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Fabricators' Insights on Clear Communication of Bridge Design Requirements

January 24, 2019

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Course Description

Fabricators' Insights on Clear Communication of Bridge Design Requirements
January 24, 2019

As project delivery schedules are continually accelerated, clear communication of bridge design requirements becomes increasingly important in order to maintain the structural steel delivery milestones. Some of the most common contract plan issues or errors associated with steel bridges are presented, along with suggestions on how to avoid them. A brief introduction to BIM for bridges, and its potential advantages, is also offered from the perspective of a steel bridge fabricator.

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Learning Objectives

- Describe how excessive reliance on standard details may prevent the timely delivery of construction projects
- Explain the importance of considering the construction sequence of steel bridges during the design phase.
- Identify the functions performed by building information modeling (BIM) in modern steel design and construction.
- List the steps of the steel fabricators' preferred workflow that makes use of sharing digital BIM models.

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Fabricators' Insights on Clear Communication of Bridge Design Requirements

Bradley J. Dillman, P.E.
Vice President of Engineering
High Steel Structures LLC
Lancaster, Pennsylvania

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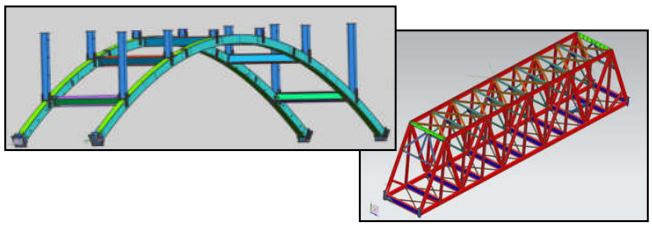
Presentation Overview

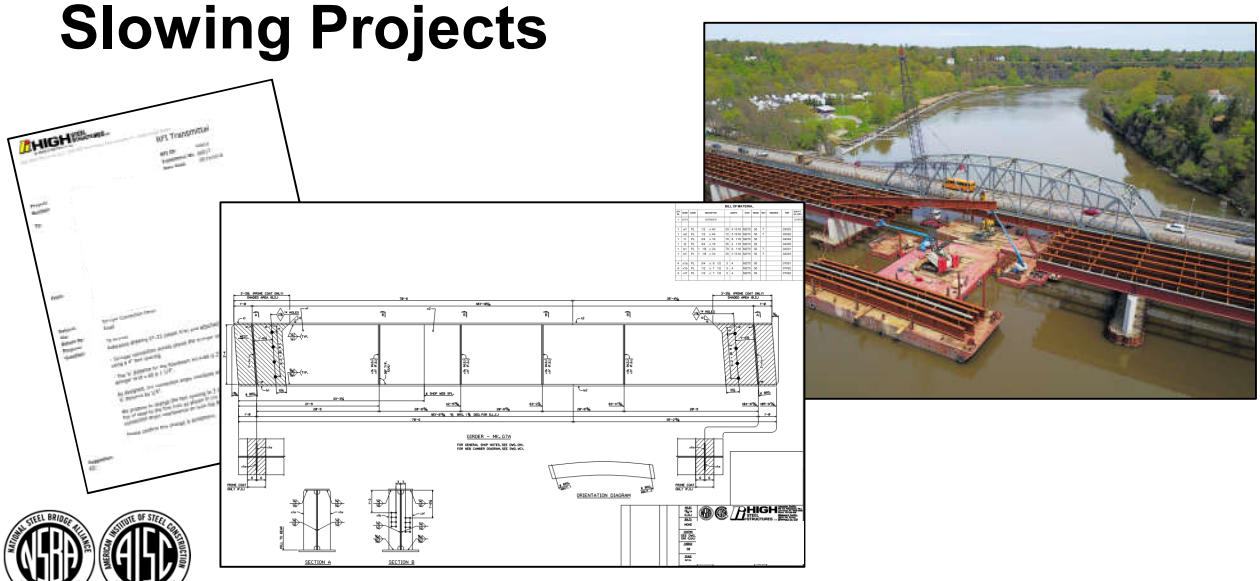
Part I: Five Common Design Issues Slowing Projects

Part II: BIM for Bridges in Structural Steel Fabrication



9

Part I: Five Common Design Issues Slowing Projects



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Collective Intent

- **Deliver the project to the Owner as efficiently as possible**
  - Cost, Time, Both . . .
- **How, from Fabricators' Perspective?**
  - Detail steel with as few questions as possible
- **Presentation Objective**
  - Raise awareness of common issues

Request for Information

Subject:	Scupper Support Coating Requirement		
Number:	0002	**Date:**	10/30/2017
CSI Code:		**Author:**	
Status:	Open	**Reason:**	Clarification
Cost Effect:		**Time Effect:**	
Reference:			

Question:

Reference design sheet 3 of 85, General Notes for SB-257, which states "Paint all structural steel in accordance with section 1060 and the special provisions.

Also, reference design sheet 4 of 138, General Notes for SB-258 & SB-259, which states "Paint all structural steel within 10'-0 of each end of the bridge in accordance with section 1060 and the special provisions.

The contract drawings do not specifically address the scupper downspout supports or the welded support tab plates, however the PA DOT standard drawing BC-751 (Bridge Drainage Scupper Details), sheet 1 of 7, note 5, states to galvanize all materials in accordance with Pub. 408, Section 1105.02(b)1, after fabrication. Please note that these scupper downspout support tab plates are shop welded to the girders as part of the girder fabrication process, prior to any coating operations.

1. For the welded scupper support tabs that fall in the painted girders of SB-257, we request permission to paint along with the girder, in lieu of galvanizing.
2. For the welded scupper support tabs that are in the unpainted portion of the girders on SB-258 & SB-259, we request to utilize AASHTO M270 Grade 50W material and leave them unpainted, to weather the same as the girder steel.
Please verify this is acceptable?

Proposed Solution:			
Official Responder:		**Due Date:**	11/3/2017
Date Responded:	11/3/2017		

Response:

Question 1; Yes, it is acceptable to use painted steel for the scupper support tabs.

Question 2; Yes, it is acceptable to use unpainted Grade 50W steel for the scupper support tabs.

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#5 – Primary Member Designation, Fracture Critical Member (FCM) Designation Charpy V-Notch (CVN) Requirements

13

Primary Member Designation, FCM, CVN

- **Objective: Clear definition member designations, material and testing requirements**
- **Recognize impact on fabrication:**
  - Material ordering and testing
  - Fabrication methods/techniques
  - Quality control requirements (weld testing and repairs)

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Primary Member Designation

- **Clear and accurate designation is critical**
  - AASHTO LRFD Bridge Design Specifications, 8th Ed

Table 6.6.2.1-1—Member or Component Designations

Member or Component Description	Member or Component Designation
Girders, beams, stringers, floorbeams, bent caps, bulkheads, and straddle beams	Primary
Truss chords, diagonals, verticals, and portal and sway bracing members	Primary
Arch ribs and built-up or welded tie girders	Primary
Rigid frames	Primary
Gusset plates and splice plates in trusses, arch ribs, tie girders, and rigid frames	Primary
Splice plates and cover plates in girders, beams, stringers, floorbeams, bent caps, and straddle beams	Primary
Bracing members supporting arch ribs	Primary
Permanent bottom-flange lateral bracing members and mechanically fastened or welded bottom-flange lateral connection plates in straight and horizontally-curved bridges	Primary
Top flange lateral bracing members or struts and top flange lateral connection plates in straight and horizontally-curved bridges	Secondary
Diaphragm and cross-frame members and mechanically fastened or welded cross-frame gusset plates in straight bridges	Secondary
Diaphragm and cross-frame members and mechanically fastened or welded cross-frame gusset plates in horizontally-curved bridges	Primary
Diaphragm and cross-frame members, and mechanically fastened or welded cross-frame gusset plates and bearing stiffeners at supports in bridges located in Seismic Zones 3 or 4	Primary
Bearings, filler plates, sole plates, and masonry plates	Secondary
Mechanically fastened or welded longitudinal web and flange stiffeners	Primary
Mechanically fastened or welded transverse intermediate web stiffeners, transverse flange stiffeners, bearing stiffeners, and transverse connection plates	Secondary
Mechanically fastened or welded batten plates and stay plates, lacing, and continuous nonperforated or perforated plates in built-up members	Primary
Eyebars and hanger plates	Primary
Miscellaneous structural components or attachments not mentioned above joining two primary members	Primary
Miscellaneous nonstructural components or attachments (e.g., expansion dams, drainage material, brackets, other miscellaneous attachments)	Secondary

