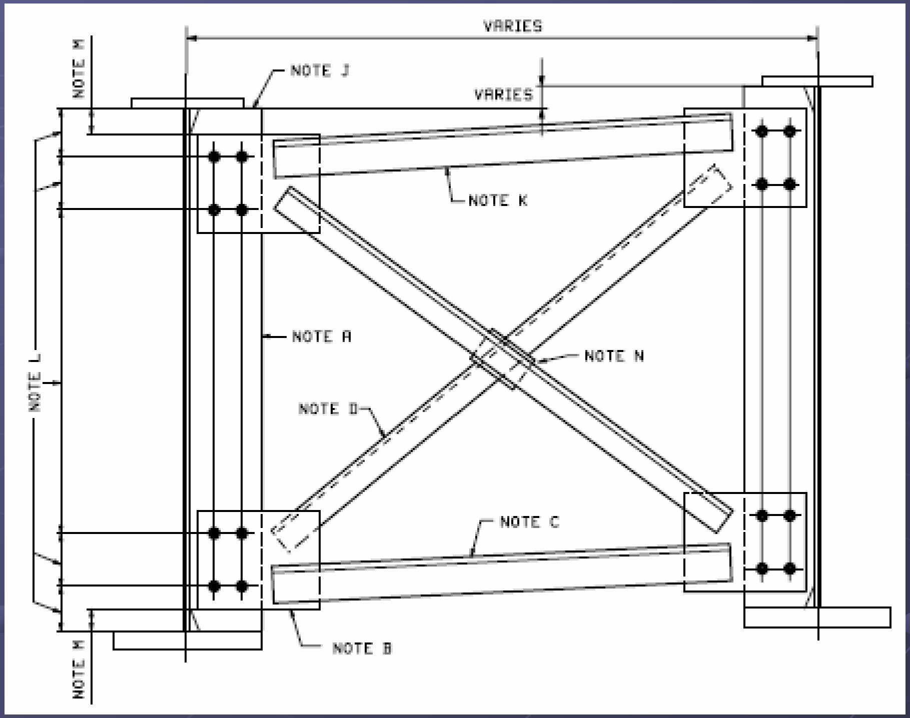
- Minimize Diaphragm Variations
  - Stiffener sizes
    - Any change in size or configuration is a chance for error
  - Quantity and Diameter of bolts
    - Minimize variation in diameter (retooling, multiple wrenches in field)
    - Minimize quantity changes
  - Cross frame member sizes
    - Use “Common” sizes, combine where practical
    - Heavy sections are an issue right now

