

Steel Bridge Excellence:  
Keys to Effective Construction  
Western Bridge Engineer's Seminar  
24 – 27 September 2007

Ronnie Medlock  
High Steel Structures, Inc.

# High Steel Structures

1931 - Sanford H. High purchased King Welding Company (Later named High Welding Company)



# High Steel Structures

- Largest steel girder manufacturer in the U.S.
- Four facilities
- ISO 9001 Certified
- 14 State market area
- AISC certified
  - Bridges
  - Building
  - Erection



# Excellence



# Excellence

- Durable
- Economical
- On time
- Aesthetic



# Durability



# Weathering Steel Cost Savings

## Cost savings

- First cost
- In service cost



# Weathering Steel Performance

- Detailing is Key

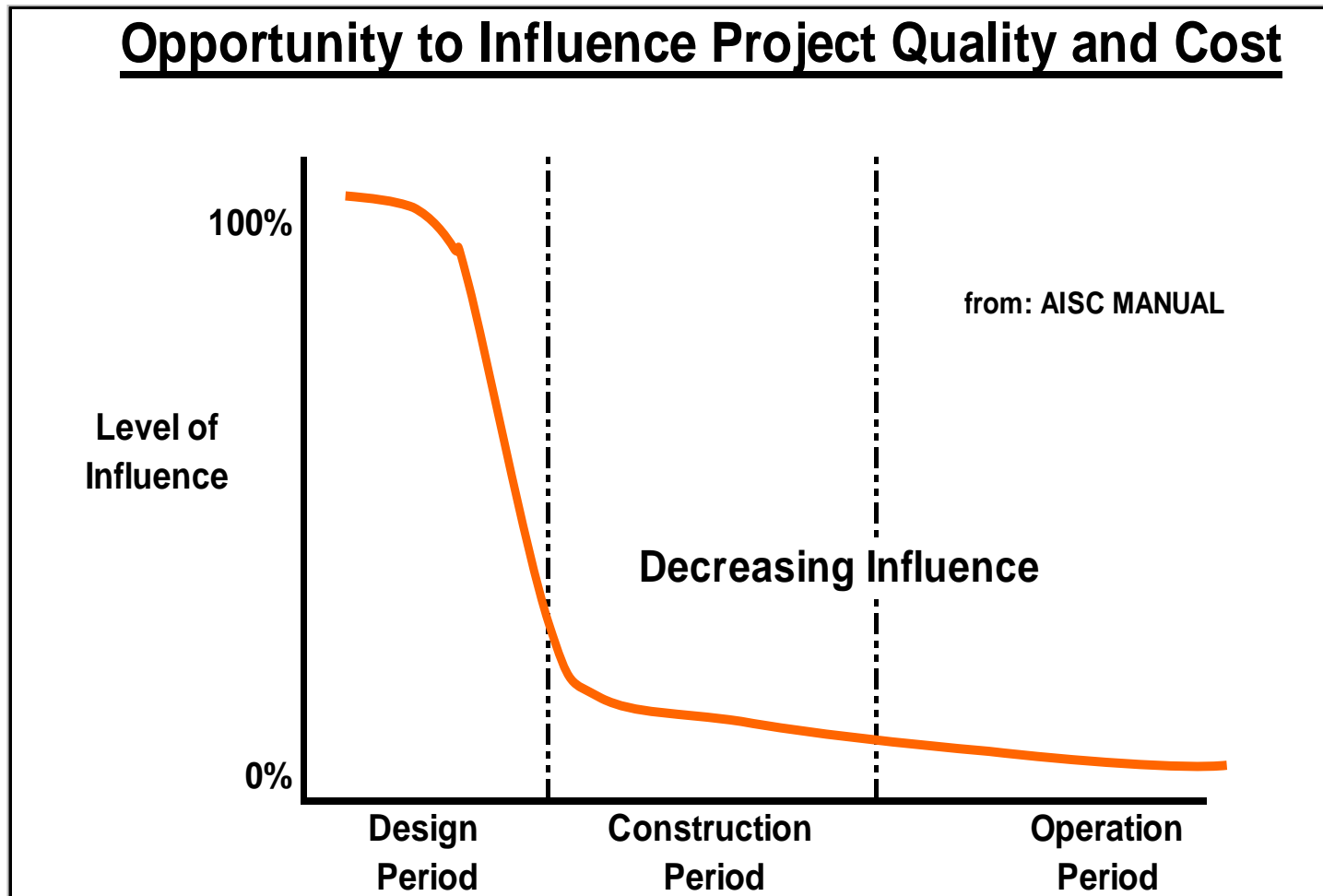




# Cleaning and Painting



# Economy



# Design Economy

- Standard
- Special

# Design Economy

- Standard
  - Understood details, readily available materials, known connections, proven processes
- Special
  - Mysterious details, hard to find materials, difficult (or impossible) connections to fabricate, unproven processes

# AASHTO / NSBA Steel Bridge Collaboration

- Standardization
- Website:

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

- Listserv

# Collaboration Standard G12.1

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

AASHTO/NSBA Steel Bridge Collaboration  
G 12.1 - 2003



**Guidelines for Design for Constructibility**

AASHTO/NSBA Steel Bridge Collaboration



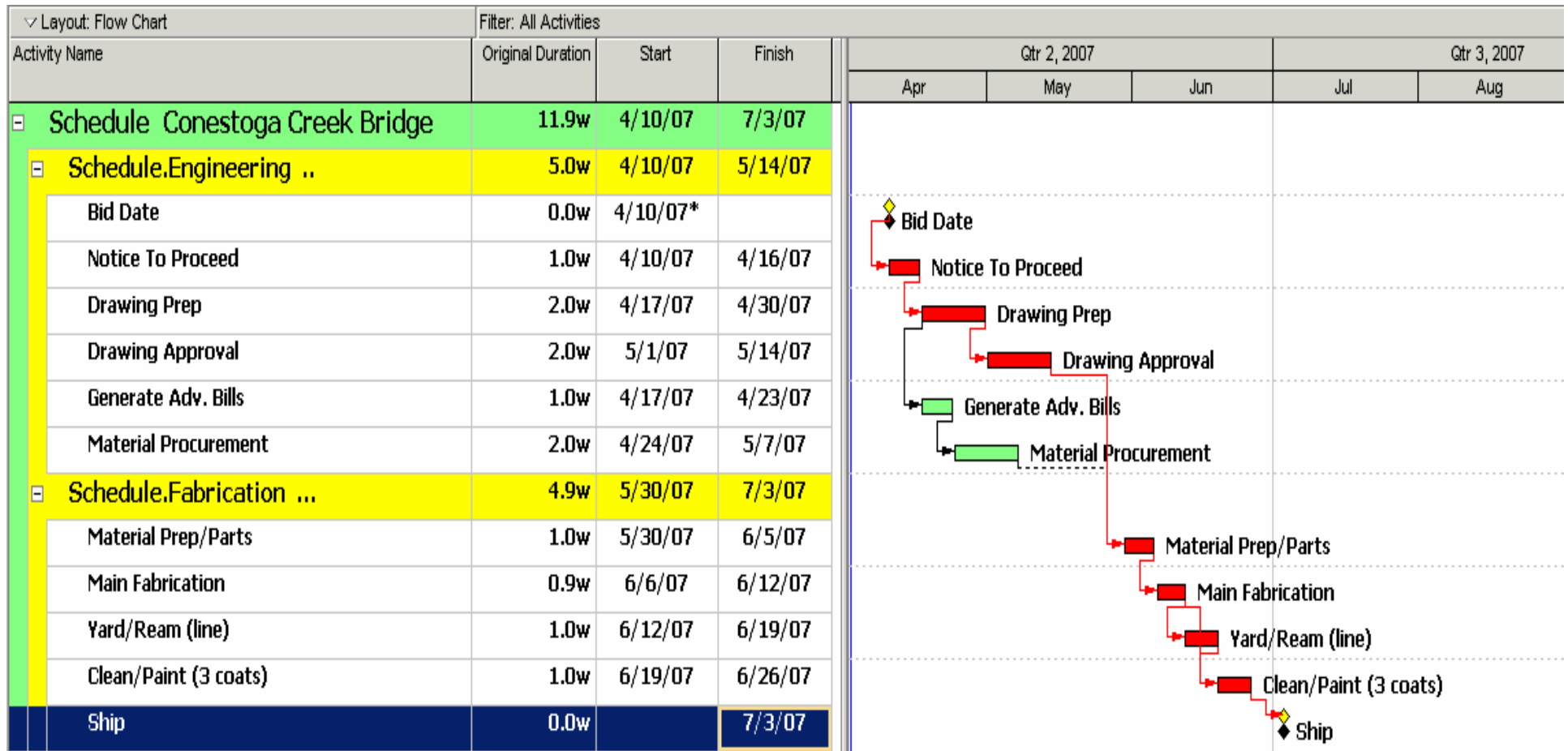
# Material

Economy =

- Optimal availability  
*Consider lead times!*
- Minimal plate thickness variances
- Use of bar stock
- Minimal shape variances