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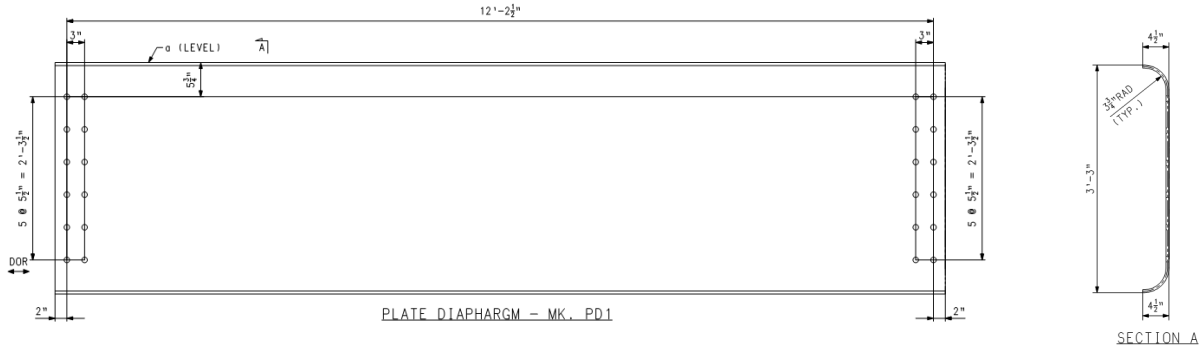
Primary Member Designation

- **Impact on Fabrication - Punching vs. Drilling Holes**
  - Primary members ⟹ Only drilling permitted



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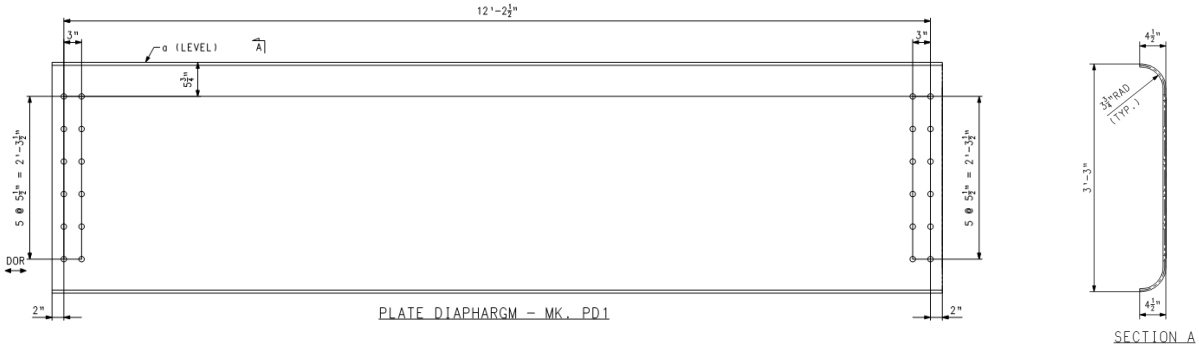
Primary Member Designation

- **Impact on Fabrication - Punching vs. Drilling Holes**
  - Primary members ⟹ Only drilling permitted

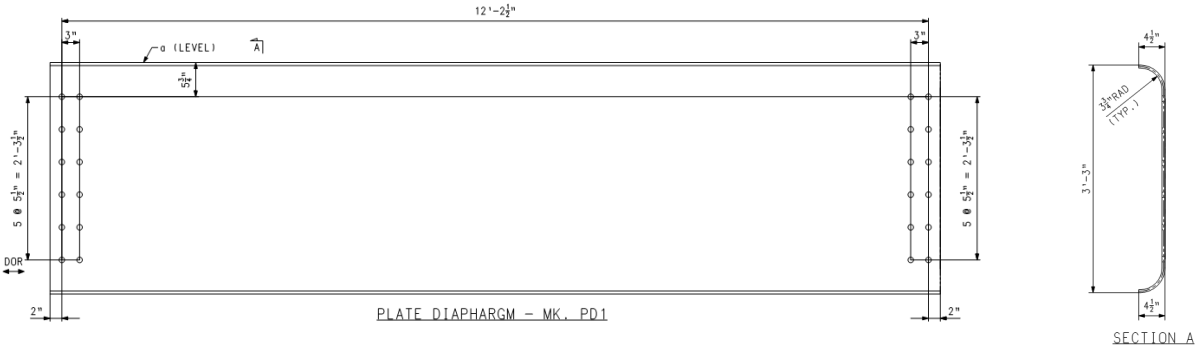


Cost Impact: Drilling can be 2x Cost of Punching

17

Primary Member Designation

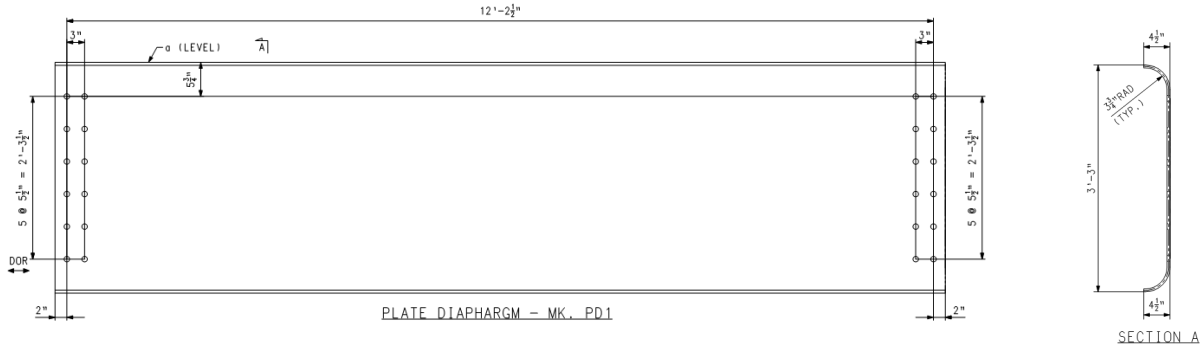
- **Impact on Fabrication – Cold vs. Heat Bending**
  - Primary members ⟹ Only heat bending permitted



18

Primary Member Designation

- **Impact on Fabrication – Cold vs. Heat Bending**
  - Primary members ⟹ Only heat bending permitted



Cost Impact: Heat Bend > 3x Cost of Cold Bend

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Fracture Critical Member Designation

- **AASHTO LRFD Bridge Design Specifications, 8th Ed**

6.6.2.2—Fracture-Critical Members

The Engineer shall have the responsibility for identifying and designating on the contract plans which primary members or portions thereof are fracture-critical members (FCMs). The contract documents shall require that all members meeting the definition of a FCM be fabricated according to the provisions of Clause 12 specified in the AASHTO/AWS D1.5M/D1.5 *Bridge Welding Code*. Members or portions thereof that are not subject to a net tensile stress under Strength Load Combination I shall not be designated as FCMs.

Where a refined analysis has shown that a simulated fracture of a primary member or a portion thereof for which the redundancy is not known by engineering judgment, does not result in a portion of or the entire bridge to collapse, that member or portion thereof shall still be fabricated according to the provisions of Clause 12 specified in the AASHTO/AWS D1.5M/D1.5 *Bridge Welding Code*. These special members or portions thereof shall be identified as System Redundant Members (SRMs) in the contract documents. The criteria, assumptions, and other pertinent information related to the refined *analysis* used to demonstrate the redundancy shall be retained and included in the inspection records or permanent bridge file.