Economic Fabrication

- Cross frame details

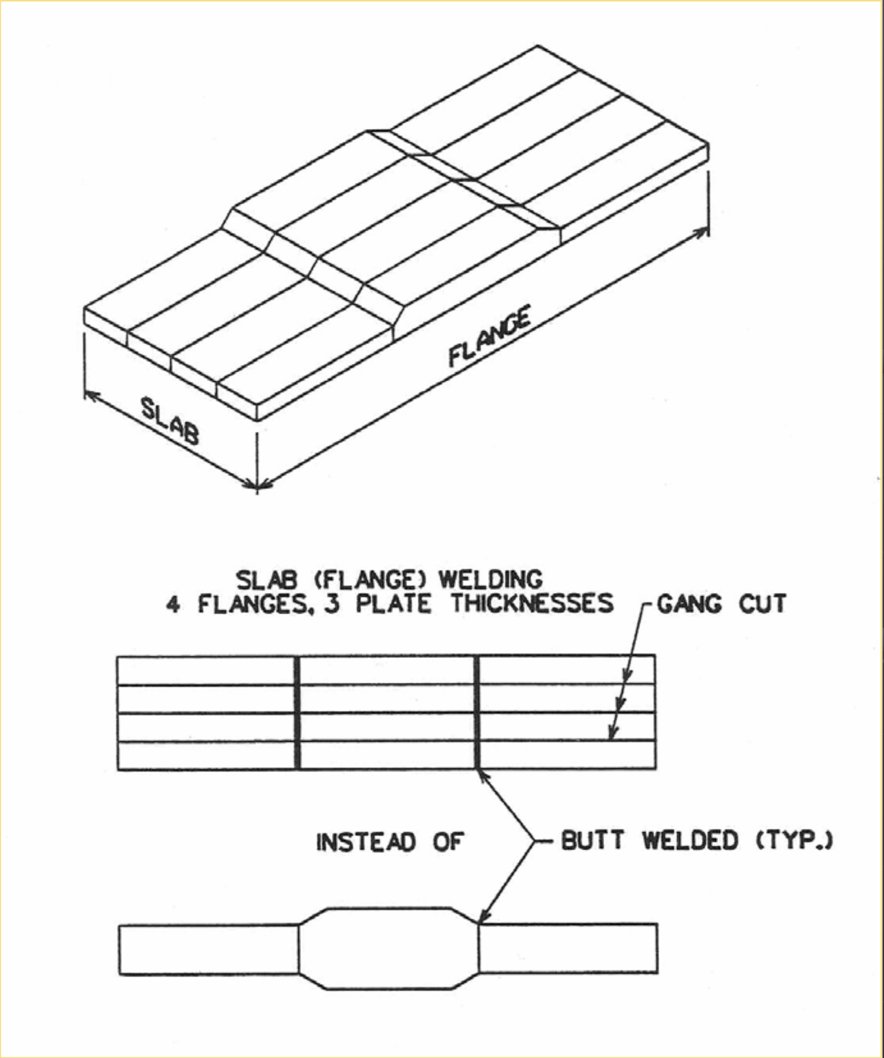






Economic Fabrication

- Slab Welding
  - Vary thickness, not width
  - Eliminates excess run-off tabs
  - Minimum slab width is 48”, preferably 72-96”



Economic Fabrication

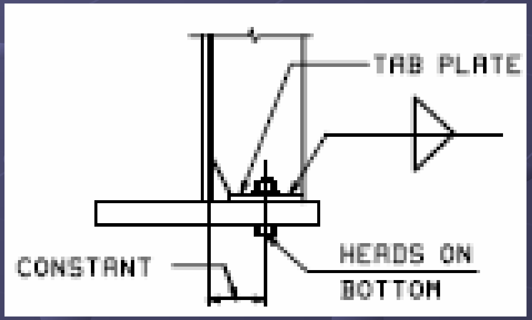
- Stiffener fitting
  - Bearing Stiffeners
    - Use “Fit to Bear” and fillet welds in lieu of CJP
  - Connection Stiffeners
    - Use fillet welds in lieu of “Tight Fit”
  - Intermediate Stiffeners
    - Consider increasing web thickness to eliminate stiffeners
  - Use standard cope size per structure

Economic Fabrication

- NJ End Diaphragm Details
  - Expansion joints connected to structure
    - Slots in top flange of end diaphragms
      - Must be burned or machined
    - ½”ø bars welded to end diaphragms
  - Prefabrication steps prior to fabrication of diaphragm

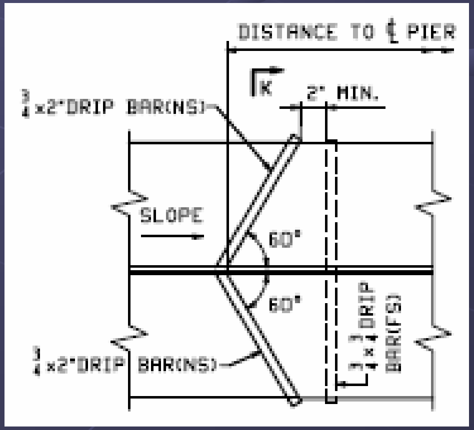
Economic Fabrication

- Avoid “tab” plate connection to flange
  - Expensive detail
    - Drill flange
    - Fit stiffener and plate
    - Tack weld stiffener to plate
    - Pull out of assembly, weld
    - Re-fit assembly, bolt assembly to flange
      - If painted, grind and prime prior to bolting
    - Weld stiffener to web, flange