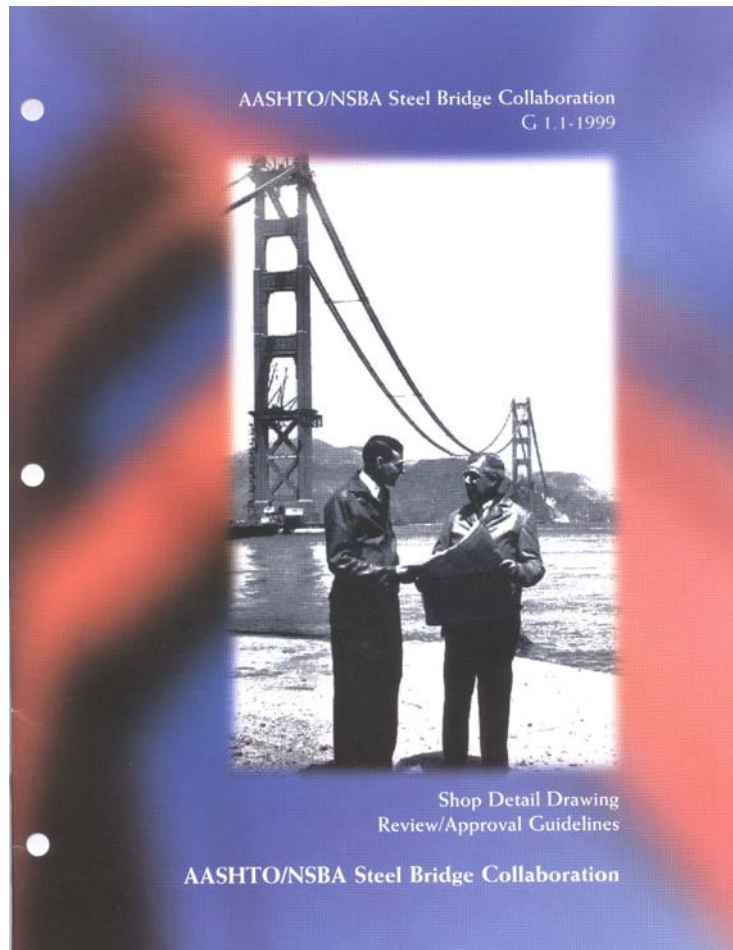


# Fabrication Cycle Time



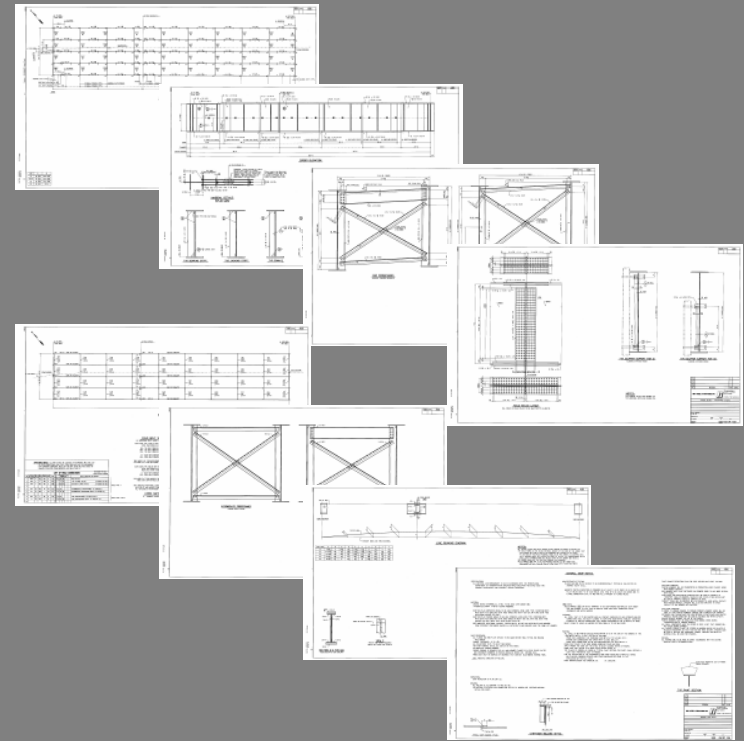
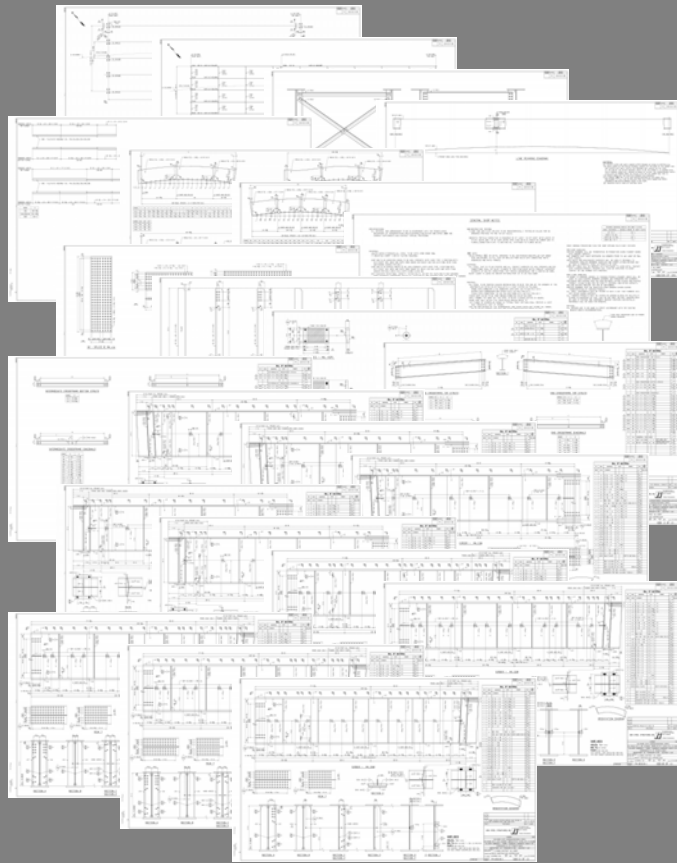