C6.6.2.2

Secondary members and diaphragm or cross-frame members in horizontally-curved bridges should not be designated as FCMs.

When designating some rolled shapes as FCMs, it may not be possible to secure shapes that are produced using fine-grained practices. In such cases, the fine-grained practices should be waived.

Where refined analysis has demonstrated that collapse would not occur following simulated failure of a member for which the redundancy is not known by engineering judgment, the members or portions thereof should not be subjected to the hands-on in-service inspection requirements described in 23 CFR 650. FHWA (2012a) recommends identifying such members or portions thereof as System Redundant Members (SRMs), and noting in the contract documents that SRMs are to be fabricated in accordance with Clause 12 of the AASHTO/AWS D1.5M/D1.5 *Bridge Welding Code*.

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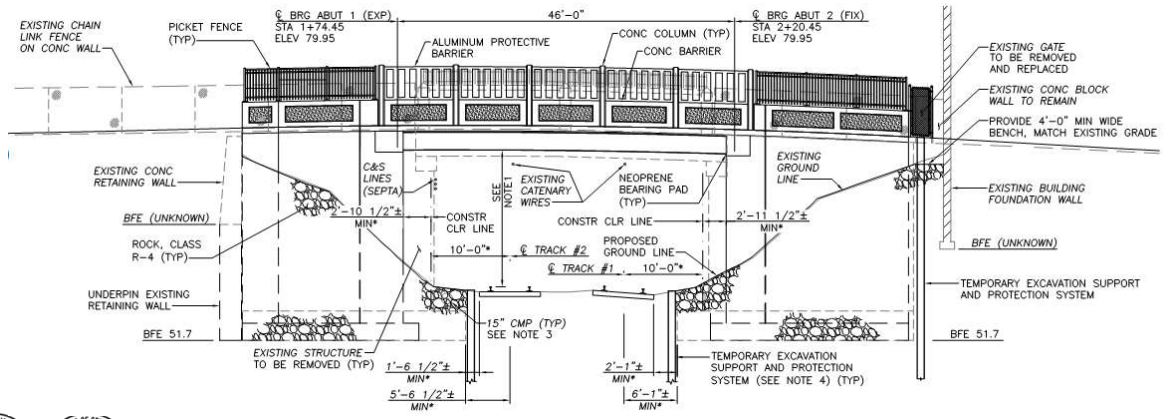
Fracture Critical Member Designation

- **Case Study – Simple Span Stringer Bridge**



Bridge Elevation

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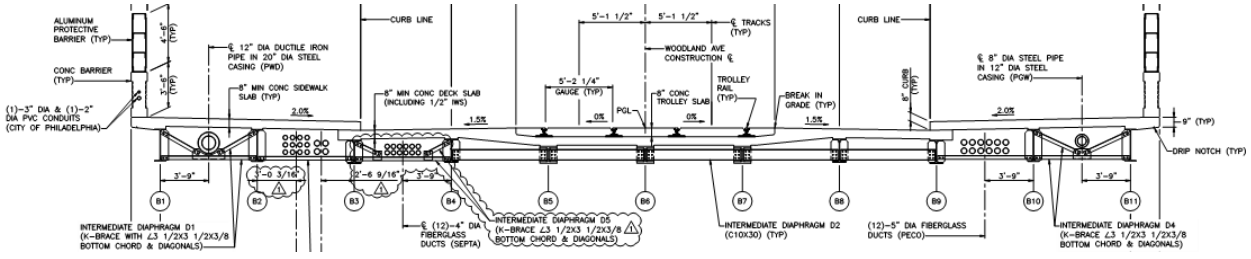
Fracture Critical Member Designation

- **Case Study – Simple Span Stringer Bridge**



Bridge Section

22

Fracture Critical Member Designation

- **Case Study – Simple Span Stringer Bridge**

2.01 MATERIALS

A. Structural Steel: Provide structural steel in accordance with the following specifications as applicable and as indicated on the Contract Drawings.

1. General Requirements: ASTM A6.
2. Bridge Structural Steel (Weathering Steel):
   a. Structural Steel Shapes, Angles and Plates for the Bridge Superstructure: ASTM A709/A709M, Grade 50W.
   b. All new structural steel shapes, plates and bars shall be classified as Fracture Critical Members and meet temperature Zone 2 requirements with a minimum service temperature of -30°F.

23

Fracture Critical Member Designation

- **Case Study – Simple Span Stringer Bridge**

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Cost Impact: FCM adds min. 5% to material cost

24

Fracture Critical Member Designation

- **FCM Impacts on Fabrication**
  - FCM-specific weld PQR's required
  - Pre-blasting steel prior to fabrication may be required
  - Higher preheat temperatures required for welding
  - Additional requirements for baking and controlling flux
  - Additional weld NDT and longer wait periods for NDT
  - More frequent QC auditing of welding
  - Approvals for weld repairs; post-heat required on repairs

25

Fracture Critical Member Designation

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  - Additional requirements for baking and controlling flux
  - Additional weld NDT and longer wait periods for NDT
  - More frequent QC auditing of welding
  - Approvals for weld repairs; post-heat required on repairs

Impact: Additional time and cost

26

Charpy V-Notch Requirements

- **Clear and complete requirements are essential**

IN ADDITION TO THE ITEMS LISTED IN _____, THE FOLLOWING ELEMENTS OF _____ SHALL BE FURNISHED TO MINIMUM CHARPY V-NOTCH FRACTURE TOUGHNESS REQUIREMENTS:

- ARCH RIB FLANGE AND WEB PLATES SUBJECT TO TENSILE STRESS
- ARCH RIB SPLICE PLATES
- ARCH RIB LATERAL BRACING

THE FOLLOWING ELEMENTS SHALL HAVE A MINIMUM CHARPY V-NOTCH (CVN) VALUE OF 25 FT-LBS AT 40° F IN LIEU OF THE CVN IMPACT REQUIREMENTS GIVEN IN SUBSECTION _____. TESTING SHALL BE AT THE "H" FREQUENCY.

- TIE BEAMS AND TIE BEAM SPLICE PLATES
- ARCH KNUCKLES
- BRIDGE HANGER ASSEMBLIES

27

Charpy V-Notch Requirements

- **Clear and complete requirements are essential**

1

IN ADDITION TO THE ITEMS LISTED IN _____, THE FOLLOWING ELEMENTS OF _____ SHALL BE FURNISHED TO MINIMUM CHARPY V-NOTCH FRACTURE TOUGHNESS REQUIREMENTS:

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- ARCH KNUCKLES
- BRIDGE HANGER ASSEMBLIES

28

Charpy V-Notch Requirements

- **Clear and complete requirements are essential**

1

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- ARCH KNUCKLES
- BRIDGE HANGER ASSEMBLIES

Which plates are subject to tensile stress?

29

Charpy V-Notch Requirements

- **Clear and complete requirements are essential**

2

IN ADDITION TO THE ITEMS LISTED IN _____, THE FOLLOWING ELEMENTS OF _____ SHALL BE FURNISHED TO MINIMUM CHARPY V-NOTCH FRACTURE TOUGHNESS REQUIREMENTS:

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- ARCH KNUCKLES
- BRIDGE HANGER ASSEMBLIES

30

Charpy V-Notch Requirements

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- TIE BEAMS AND TIE BEAM SPLICE PLATES
- ARCH KNUCKLES
- BRIDGE HANGER ASSEMBLIES

2

These are FCM values.
Are these FCM?