Economic Fabrication

- Avoid placing stiffeners too close to each other
  - Rule of thumb – for each inch of stiffener width, allow same clearance face to face of stiffeners, with a minimum of 6”
- Drip bars
  - Weld in lieu of bolting



Assembly

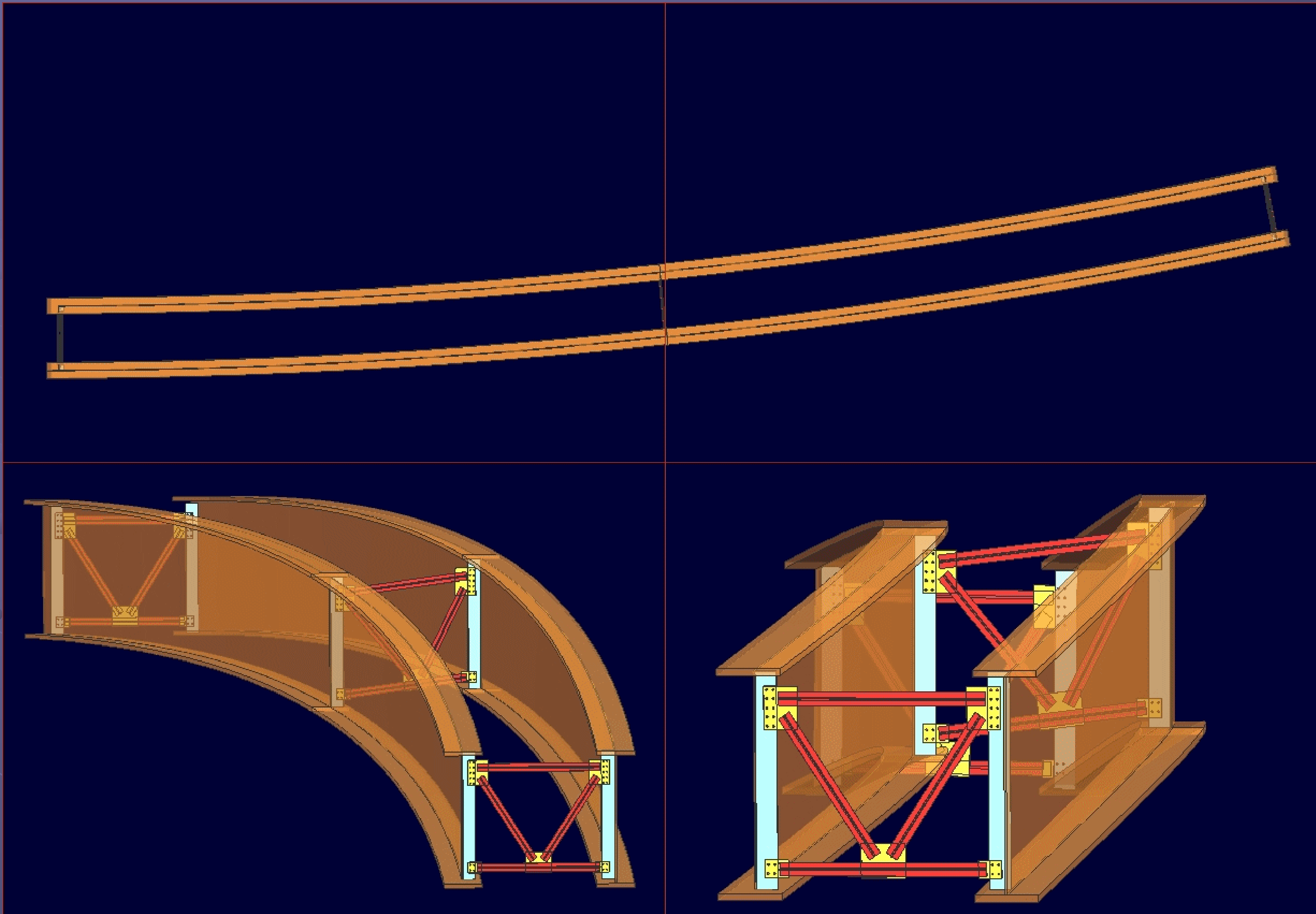
- Assembly requirements (main members)
  - Most specifications require 3 contiguous sections to be set up (minimum)
  - Current measuring technology will allow 2 sections to be assembled with no decrease in accuracy
    - Increases fabricator’s flexibility
    - Decreases cycle time of fabrication