# Shop Drawing Review

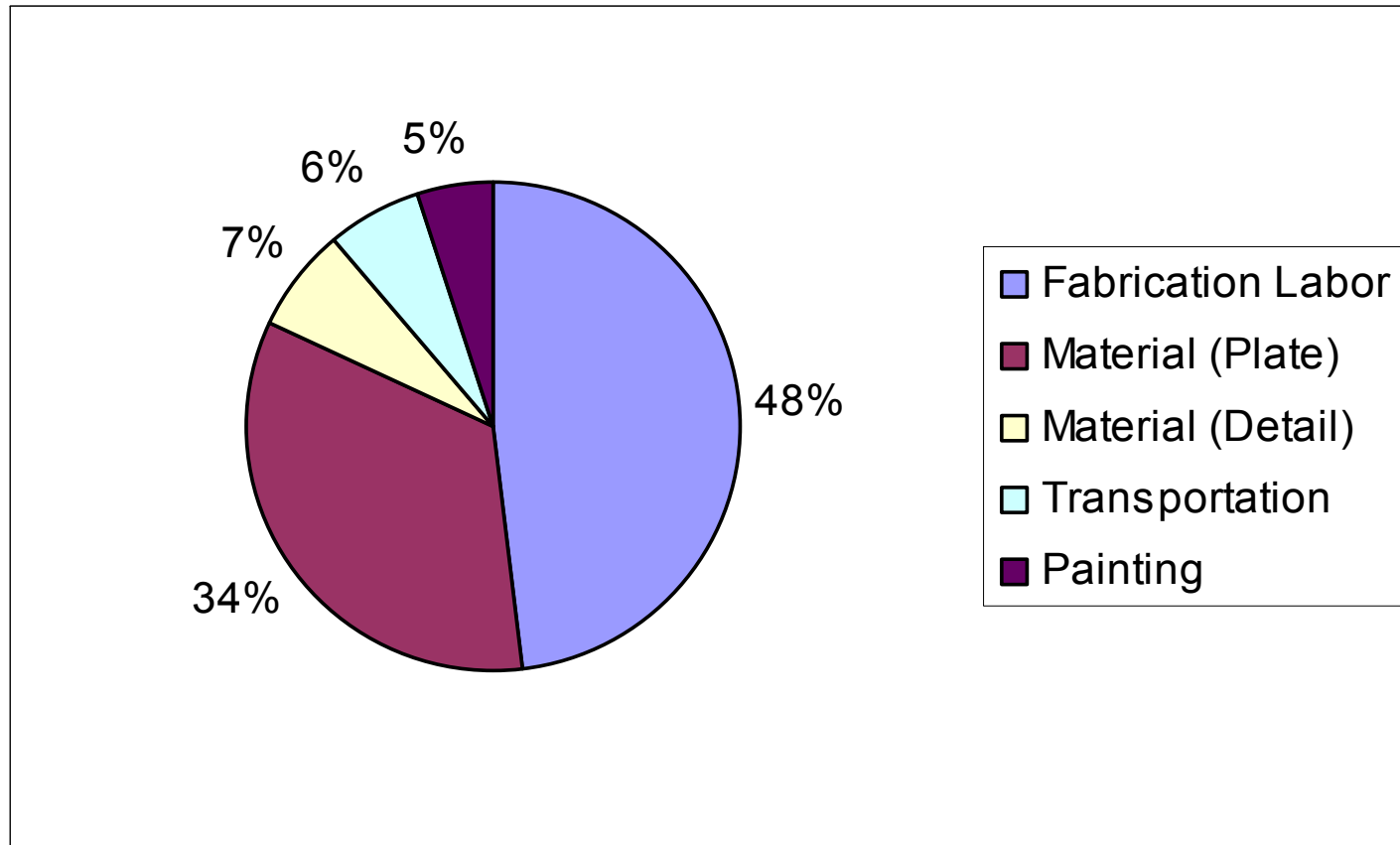


- Responsibility
- Expediency
- Approved / approved as noted

# Design Intent Drawing Comparison

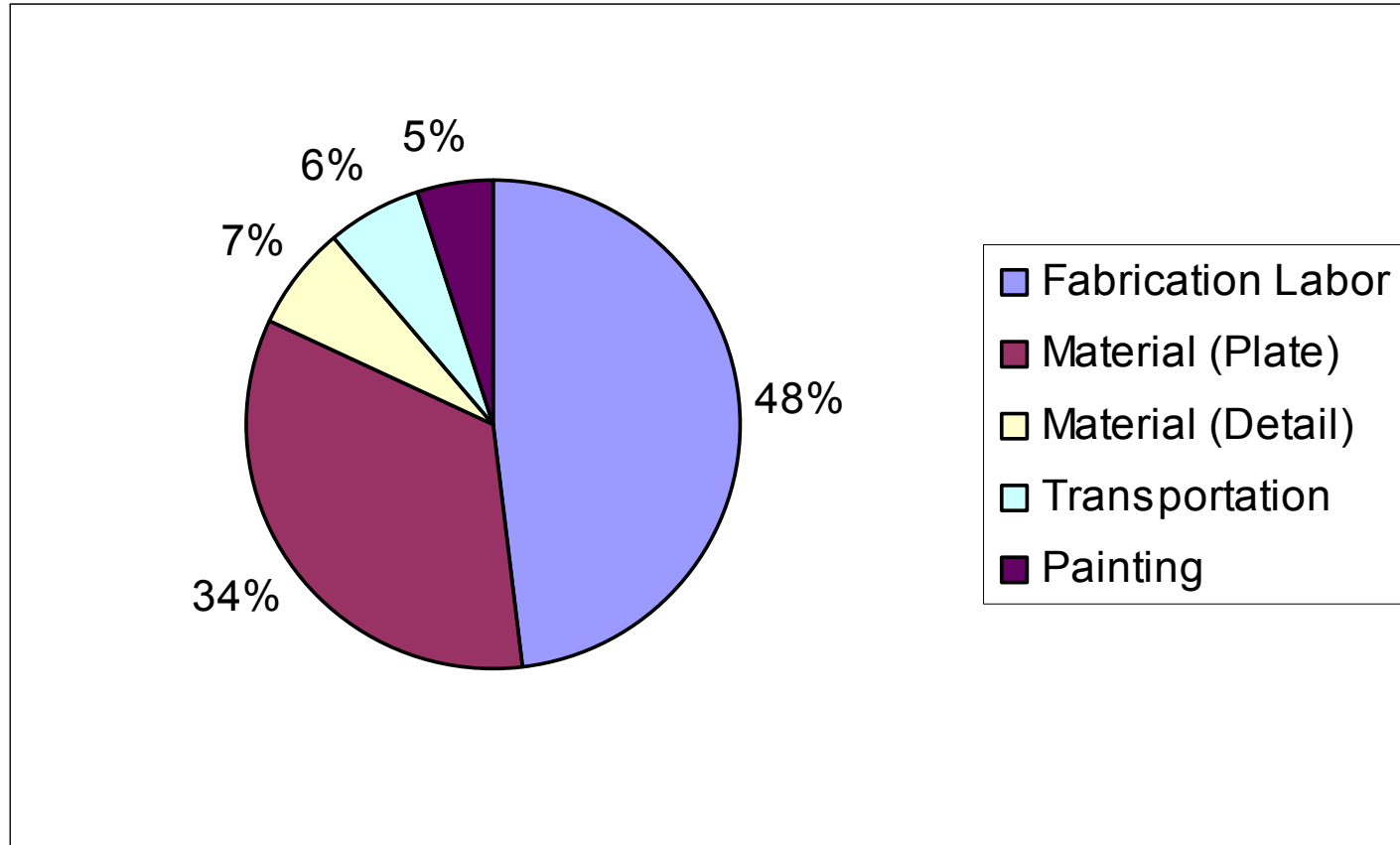


# Fabrication Cost



Economy = least weight?

# Fabrication Cost



~~Economy = least weight?~~

# Welding



# Economic Flanges

- When to change area?
  - Shop splices within a shipping piece
    - 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?

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

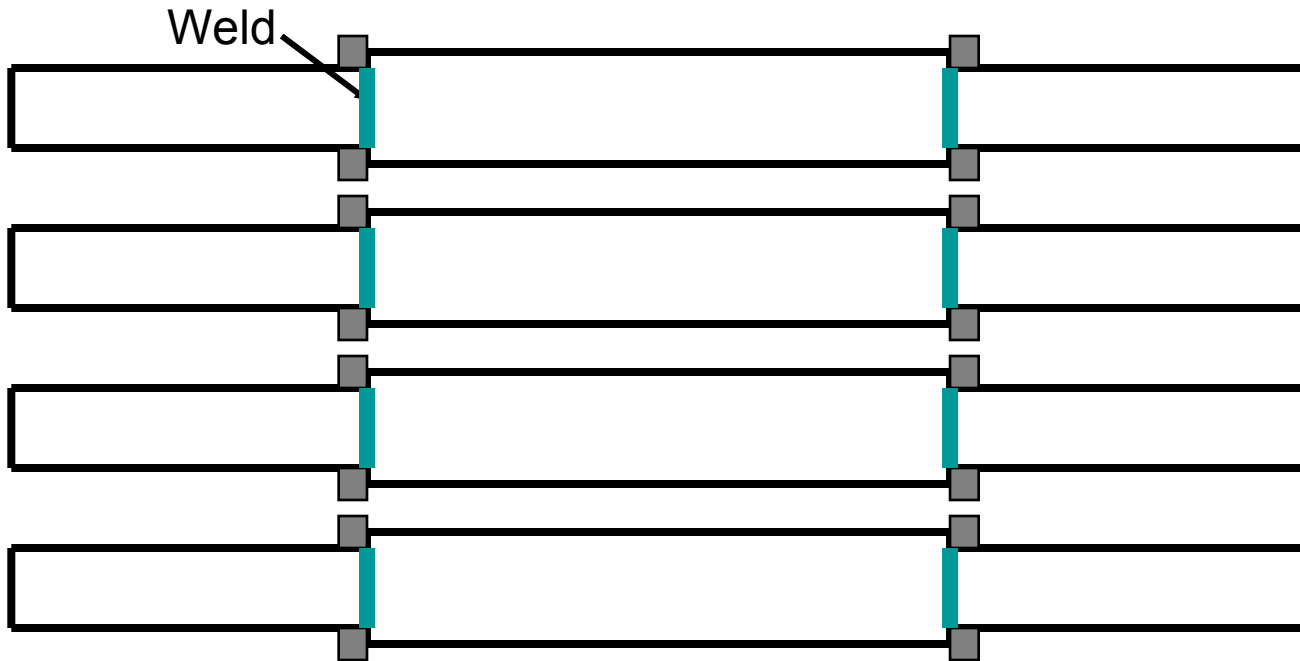
**Weight Saving Factor Per Inch of Plate Width  
for ASTM A709-Gr 50 Non-Fracture Critical Flanges Requiring Zone 1 CVN Testing**