31

Charpy V-Notch Requirements

- **Clear and complete requirements are essential**

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- TIE BEAMS AND TIE BEAM SPLICE PLATES
- ARCH KNUCKLES
- BRIDGE HANGER ASSEMBLIES

Impact: Material order—accuracy; lead time; cost

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#4 – Details of Stiffeners and Connection Plates

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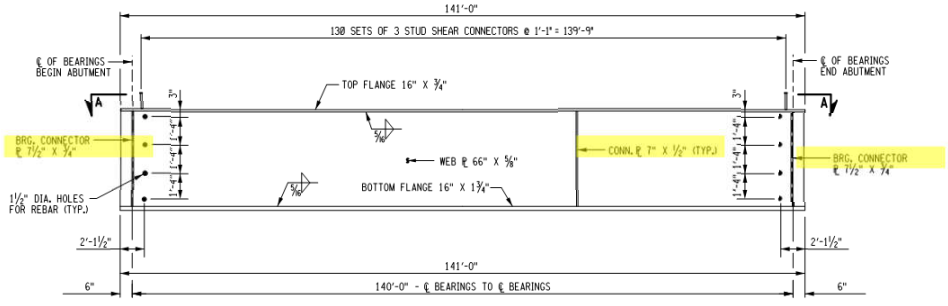
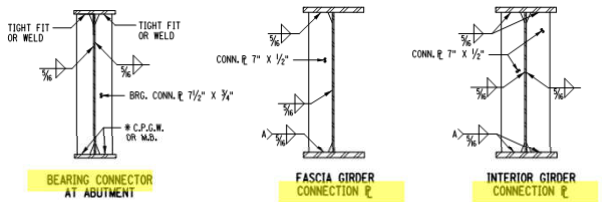
Details of Stiffeners and Connection Plates



GIRDER ELEVATION (FASCIA AND INTERIOR)
NOT TO SCALE



BEARING CONNECTOR AT ABUTMENT
FASCIA GIRDER CONNECTION ℄
INTERIOR GIRDER CONNECTION ℄

GIRDER SECTIONS
NOT TO SCALE

34

Details of Stiffeners and Connection Plates

- **Objective: Clear definition geometry of the plates and their connection to the component**

- **Recognize impact on fabrication:**
  - Plate preparations (beveling for fit, milling)
  - Weld details and preparation required

35

Details of Stiffeners and Connection Plates

- **Clear definition of plates vertical or normal to grade**

ALL ENDS OF GIRDERS AND THE BEARING STIFFENERS SHALL BE VERTICAL. ALL CONECTION PLATES AND INTERMEDIATE STIFFENERS SHALL BE PERPENDICULAR TO THE TOP FLANGES.

36

Details of Stiffeners and Connection Plates

- **Clear definition of plates vertical or normal to grade**

> ALL ENDS OF GIRDERS AND THE BEARING STIFFENERS SHALL BE VERTICAL. ALL CONECTION PLATES AND INTERMEDIATE STIFFENERS SHALL BE PERPENDICULAR TO THE TOP FLANGES.

Impact:

- **Vertical plates typically required beveled ends**
- **Perpendicular plates do not require beveled ends**

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Details of Stiffeners and Connection Plates

- **Clear definition of the fit and welding requirements**
  - Tight Fit – Gap up to 1/16" allowed (AWS D1.5)
  - Mill to Bear – 75% area in contact (AWS D1.5)
  - Weld Details – Fillet weld, PJP, CJP

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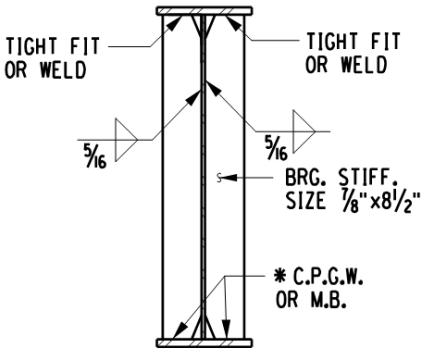
Details of Stiffeners and Connection Plates

- **Clear definition of the fit and welding requirements**

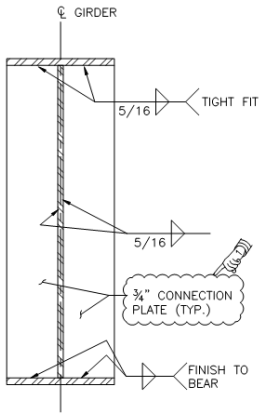


BEARING STIFFENER
AT ABUTMENT

39

Details of Stiffeners and Connection Plates

- **What's less than desirable here?**



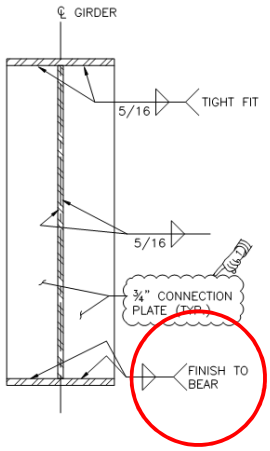
CROSS FRAME CONNECTION
PLATES INTERIOR
SCALE: 1"=1'-0"

40

Details of Stiffeners and Connection Plates

- **What's less than desirable here?**

Finish to Bear unnecessary at a connection plate that is not a bearing stiffener



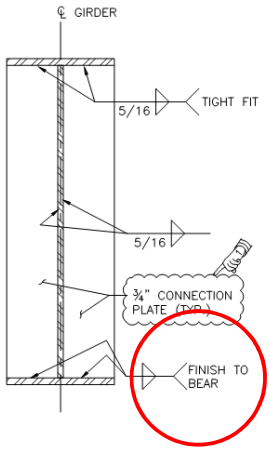
CROSS FRAME CONNECTION PLATES INTERIOR
SCALE: 1"=1'-0"

41

Details of Stiffeners and Connection Plates

- **What's less than desirable here?**

Impact:
Finish to Bear adds at least 25% to cost of each connection plate

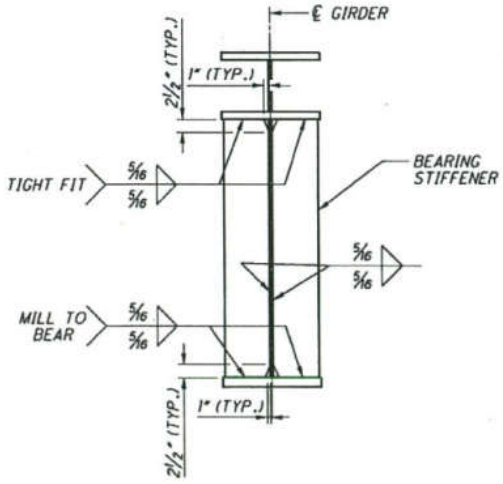


CROSS FRAME CONNECTION PLATES INTERIOR
SCALE: 1"=1'-0"

42

Details of Stiffeners and Connection Plates

- **What's less than desirable here?**

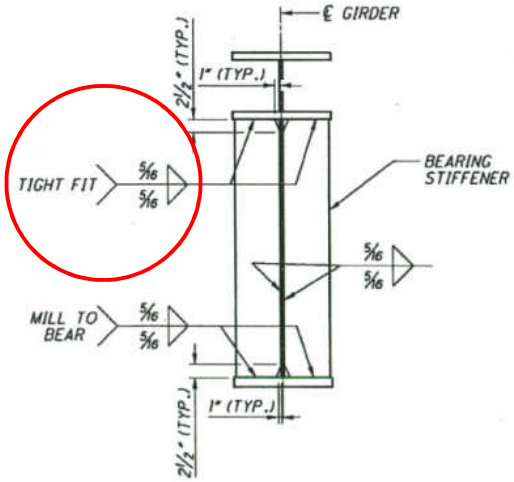


BEARING STIFFENER DETAIL
(PIER 11 ONLY)

43

Details of Stiffeners and Connection Plates

- **What's less than desirable here?**



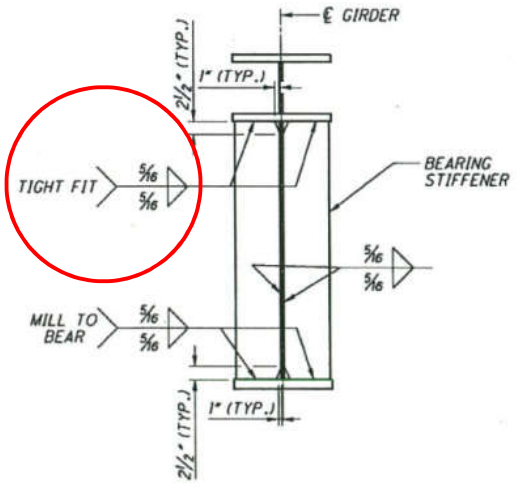
BEARING STIFFENER DETAIL
(PIER 11 ONLY)