Assembly

- Cross frames are not required in set-up, unless specifically required by contract documents
- Cross frames are accurately fabricated to calculated dimensions
- Girders are next...

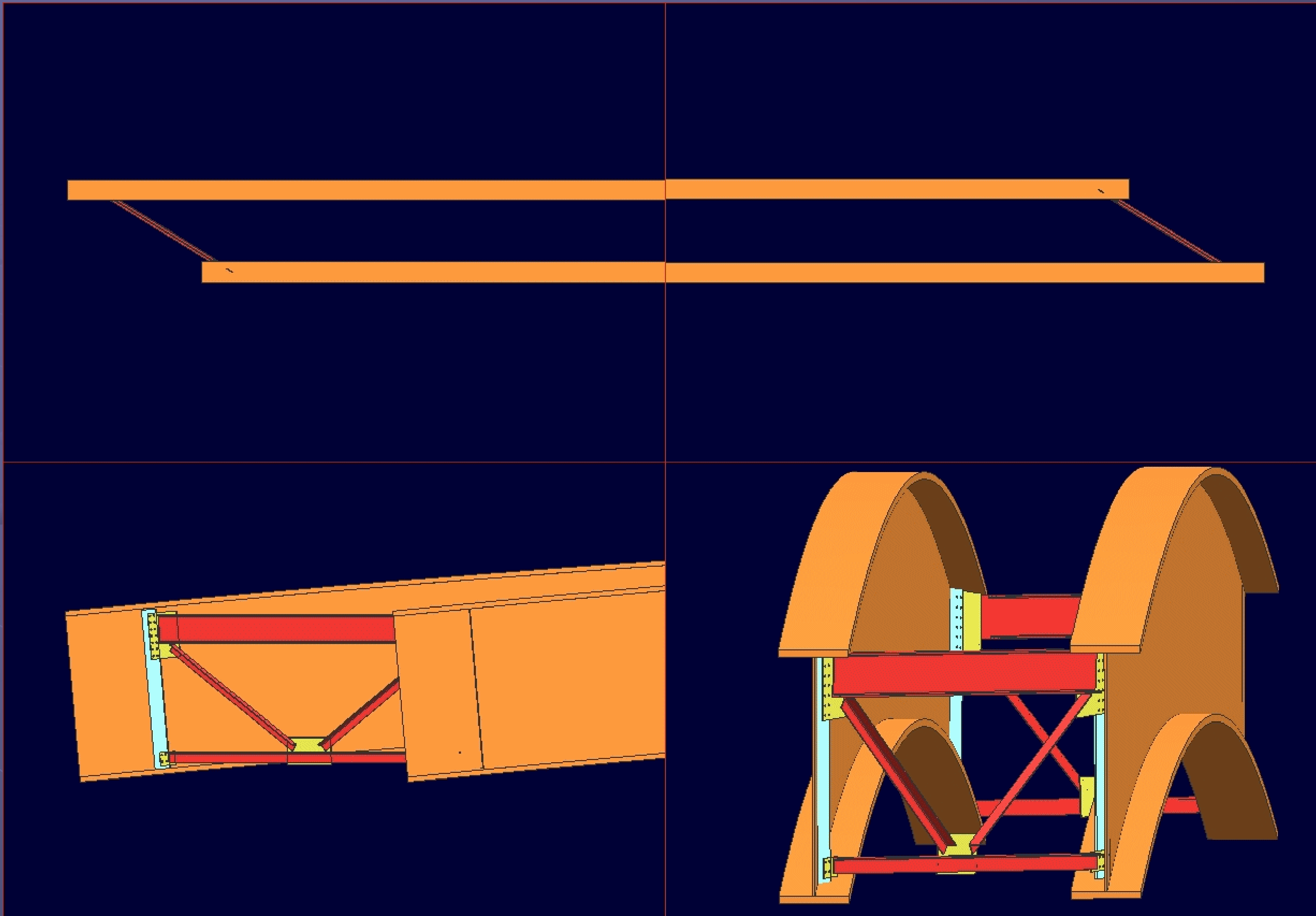
Curved Structures

- Curved girders deflect different amounts due to varying span lengths of each girder
- Curved girders have a tendency to “roll” during deflection
  - Top flange away from center of curve
  - Bottom flange towards center of curve



Skewed Structures

- Skewed girders deflect similar amounts per girder line
- Due to the skew and associated framing, skewed girders will deflect vertically, and rotate transversely during deflection



Curved/Skewed Structures

- Define expectations of erected and final position on the plans
- Sample note:

17. FABRICATE THE GIRDERS AND CROSS FRAMES SUCH THAT ALL GIRDER WEBS ARE PLUMB VERTICAL AFTER THE STEEL GIRDERS AND CROSS FRAMES HAVE BEEN FULLY ERECTED (I.E. PRIOR TO POURING THE DECK). INCLUDE ON THE SHOP DRAWINGS THE AMOUNT OF LATERAL DEFLECTION THE ERECTOR WILL HAVE TO IMPART ON THE GIRDERS IN ORDER TO INSTALL THE CROSS FRAMES.

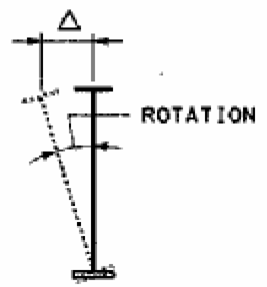
THE FOLLOWING GIRDER MOVEMENTS ARE GIVEN AS APPROXIMATE ANTICIPATED MAXIMUM DIFFERENTIAL LATERAL DEFLECTIONS AND RESULTING LATERAL ROTATIONS. THESE VALUES ARE BASED ON ALL CROSS FRAMES INSTALLED AND CONNECTIONS FULLY TIGHT. ADDITIONAL INFORMATION IS AVAILABLE UPON REQUEST.

UNIT 1: LOCATION AT 0.5L IN SPAN 3

	STEEL ONLY	STEEL AND CONCRETE
DIFFERENTIAL LATERAL DEFLECTION -Δ (in.):	0.21	0.38
ROTATION (radians):	0.0025	0.0045

UNIT 2: LOCATION AT 0.4L IN SPAN 5

	STEEL ONLY	STEEL AND CONCRETE
DIFFERENTIAL LATERAL DEFLECTION -Δ (in.):	0.55	1.09
ROTATION (radians):	0.0066	0.0130



LATERAL DEFLECTION

NOT TO SCALE

FIELD WELDING (CONT'D)