# Economic Flanges

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

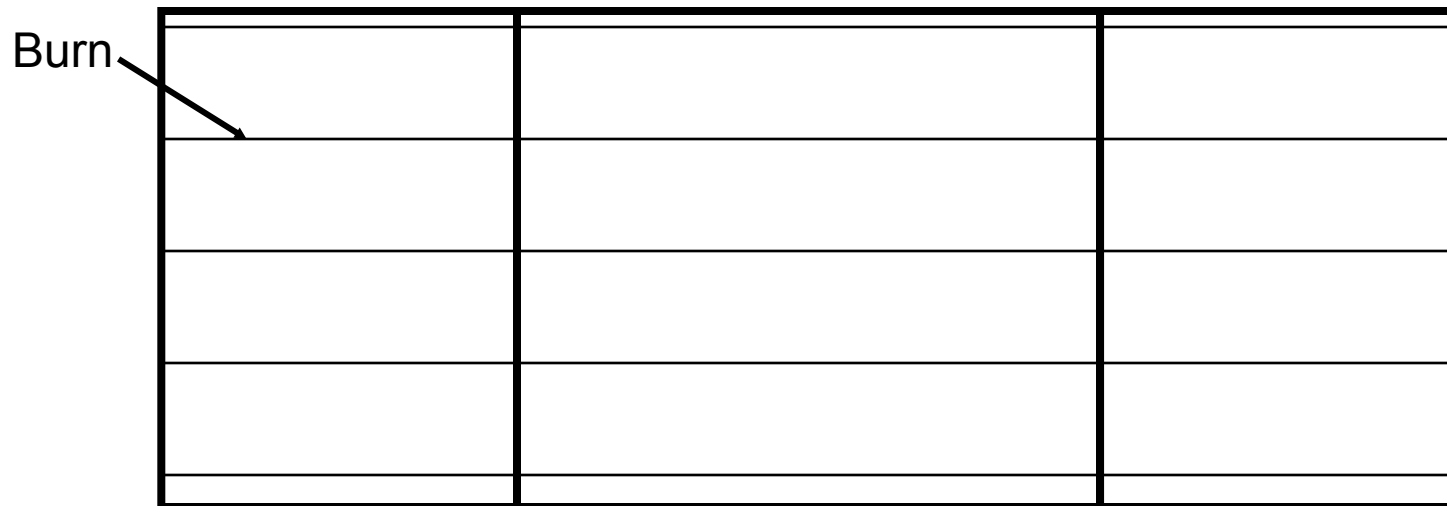


- *Flange Sizing - change width*



**8 Welds**

- *Flange Sizing - change thickness*

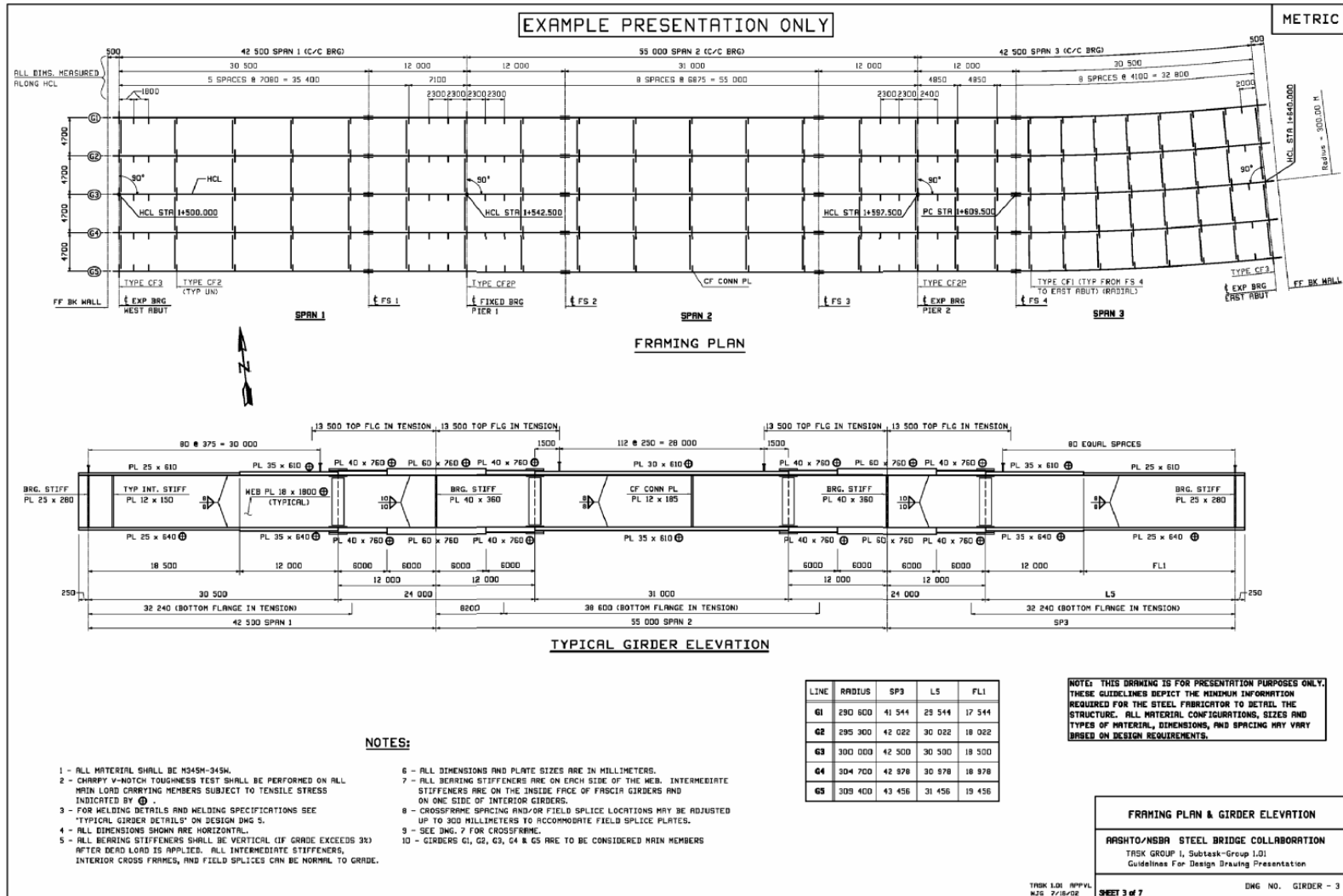


**Two welds**

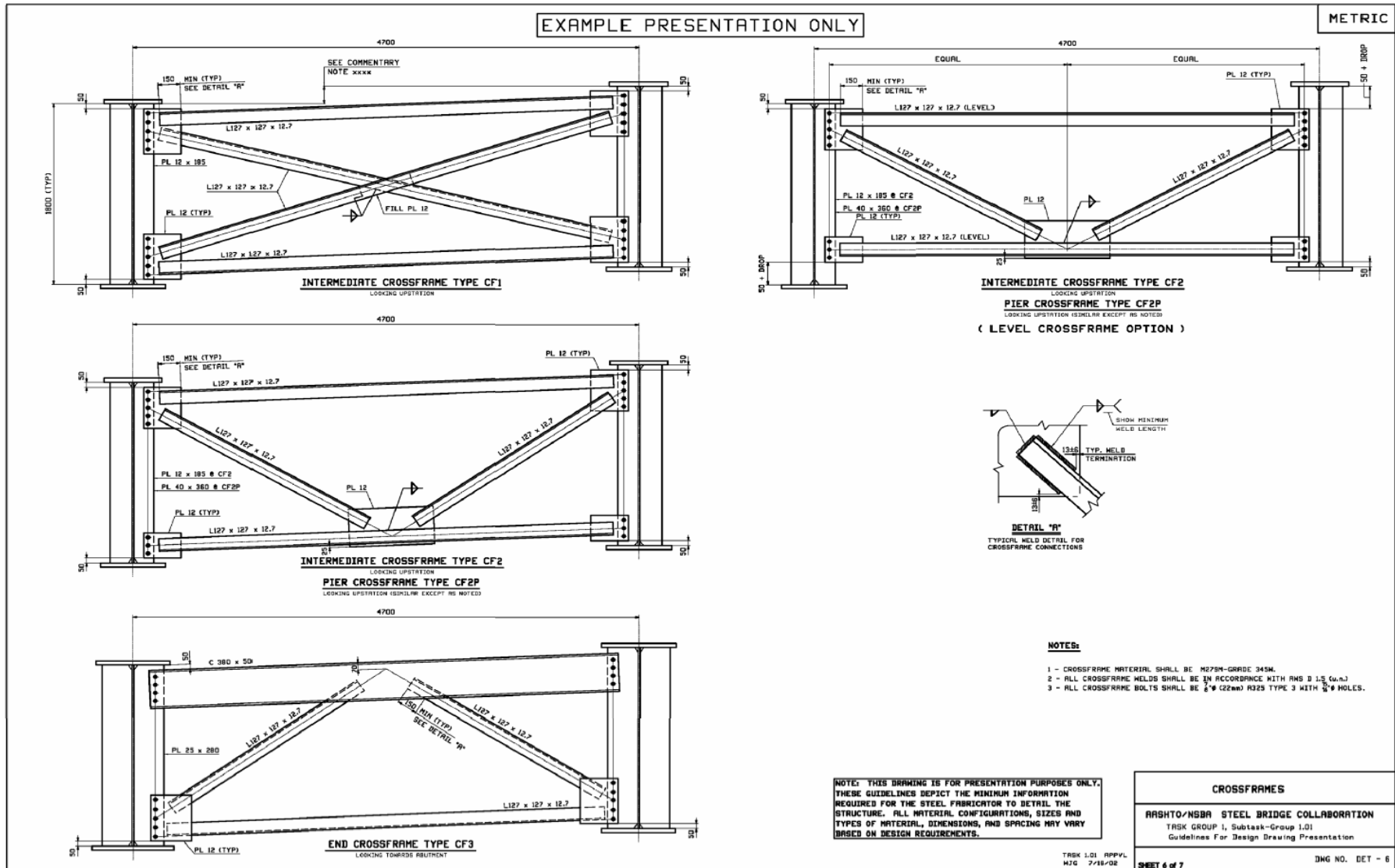


# G1.2 Detailing Guide

## Framing Plan & Girder Elevation



# G1.2 – Framing Details



# Detailing

## NOTES FOR STEEL GIRDERS

- IF THE GIRDERS CANNOT BE SHIPPED IN THE LENGTHS SHOWN ON THE PLANS, FIELD SPLICES WILL BE PERMITTED AT THE REQUEST OF THE CONTRACTOR, BUT NO COMPENSATION WILL BE ALLOWED FOR THE SPLICES.
- IF THE GIRDERS CAN BE FABRICATED IN LENGTHS LONGER THAN THE SECTIONS SHOWN ON THE PLANS BY ELIMINATING FIELD SPLICES, FIELD SPLICES MAY BE OMITTED AT THE REQUEST OF THE CONTRACTOR. THE CONTRACTOR ASSUMES FULL RESPONSIBILITY FOR SECURING A MAILING PERMIT. APPROVAL FOR ELIMINATION OF A FIELD SPlice AT THE SHOP DRAWING PHASE DOES NOT OBLIGATE THE DEPARTMENT TO ISSUE A MAILING PERMIT.
- DO NOT USE FORM SUPPORT SYSTEMS THAT WILL CAUSE UNACCEPTABLE OVERSTRESS OR DEFORMATION TO PERMANENT BRIDGE MEMBERS.
- ALL FASTENERS ARE 3/4" DIAMETER AASHTO M 164 (ASTM A 325), TYPE 1, HIGH STRENGTH BOLTS, EXCEPT AS NOTED.
- REPAIRING OF FIELD SPLICES IS REQUIRED IN THE FABRICATION SHOP.
- PREPARE BEARING AREAS AS SPECIFIED IN PUBLICATION 408/2003, SECTION 1001.31.K.I.B.
- DO NOT MAKE WELDS BY MANUAL SHIELDED METAL ARC PROCESS FOR PRIMARY GIRDER WELDS, SUCH AS FLANGE-TO-WEB WELDS OR FOR SHOP SPLICES OF WEBS AND FLANGES.
- WELDING OF REINFORCEMENT BARS DURING FABRICATION OR CONSTRUCTION IS NOT PERMITTED UNLESS SPECIFIED.
- PROVIDE WELDED STUD SHEAR CONNECTORS MANUFACTURED FROM STEEL CONFORMING TO ASTM A 108.
- SET ANCHOR BOLTS TO TEMPLATE OR IN PREFORMED HOLES. DO NOT DRILL UNLESS SPECIFICALLY INDICATED ON PLANS. FILL THE PREFORMED HOLES WITH NON-SHRINK GROUT. FILL THE CLEARANCE BETWEEN ANCHOR BOLTS AND HOLES IN MASONRY PLATES WITH APPROVED NON-HARDENING CAULKING COMPOUND CONFORMING TO PUBLICATION 408/2003, SECTION 705.8.
- PAINT STRUCTURAL STEEL IN ACCORDANCE WITH PUBLICATION 408/2003, SECTION 1060.
- PROVIDE CHAMPY V-NOTCH (CVN) TESTING AS PER PUBLICATION 408/2003, SECTION 1105.02(A) 4. TEST THE FOLLOWING COMPONENTS IN ACCORDANCE WITH THESE REQUIREMENTS:
  - ALL GIRDER WEBS AND BOTTOM FLANGE PLATES
  - ALL FIELD SPlice MATERIAL
  - ALL CROSS-FRAME COMPONENTS AND CROSS-FRAME CONNECTION PLATES
- DO NOT WELD PERMANENT DECK FORMS OR OTHER ATTACHMENTS TO GIRDER TOP FLANGES IN TENSION AREAS (NEGATIVE OR REVERSE MOMENT REGIONS).
- NONDESTRUCTIVELY TEST THE FOLLOWING SPECIFIC WELDS. TEST ALL OTHER WELDS AS PER PUBLICATION 408/2003.
  - FLANGE-TO-FLANGE BUTT WELDS\*\*
  - WEB-TO-WEB BUTT WELDS\*\*
  - WEB-TO-FLANGE FILLET WELDS\*\*
  - CONNECTION PLATE-TO-GIRDER FILLET WELDS\*\*
  - POT BEARING FILLET WELDS\*\*

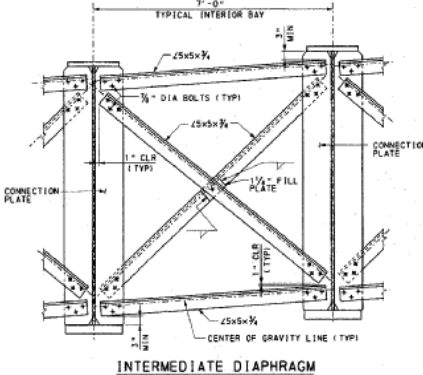
\*\* TEST USING RADIOGRAPHIC INSPECTION  
\*\*\* TEST USING MAGNETIC PARTICLE METHOD
- PROVIDE STANDARD SIZE HOLES FOR ALL BOLTS, INCLUDING CROSS-FRAME CONNECTIONS. OVERSIZED HOLES ARE NOT PERMITTED.
- STABILITY OF PARTIAL GIRDERS AND COMPLETE GIRDERS IS TO BE MAINTAINED BY THE CONTRACTOR DURING ERECTION, UNTIL ALL GIRDERS AND DIAPHRAGMS ARE IN PLACE AND ALL BOLTS ARE PROPERLY INSTALLED. ERECTION LOADS INCLUDING SELF-WEIGHT OF THE STEEL MEMBERS, WIND LOADING AND CONSTRUCTION LIVE LOAD EFFECTS ARE TO BE EVALUATED BY THE CONTRACTOR FOR STABILITY, STRESSES AND DEFLECTIONS ON THE STEEL MEMBERS DURING ANY STAGE OF ERECTION.
- 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.