Tight fit is an unnecessary constraint for fillet welds—AWS D1.5 inherently controls fit-up for fillet welds; has provisions for gaps >1/16"

44

Details of Stiffeners and Connection Plates

- **What's less than desirable here?**



BEARING STIFFENER DETAIL
(PIER 11 ONLY)

Impact:

Potential repair and delays due to unnecessary fit constraint

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#3 – Use of Standard Details *(When N/A)*

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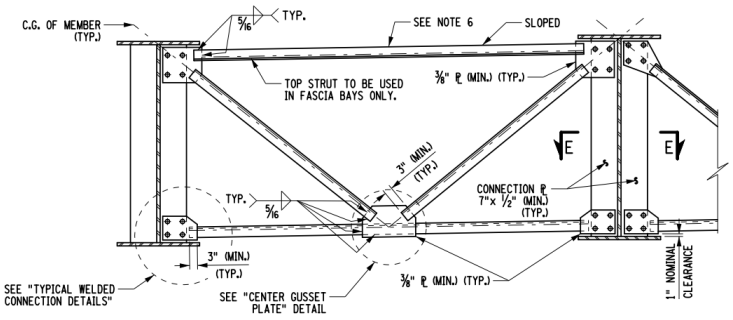
#3 - Use of Standard Details *(When N/A)*

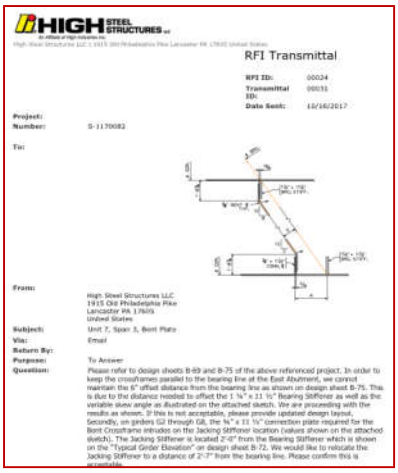
- **Standard details can be very good, IF used properly**
  - Appropriate for particular geometry
  - Appropriate for particular location
  - Appropriate for adjacent details



47

#3 - Use of Standard Details *(When N/A)*

- **Standard details can be very good, IF used properly**
  - Appropriate for particular geometry
  - Appropriate for particular location
  - Appropriate for adjacent details
- **If one of more of these is not true:**
  - Detailer lays out alternatives
  - Submits Request for Information
  - Waits

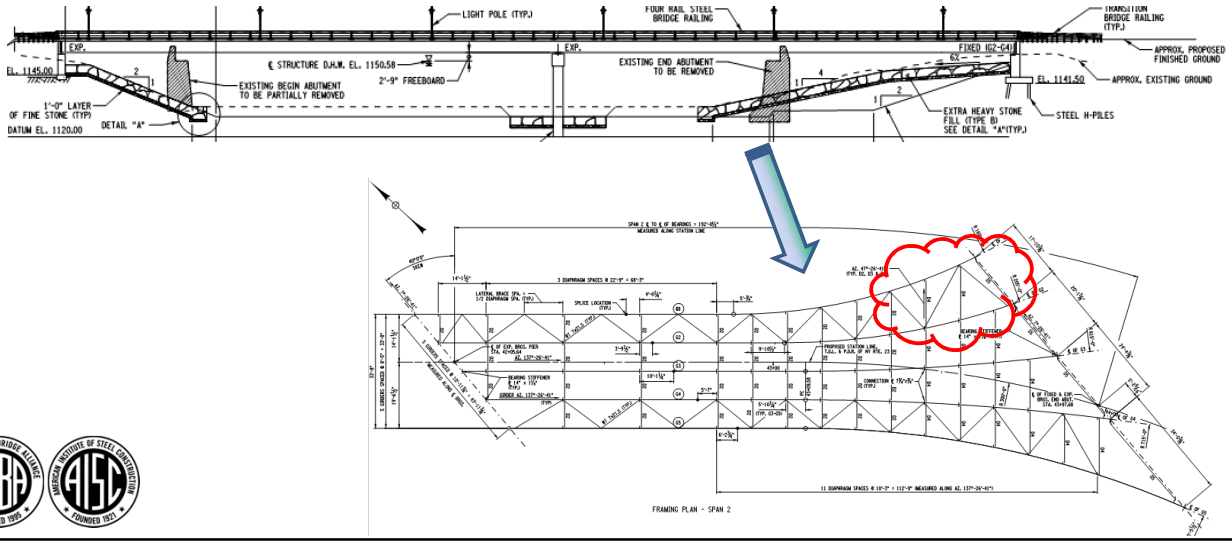

HIGH STEEL STRUCTURES

RFI Transmittal

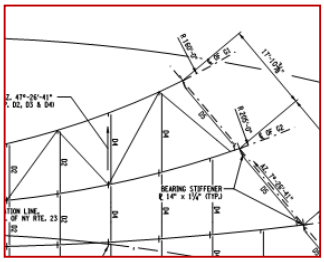
48

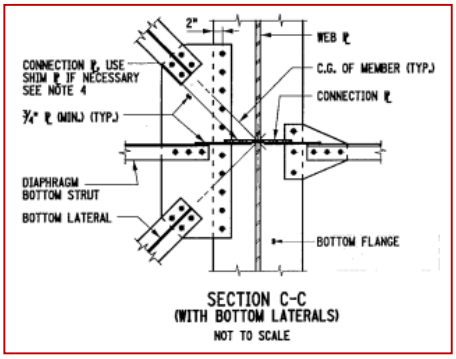
Use of Standard Details *(When N/A)*

- **Case Study – Two Span Girder Bridge, Skewed, Flared**



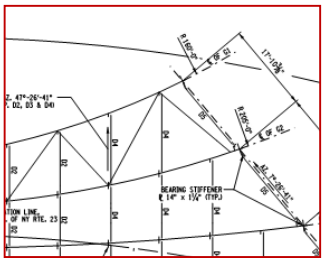
Use of Standard Details *(When N/A)*

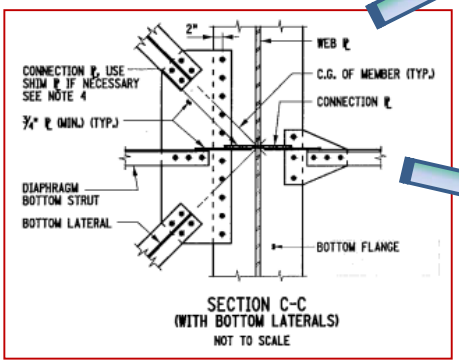


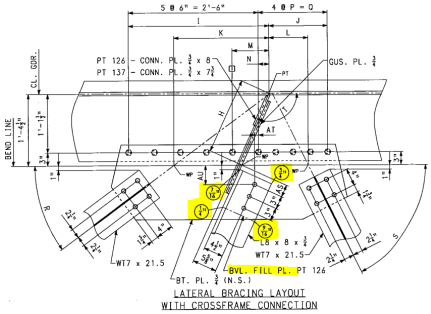


Standard connection detail in Contract Plans

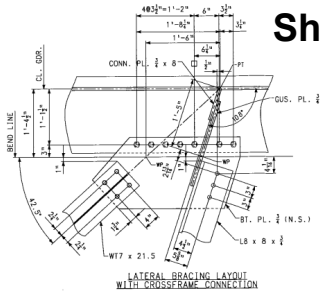
Use of Standard Details *(When N/A)*







Shop drawings

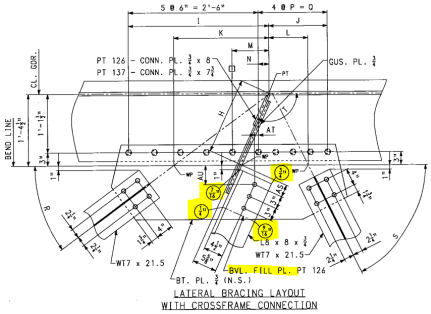


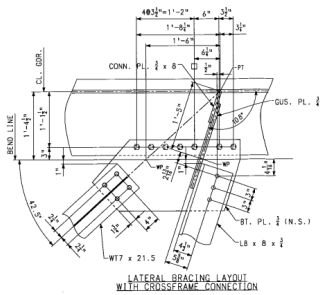
51

Use of Standard Details *(When N/A)*

Impact:

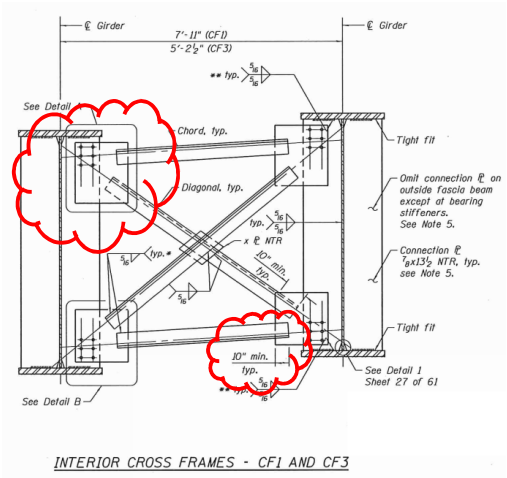
- **Beveling Conn Plate increases cost 25% to 35%**
- **PJP Weld at Conn Plate is 3x cost of normal fillet welded Conn Plate**
- **Compound beveled fill plates could be ~$200 ea. (fabrication only)**





52

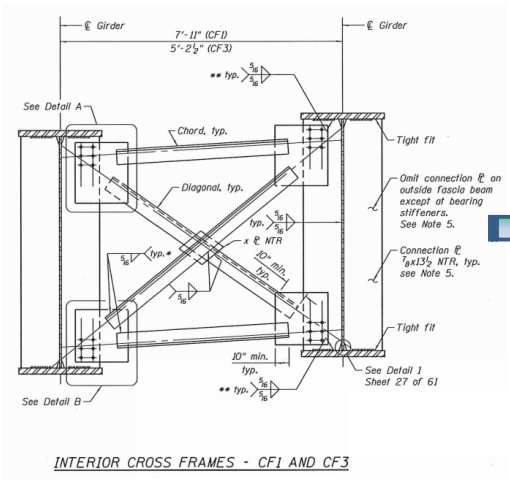
Use of Standard Details *(When N/A)*

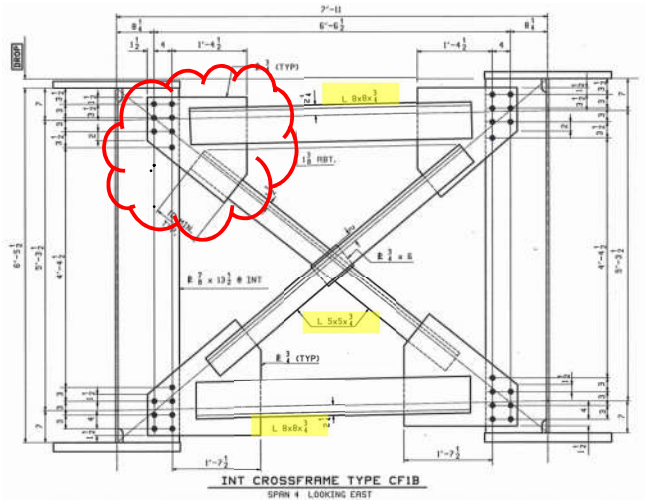


Standard cross frame detail in Contract Plans

Member sizes charted

Use of Standard Details *(When N/A)*



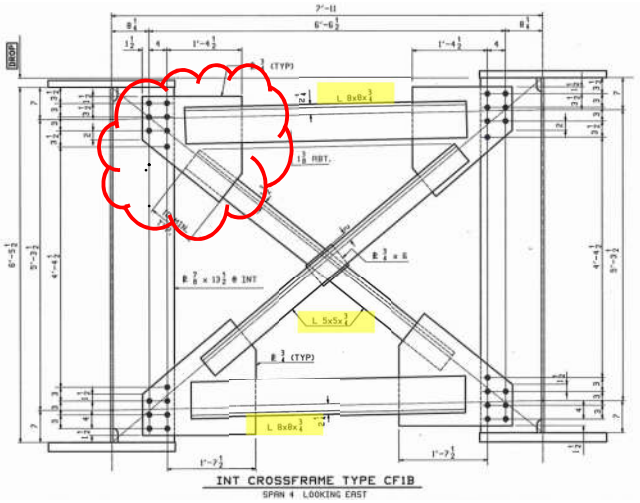


Shop drawing

Use of Standard Details *(When N/A)*

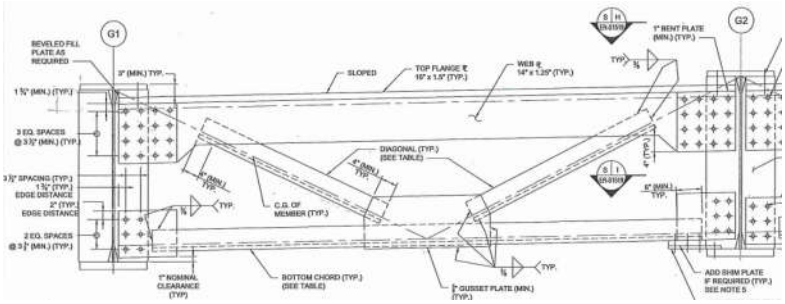
Impact:

- **Larger gusset plates**
- **Four additional bolts at each cross frame (fabrication and erection impact)**



55

Use of Standard Details *(When N/A)*

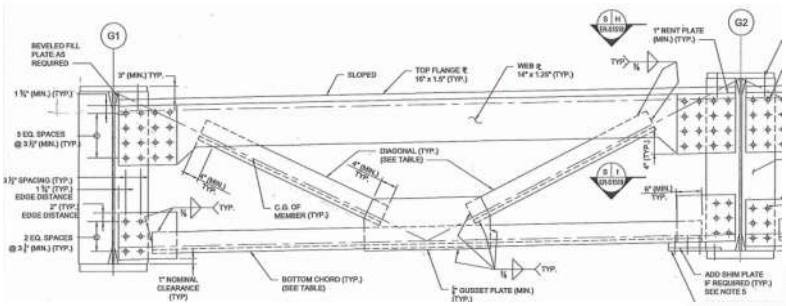


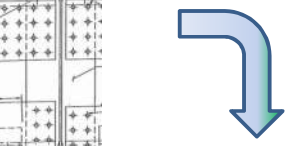
Standard cross frame detail in Contract Plans