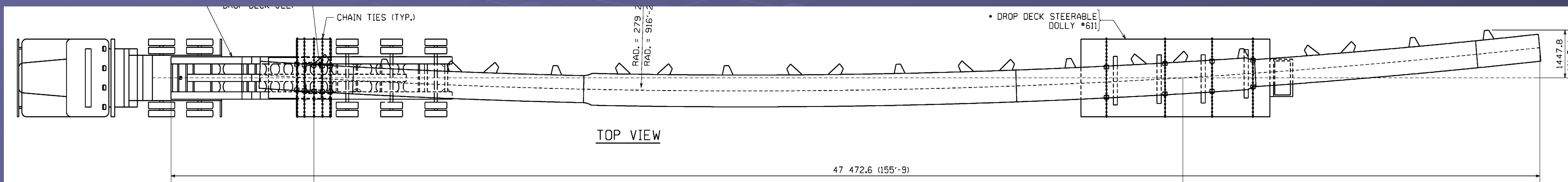
Curved/Skewed Structures

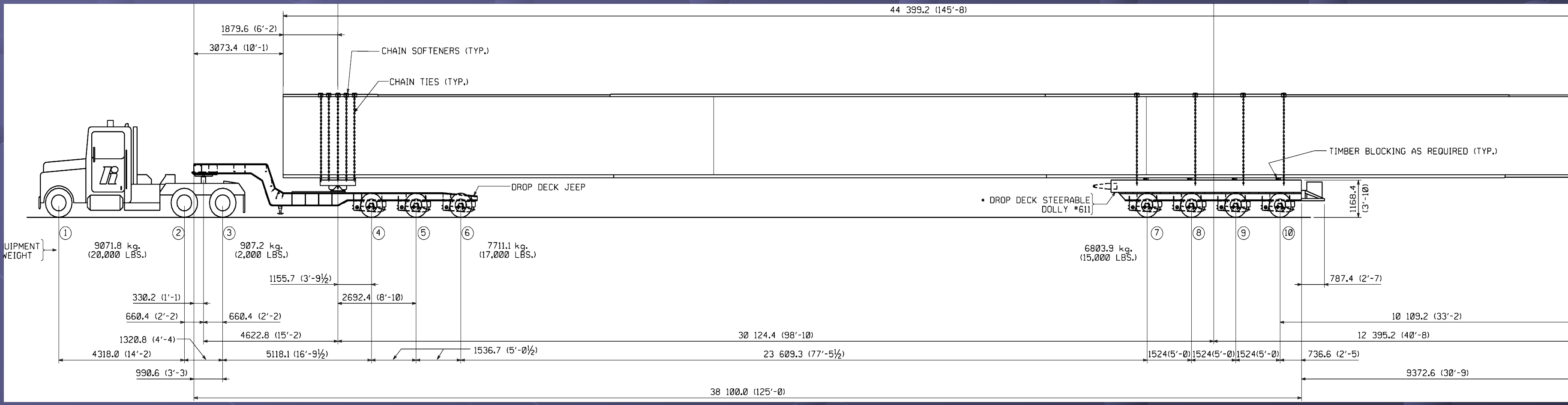
- Use welded cross frames instead of knock down cross frames
  - Hold geometry better
  - Quicker to erect (1 vs. 3 crane picks)

Shipping

- Generally, shipping is biggest constraint on member size
- Rule of thumb shipping envelope (member)
  - Length: 130’-0
  - Height: 9’-0
  - Width: 10’-0
    - Includes mid-ordinate for curved girders
  - When members start pushing envelope, contact fabricator or NSBA for guidance

Shipping Procedures





Shipping

- Weight is generally not an issue, unless piece is short
  - Need to be able to put enough axles under piece to stay within axle load limits

Shipping

- If piece is too large to ship via land, water is an option for delivery
- Water delivery limits competition, price may be affected

Erection

- Minimize time spent in field erecting structure
- Minimize variations in framing members
  - Less marks, less sorting, less chance for errors
- Define expectations on designs
- Provide a method for erection of structure in contract package
  - Allow substitutions with acceptable calculations

Erection

- Specify an AISC Certified Erector for complex structures
- Time spent on erection procedures is worth the effort – minimize problems in field

Summary

- Minimize variations in superstructure design
- When in doubt, ask a fabricator, shipper or erector for advice
- Design stage is where all parties have the biggest impact on structure