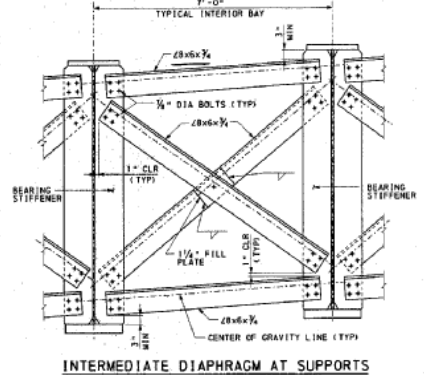
UNIT 2: LOCATION AT Q/8 IN SPAN 3	STEEL AND ONLY CONCRETE		UNIT 2: LOCATION AT Q/8 IN SPAN 5	STEEL AND ONLY CONCRETE	
	DIFFERENTIAL LATERAL DEFLECTION - Δ (in.)	ROTATION (rad/ft)		DIFFERENTIAL LATERAL DEFLECTION - Δ (in.)	ROTATION (rad/ft)
	0.21	0.38		0.55	1.09
	0.0025	0.0045		0.0066	0.0130

### FIELD WELDING

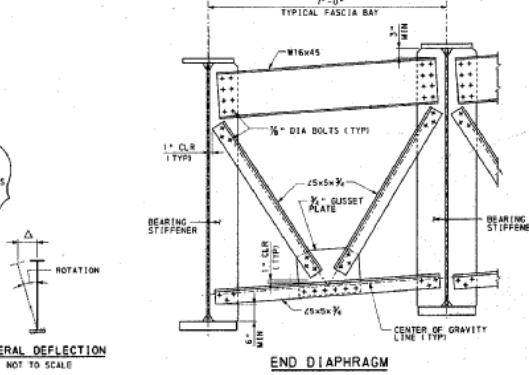
- WELDING SPECIFICATIONS: ANSI/AASHTO/AWS/D1.5 BRIDGE WELDING CODE (2002) AND THE CONTRACT SPECIAL PROVISIONS. DO NOT FIELD-WELD ON ANY PART OF THE BRIDGE, EXCEPT WHERE SHOWN ON THE DRAWINGS, WITHOUT PRIOR APPROVAL OF THE DEPARTMENT REPRESENTATIVE.
- MAKE TACK WELDS WITH THE SAME TYPE ELECTRODE AND INCORPORATE IN THE FINAL WELD. NO OTHER TACK WELDING WILL BE PERMITTED.
- DO NOT WELD WHEN SURFACES TO BE WELDED ARE MOIST OR EXPOSED TO RAIN, SNOW OR HIND, OR WHEN WELDS ARE EXPOSED TO INCIDENT CONDITIONS THAT WILL ADVERSELY AFFECT THE QUALITY OF THE WORK.



INTERMEDIATE DIAPHRAGM



INTERMEDIATE DIAPHRAGM AT SUPPORTS



END DIAPHRAGM



### FIELD WELDING (CONT'D)

- DO NOT WELD OR BURN WHEN THE TEMPERATURE IS BELOW 0-DEGREES F. PREHEAT AND MAINTAIN THE TEMPERATURE OF THE METAL TO AT LEAST 70-DEGREES F WHEN THE TEMPERATURE OF THE METAL IS BETWEEN 0-DEGREES F AND 30-DEGREES F DURING WELDING OR BURNING. EXTEND THE AREA TO BE HEATED 3 INCHES BEYOND THE WELD IN ALL DIRECTIONS.
- REMOVE BY APPLICATION OF HEAT ANY MOISTURE PRESENT AT THE POINT OF WELD. PROVIDE WIND BREAKS FOR PROTECTION FROM DIRECT WIND.
- PRIOR TO PLACING THE WELD, THOROUGHLY CLEAN ALL PORTIONS OF NEW SURFACES TO RECEIVE WELDS OF ALL FOREIGN MATTER INCLUDING PAINT FILM, FOR A DISTANCE OF 2 INCHES FROM EACH SIDE OF THE OUTSIDE LINES OF WELD.
- USE SHIELDED METAL ARC WELDING AND LOW HYDROGEN ELECTRODES COMPATIBLE WITH THE BASE METAL.

### REFERENCES:

- GENERAL NOTES
- LIST OF PENNOT STANDARD DRAWINGS
- FRAMING PLANS
- GIRDER ELEVATIONS
- GIRDER DETAILS

### SHEET:

- 5
- 3
- 44-47
- 48-57
- 61

Work	Description	By	CHK'd	Rev'd	Date
REVISIONS					

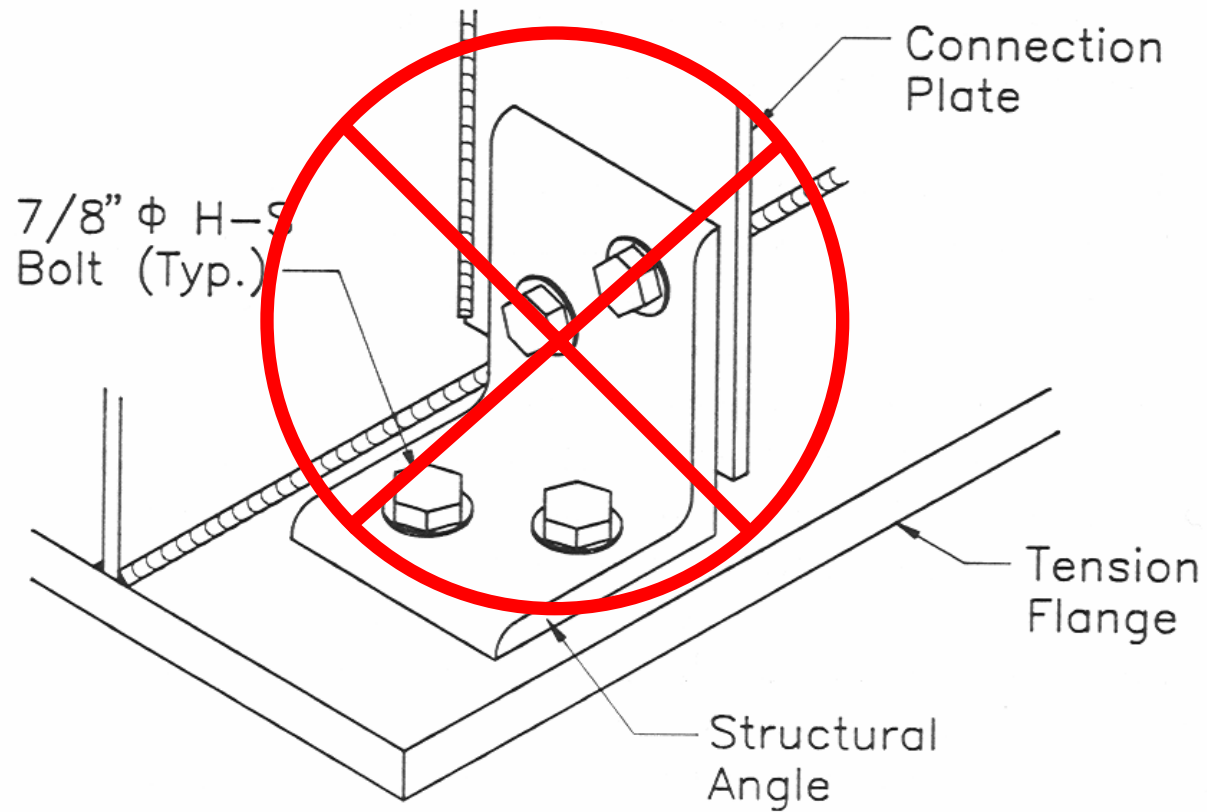


COMMONWEALTH OF PENNSYLVANIA  
DEPARTMENT OF TRANSPORTATION  
ALLEGHENY COUNTY  
S. R. 0079 SECTION A23  
SEG 0260 OFFSET 1240  
RAMP 6 STA. 221+46.00 OVER S. R. 0022 (PENN LINCOLN PARKWAY),  
S. R. 0079, CAMPBELLS RUN ROAD & RAMP F  
7 SPAN CONTINUOUS STEEL PLATE GIRDER BRIDGE  
DIAPHRAGM DETAILS

RECOMMENDED	SHEET 60 OF 129
	S - 25977

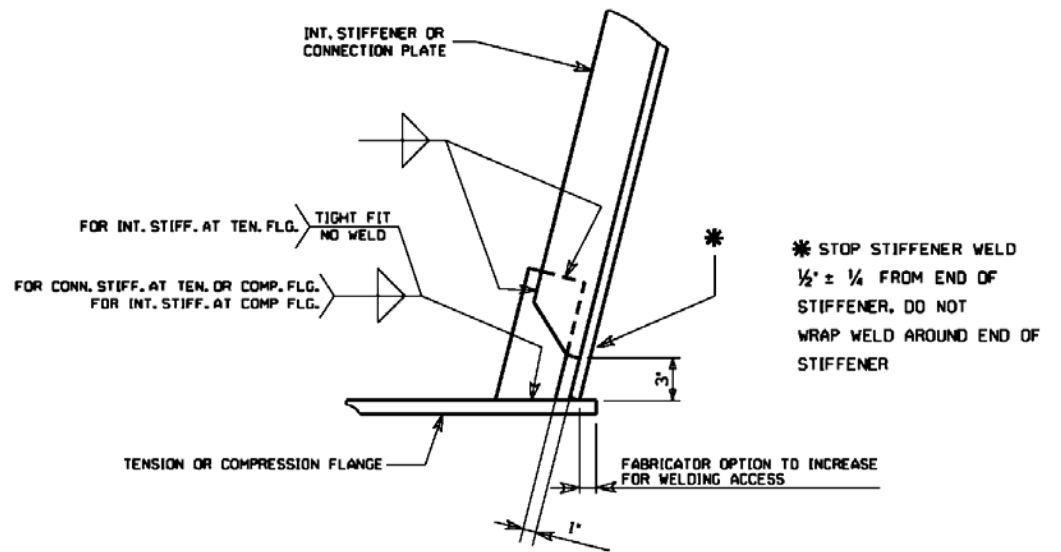
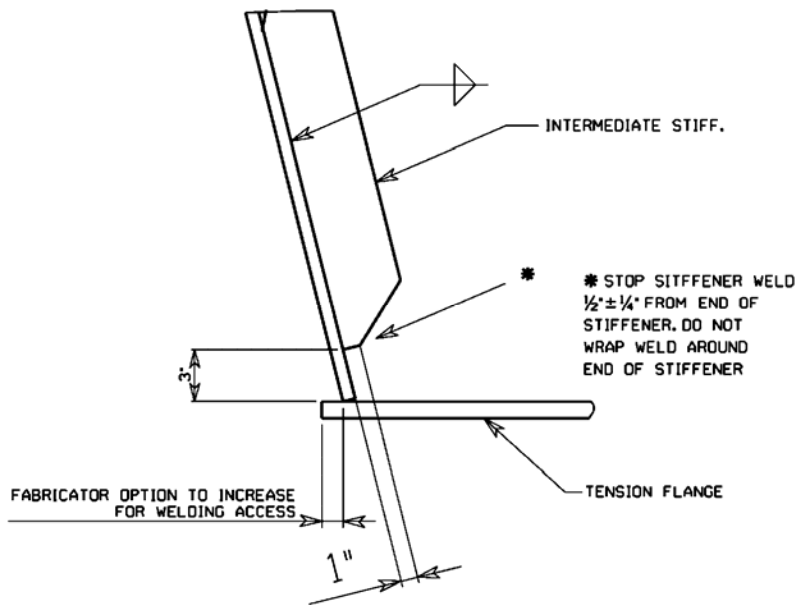
6/15/2006, 10:45 AM, C:\WORKING\DRAWING\PROJECTS\7 SPAN CONTINUOUS STEEL PLATE GIRDER BRIDGE\7 SPAN CONTINUOUS STEEL PLATE GIRDER BRIDGE\DIAPHRAGM DETAILS.PLT