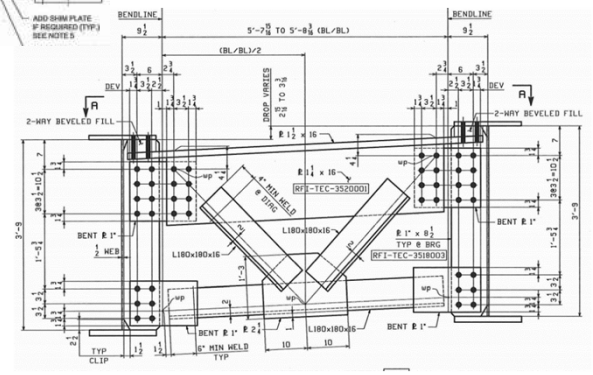
Member sizes charted

56

Use of Standard Details *(When N/A)*



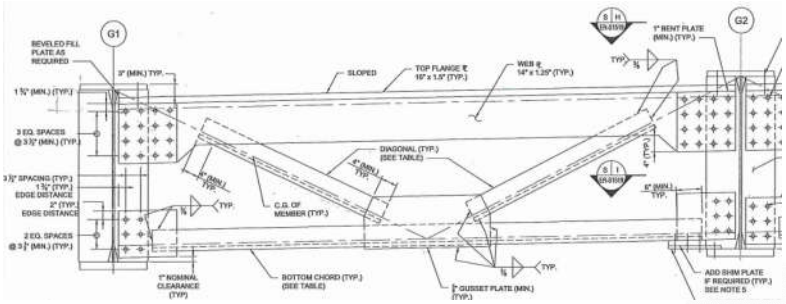


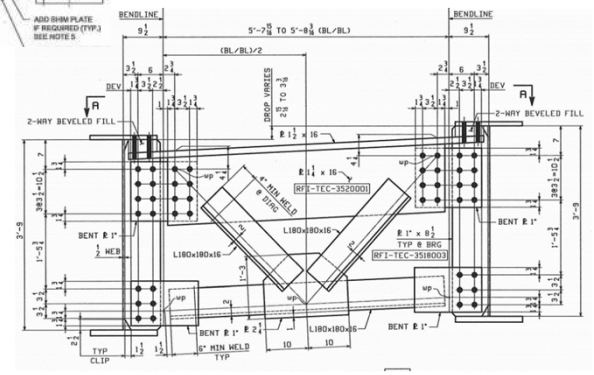


Shop drawing

57

Use of Standard Details *(When N/A)*



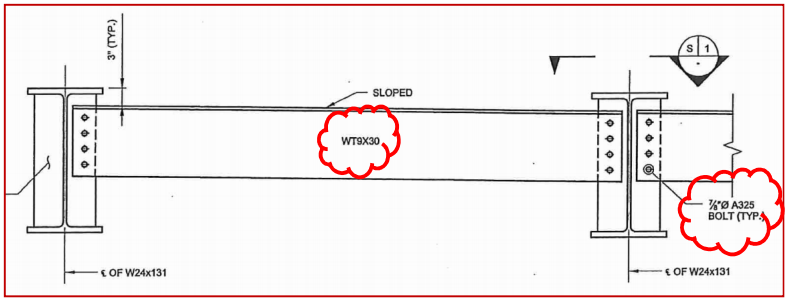


- **Actual geometry yields a vastly different frame**
- **At the least, creates delays for RFI process for approval of actual condition**

58

Use of Standard Details *(When N/A)*

- **Suggestions for avoiding the issue:**
  - Investigate nuances of structure geometry
  - Design/Model/Draw connections to-scale



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#2 – Bridge Fit

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Bridge Fit

- **Objective: Clear definition of the load condition at which various bridge components "fit" together**
- **Fit condition defines:**
  - Load state at which cross frames/diaphragms "fit" with girders having theoretically plumb webs
  - Applies to Skewed and/or Curved I-girder bridges, and important also for Trusses, Arches and Cable Stayed bridges

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Bridge Fit – I-girder Bridges

- **Generally, components "fit" together in only one dead load condition**
  - No Load (Cambered Position)
  - Steel Dead Load (Erected Position)
  - Total Dead Load (Final Position)

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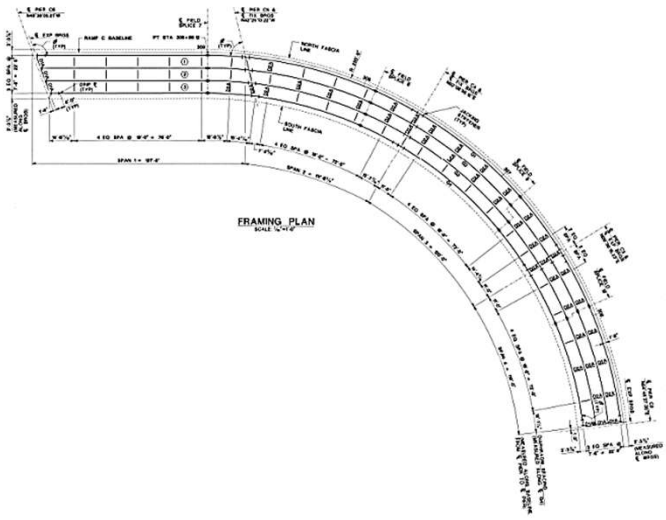
Bridge Fit – I-girder Bridges

- **Define by the load state, not by "webs plumb in . . ."**
  - No Load Fit (NLF)
  - Steel Dead Load Fit (SDLF)
  - Total Dead Load Fit (TDLF)

63

Bridge Fit and Shop Assembly

- **Case Study – Curved I-girder Bridge**



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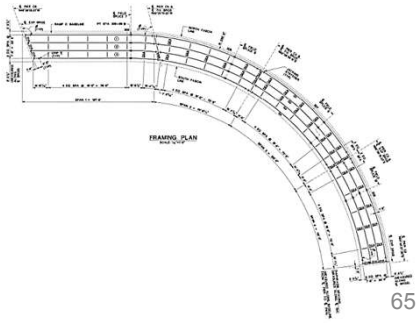
Bridge Fit and Shop Assembly

- **Specified Fit Condition:**

21. DEVELOP SHOP DRAWINGS WHICH DETAIL ALL GIRDER WEBS VERTICAL WHEN TOTAL DEAD LOADS (EXCEPT FWS) ARE APPLIED. SHOP ASSEMBLE THE ENTIRE STEEL SUPERSTRUCTURE TO ENSURE PROPER FIT FOR ALL STRUCTURAL STEEL COMPONENTS PRIOR TO FULL SIZE REAMING OF BOLT HOLES FOR SPLICES AND DIAPHRAGM CONNECTION PLATES. DISASSEMBLE PRIOR TO SHIPPING.

22. ALL CROSS FRAMES SHALL BE DETAILED TO FIT IN TOTAL DEAD LOAD CONDITIONS. ANY ADJUSTMENTS FROM SHOP FIT-UP OF BOLTED CONNECTIONS SHALL BE SUBMITTED TO THE RE FOR APPROVAL.



65

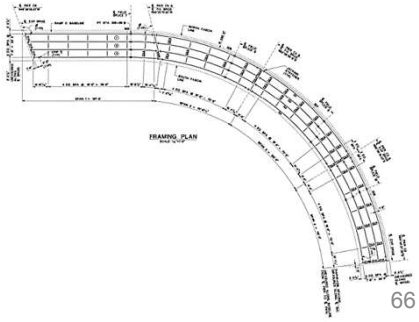
Bridge Fit and Shop Assembly

- **Specified Fit Condition:**

21. DEVELOP SHOP DRAWINGS WHICH DETAIL ALL GIRDER WEBS VERTICAL WHEN TOTAL DEAD LOADS (EXCEPT FWS) ARE APPLIED. SHOP ASSEMBLE THE ENTIRE STEEL SUPERSTRUCTURE TO ENSURE PROPER FIT FOR ALL STRUCTURAL STEEL COMPONENTS PRIOR TO FULL SIZE REAMING OF BOLT HOLES FOR SPLICES AND DIAPHRAGM CONNECTION PLATES. DISASSEMBLE PRIOR TO SHIPPING.

22. ALL CROSS FRAMES SHALL BE DETAILED TO FIT IN TOTAL DEAD LOAD CONDITIONS. ANY ADJUSTMENTS FROM SHOP FIT-UP OF BOLTED CONNECTIONS SHALL BE SUBMITTED TO THE RE FOR APPROVAL.

Fit condition clearly specified



66

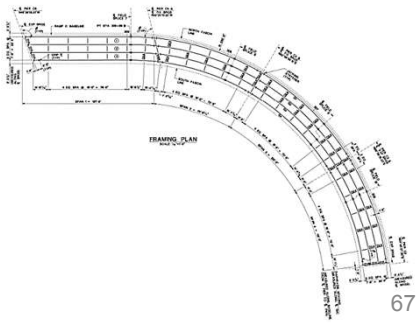
Bridge Fit and Shop Assembly

- **Specified Fit Condition:**

21. DEVELOP SHOP DRAWINGS WHICH DETAIL ALL GIRDER WEBS VERTICAL WHEN TOTAL DEAD LOADS (EXCEPT FWS) ARE APPLIED. SHOP ASSEMBLE THE ENTIRE STEEL SUPERSTRUCTURE TO ENSURE PROPER FIT FOR ALL STRUCTURAL STEEL COMPONENTS PRIOR TO FULL SIZE REAMING OF BOLT HOLES FOR SPLICES AND DIAPHRAGM CONNECTION PLATES. DISASSEMBLE PRIOR TO SHIPPING.