- *Connection Stiffener Attachment*



# Boxes

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





# Assembly

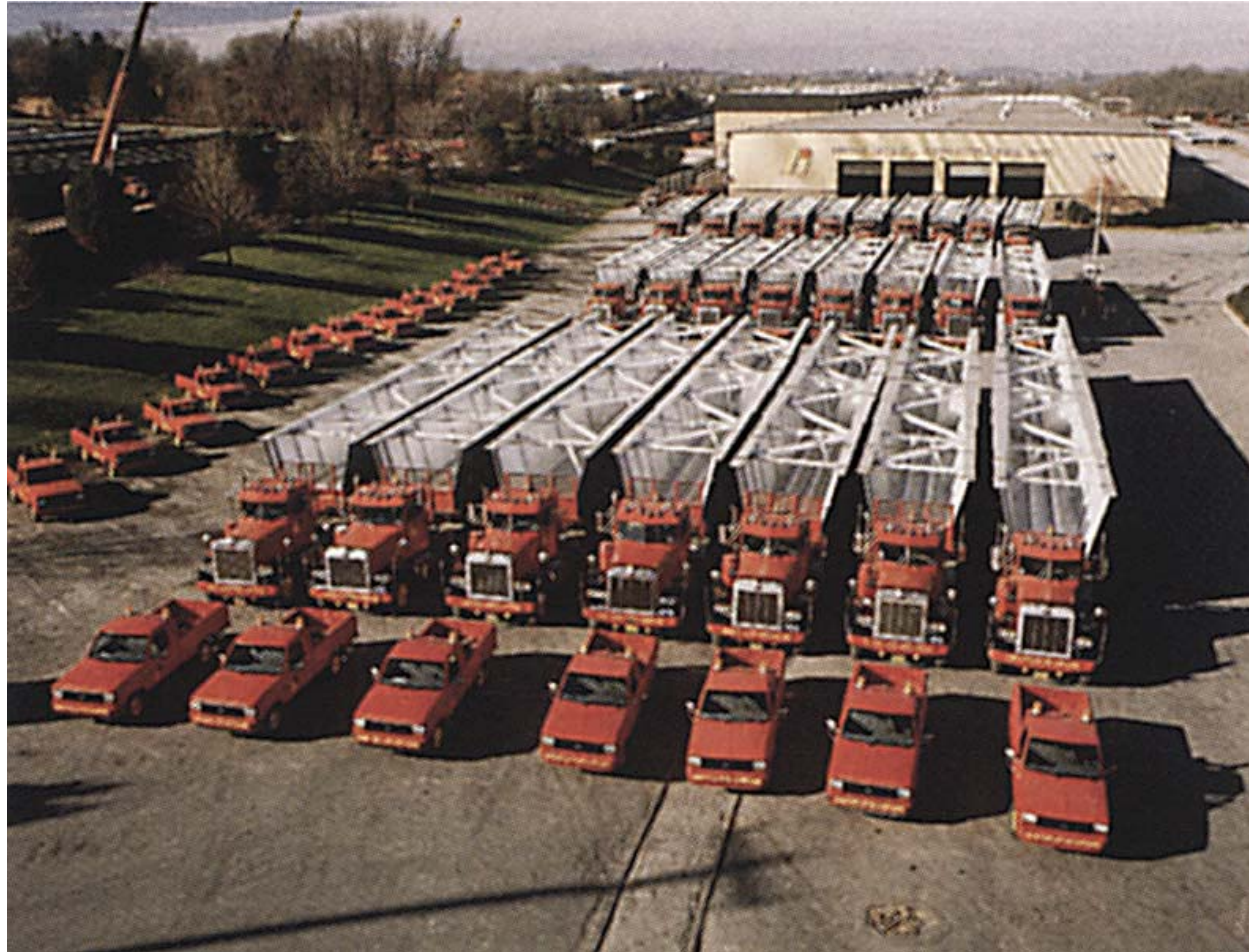


# Piece Size

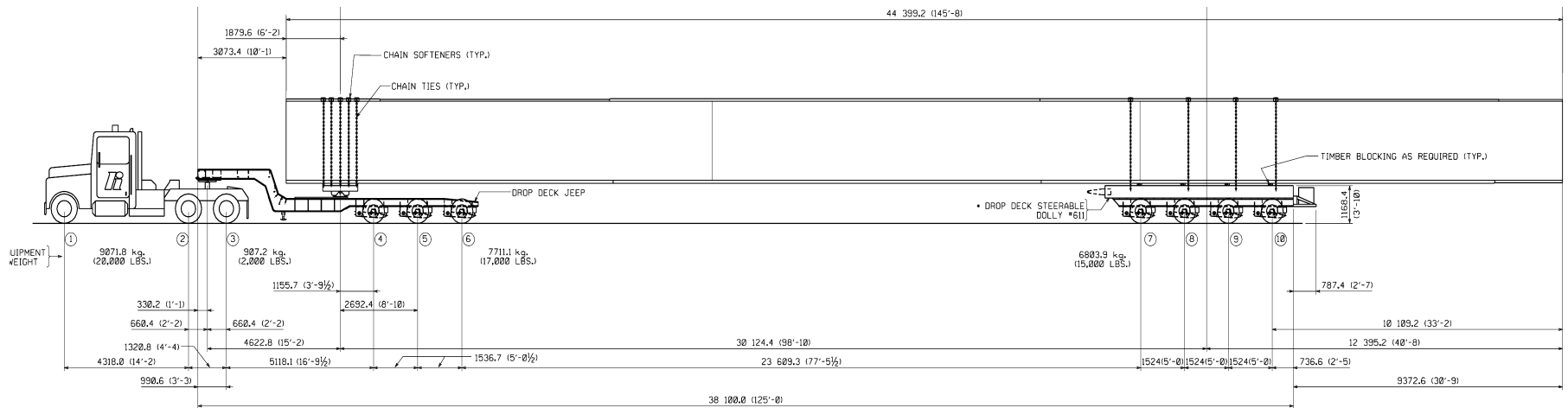
- Consider what can be readily lifted and shipped



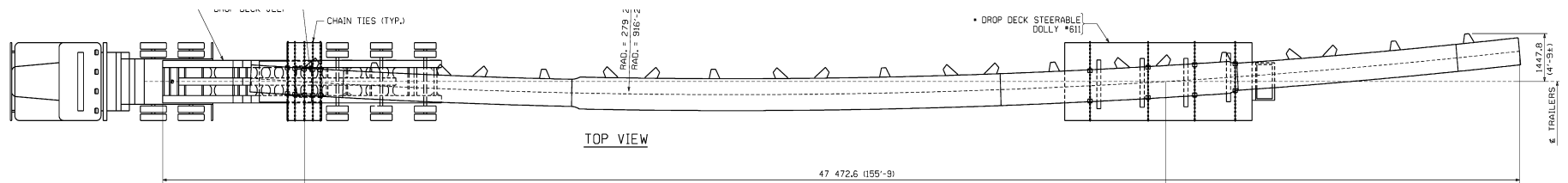
# Shipping



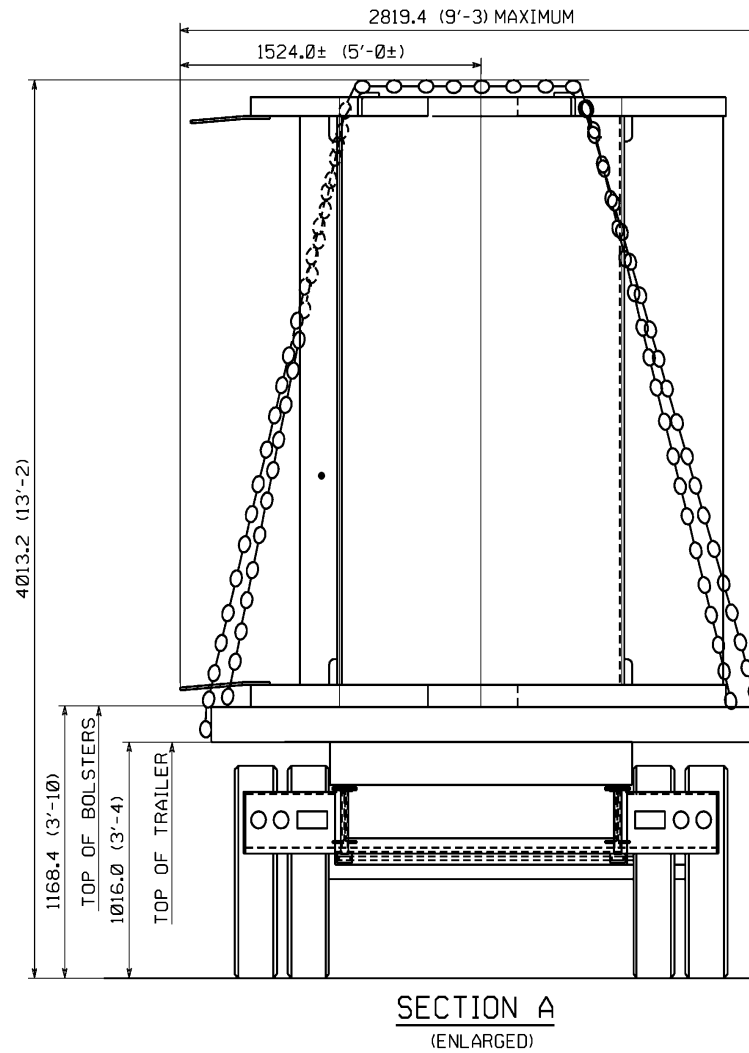
# Shipping – Shipping Procedure (Elevation)



# Shipping – Shipping Procedure (Plan)



# Shipping – Shipping Procedure (Section)



# Shipping/Fabrication Piece Limits

- Most competitive:
  - Length < 125 feet
  - Weight < 35 tons
  - Height < 9 feet tall
- Maximum (by truck):
  - Length ~ 175 feet (rules vary)
  - Weight ~ 80 tons (rules vary)
  - Height < 13.5 feet (on side) or 9.5 feet (upright)



# Erection

- Collaboration Standard
  - Qualifications
  - Certifications
  - Erection plan



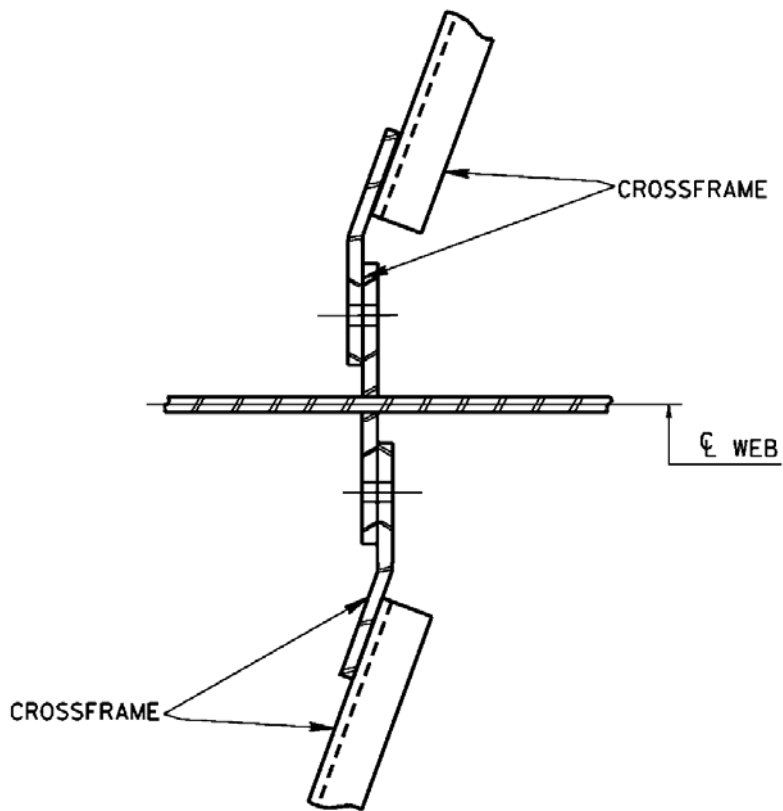


# Skewed Bridge Erection

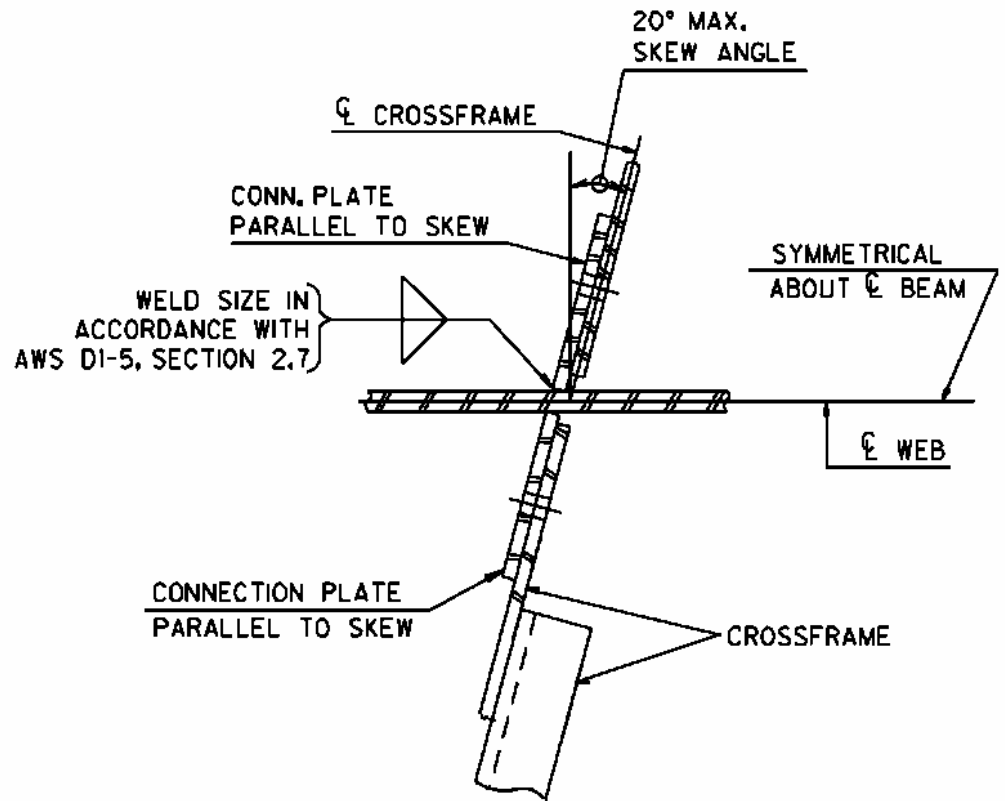




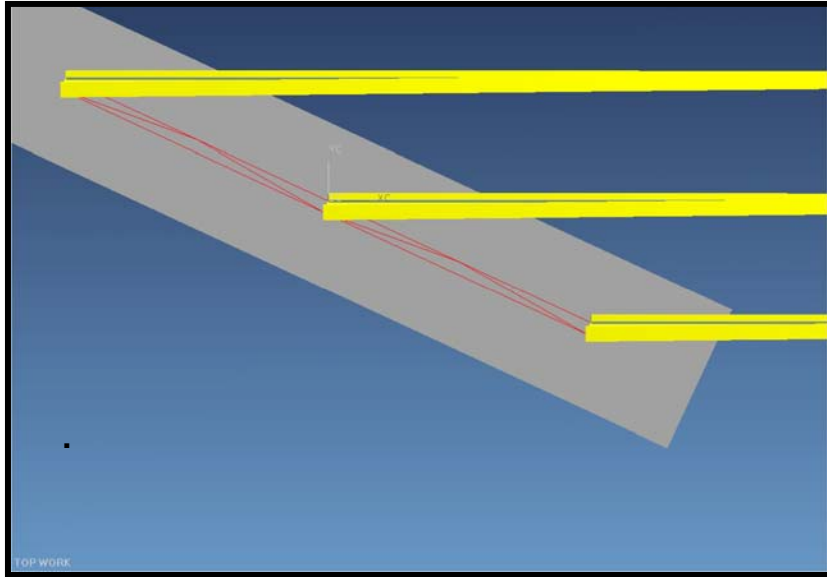
# Cross Frame Connections



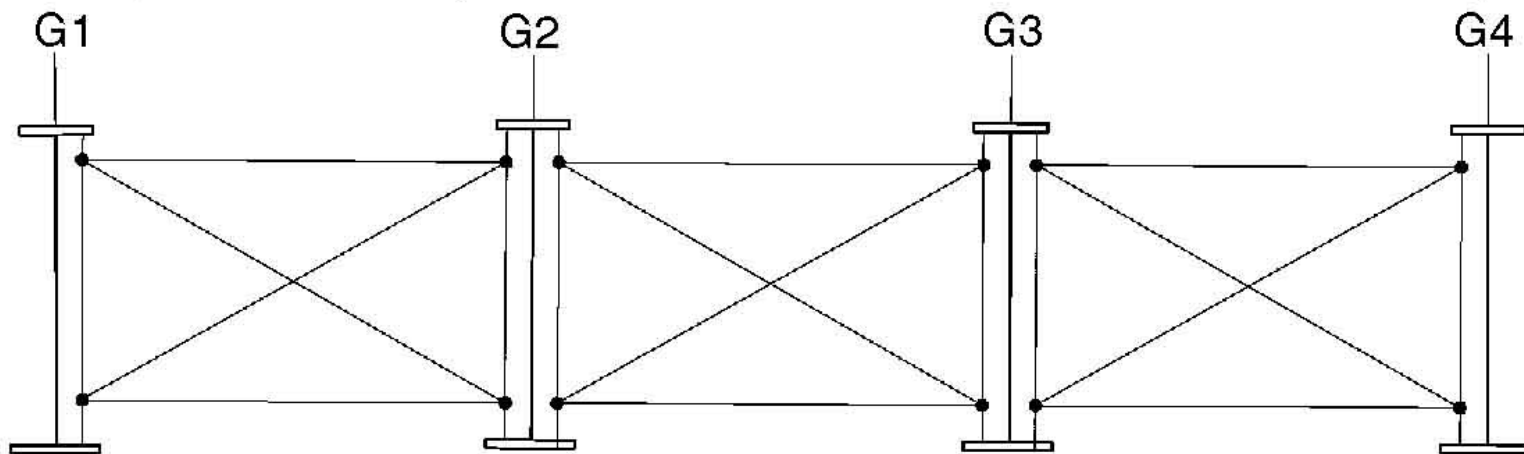
preferred (by fabricators)



20° maximum skew

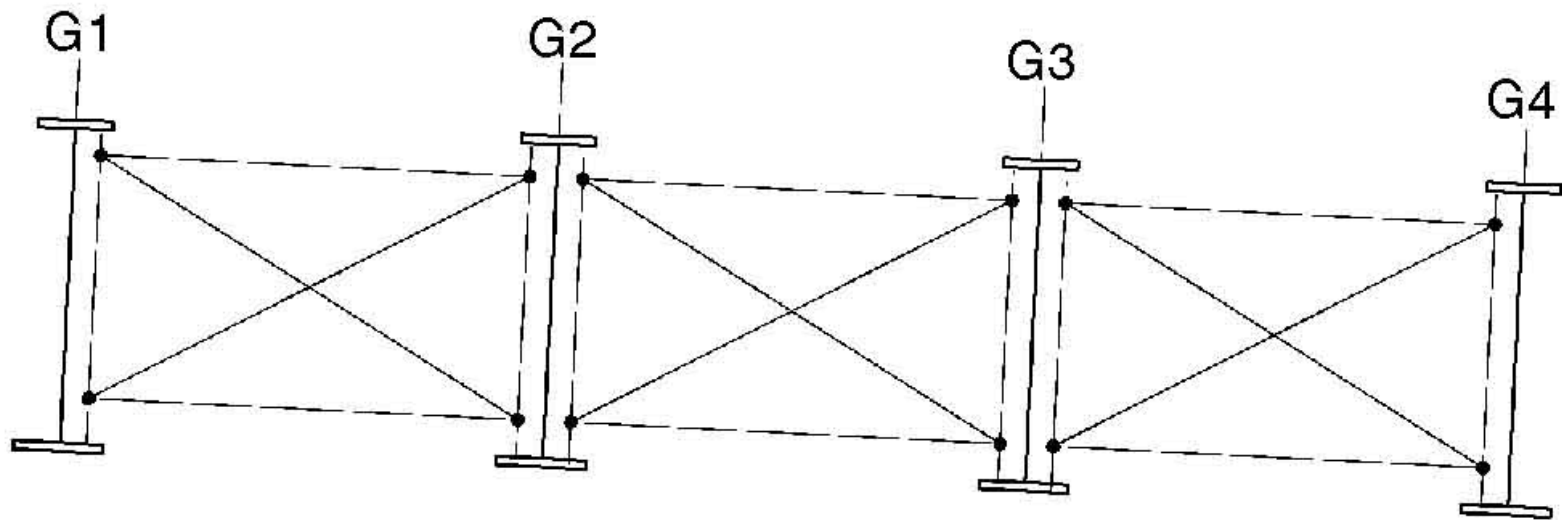


# Skewed Bridge Erection



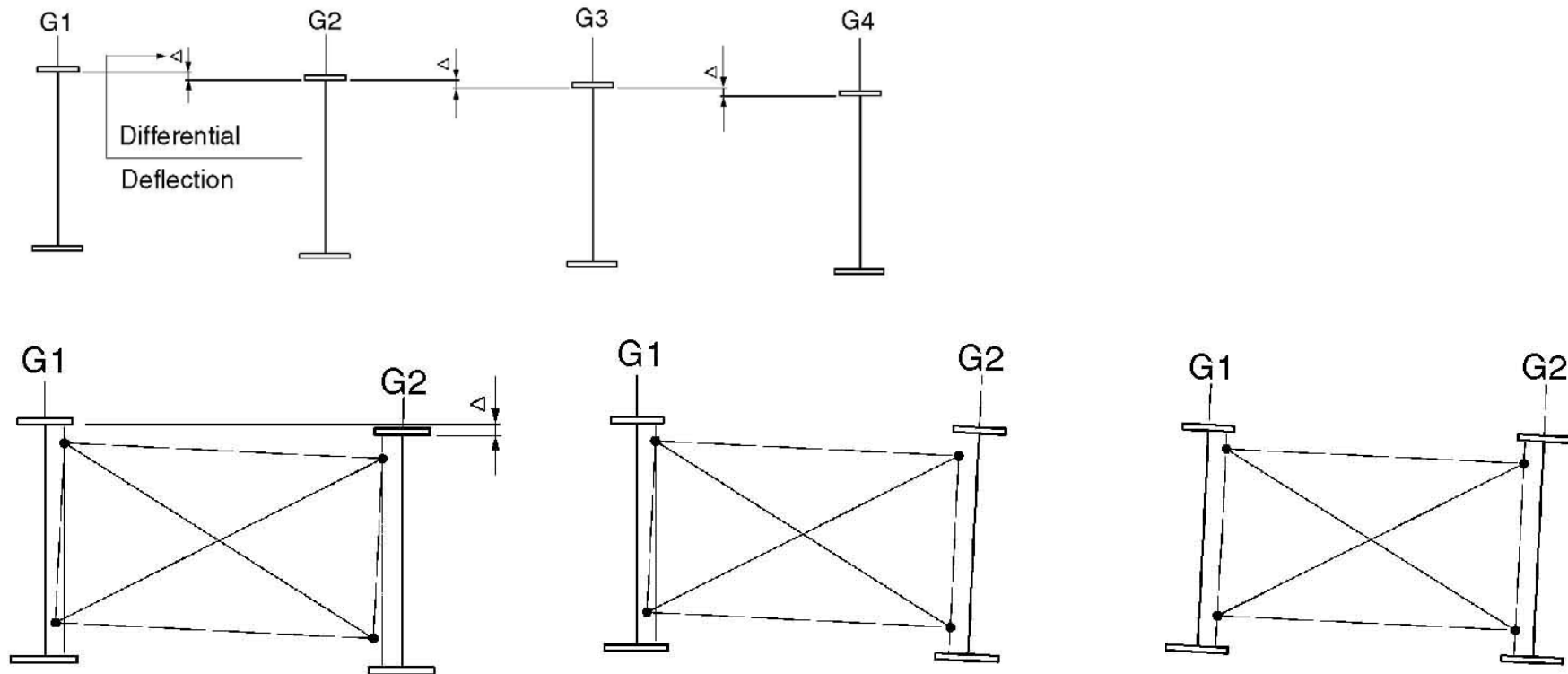
Complete Dead Load

# Skewed Bridge Erection

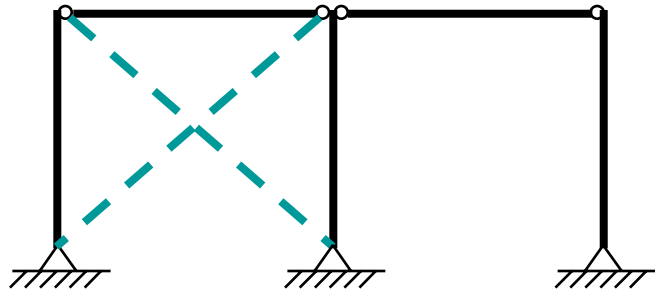


Steel Dead Load

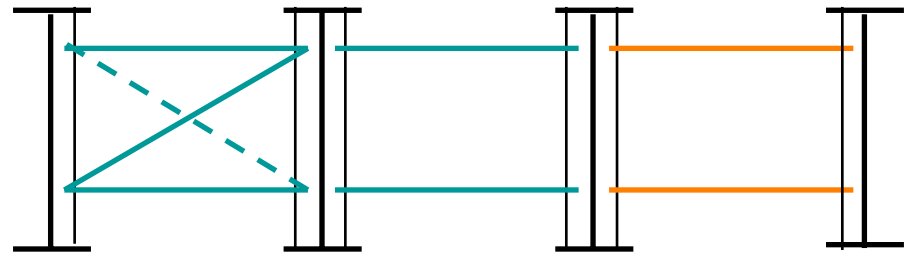
# Skewed Bridge Erection



Tighten bolts before pouring deck



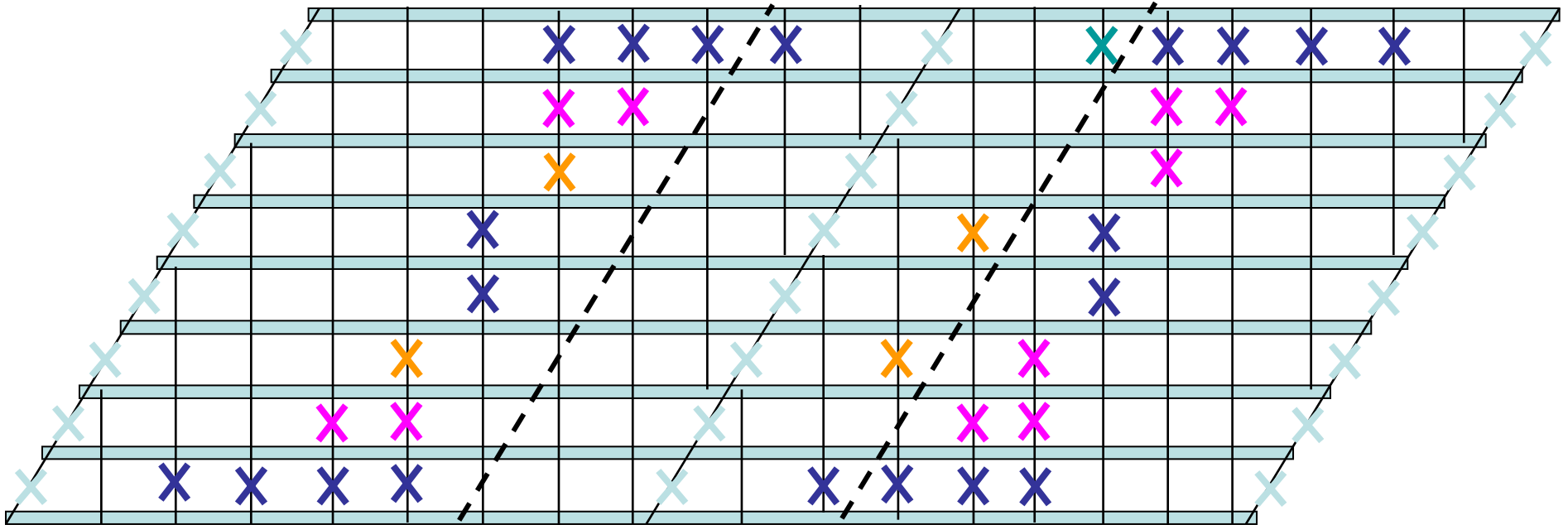
*Lean-On Bracing  
in Frames*



*Lean-On Bracing  
in Beams*



# Bracing Layout for Lubbock 9 Girder Bridge



X → added for stability during girder erection

X → added to control differential deflection

# Collaboration Standards

- G 1.1, Shop Detail Drawing Review/Approval Guidelines
- G 1.2, Design Drawing Presentation Guidelines
- G 1.3, Shop Detail Drawing Presentation Guidelines
- G 1.4, Guidelines for Design Details
- S 2.1, Steel Bridge Fabrication Guide Specification
- S 4.1, Steel Bridge Fabrication QC/QA Guide Specification
- S 8.1, Guide Specification for Zinc-Rich Primer-Based Coating Systems
- G 9.1, Steel Bridge Bearing Design and Detailing Guidelines
- G 10.1, Steel Bridge Erection Guidelines (soon to be pub.)
- G 12.1, Guidelines for Design for Constructability

# Summary

- Durability
  - Detail for infinite life
- Economy
  - Industry input
  - AASHTO / NSBA Steel Bridge Collaboration Standards
- Communication

*Thank you*