22. ALL CROSS FRAMES SHALL BE DETAILED TO FIT IN TOTAL DEAD LOAD CONDITIONS. ANY ADJUSTMENTS FROM SHOP FIT-UP OF BOLTED CONNECTIONS SHALL BE SUBMITTED TO THE RE FOR APPROVAL.

Unfortunately, does not follow current industry guidance



67

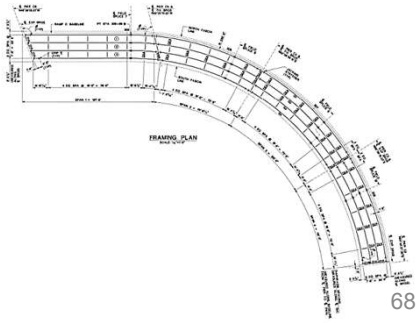
Bridge Fit and Shop Assembly

- **Specified Fit Condition with Shop Assembly:**

21. DEVELOP SHOP DRAWINGS WHICH DETAIL ALL GIRDER WEBS VERTICAL WHEN TOTAL DEAD LOADS (EXCEPT FWS) ARE APPLIED. SHOP ASSEMBLE THE ENTIRE STEEL SUPERSTRUCTURE TO ENSURE PROPER FIT FOR ALL STRUCTURAL STEEL COMPONENTS PRIOR TO FULL SIZE REAMING OF BOLT HOLES FOR SPLICES AND DIAPHRAGM CONNECTION PLATES. DISASSEMBLE PRIOR TO SHIPPING.

22. ALL CROSS FRAMES SHALL BE DETAILED TO FIT IN TOTAL DEAD LOAD CONDITIONS. ANY ADJUSTMENTS FROM SHOP FIT-UP OF BOLTED CONNECTIONS SHALL BE SUBMITTED TO THE RE FOR APPROVAL.

- **Be aware of the interaction between the specified fit condition and any shop assembly requirements**



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Bridge Fit and Shop Assembly

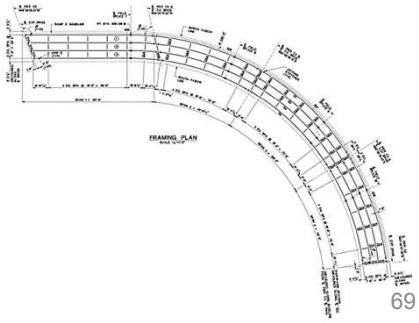
- **Specified Fit Condition with Shop Assembly**

21. DEVELOP SHOP DRAWINGS WHICH DETAIL ALL GIRDER WEBS VERTICAL WHEN TOTAL DEAD LOADS (EXCEPT FWS) ARE APPLIED. SHOP ASSEMBLE THE ENTIRE STEEL SUPERSTRUCTURE TO ENSURE PROPER FIT FOR ALL STRUCTURAL STEEL COMPONENTS PRIOR TO FULL SIZE REAMING OF BOLT HOLES FOR SPLICES AND DIAPHRAGM CONNECTION PLATES. DISASSEMBLE PRIOR TO SHIPPING.

22. ALL CROSS FRAMES SHALL BE DETAILED TO FIT IN TOTAL DEAD LOAD CONDITIONS. ANY ADJUSTMENTS FROM SHOP FIT-UP OF BOLTED CONNECTIONS SHALL BE SUBMITTED TO THE RE FOR APPROVAL.

Incompatibility of fit condition and specified shop assembly

➢ **SAFETY CONCERNS**



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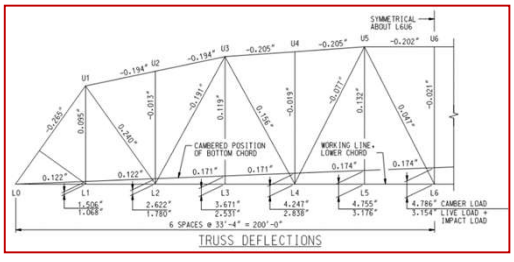
Bridge Fit – Trusses

- **Clearly define truss camber and geometry**
  - Options:
    1. Cambered Lengths, Cambered Angles

    2. Cambered Lengths, Geometric (Final) Angles



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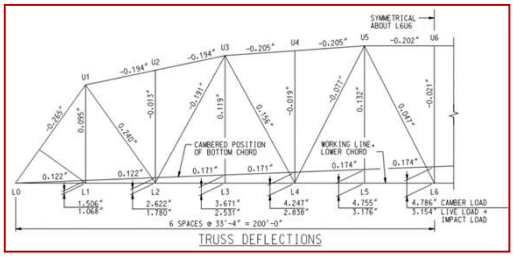
Bridge Fit – Trusses

- **Coordinate with shop assembly requirements**
  1. Cambered Lengths, Cambered Angles
     - Can be shop assembled without force fitting
  2. Cambered Lengths, Geometric (Final) Angles
     - Cannot be fully shop assembled without force fitting
     - Thus, top and bottom chords assembled separately



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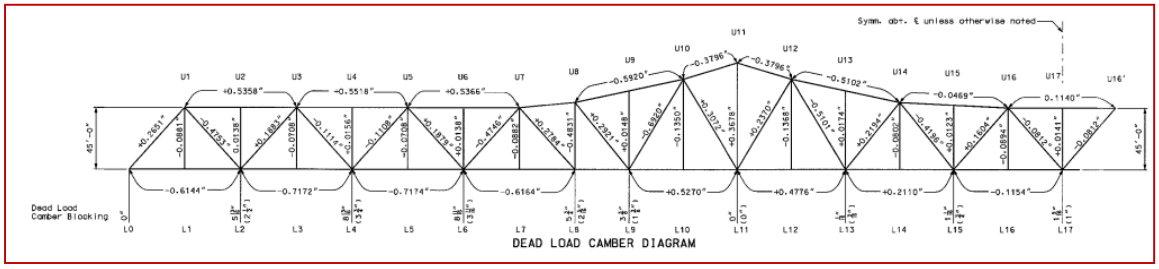
Bridge Fit – Trusses

- **Coordination with shop assembly requirements**



Notes:
Compute the lengths of members for fabrication for geometric shape of truss per notes on this sheet applied to the Elevation of Truss dimensions on Sheet No. 105 with the corrections indicated above applied to these lengths. + indicates lengthening. - indicates shortening.

What does this require for a shop assembly?

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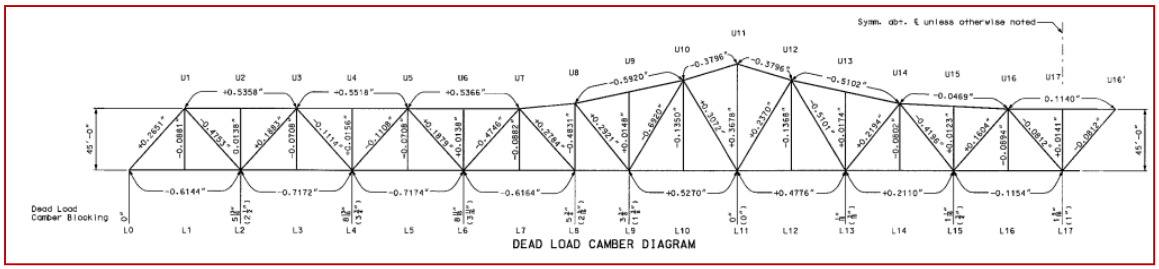
Bridge Fit – Trusses

- **Coordination with shop assembly requirements**



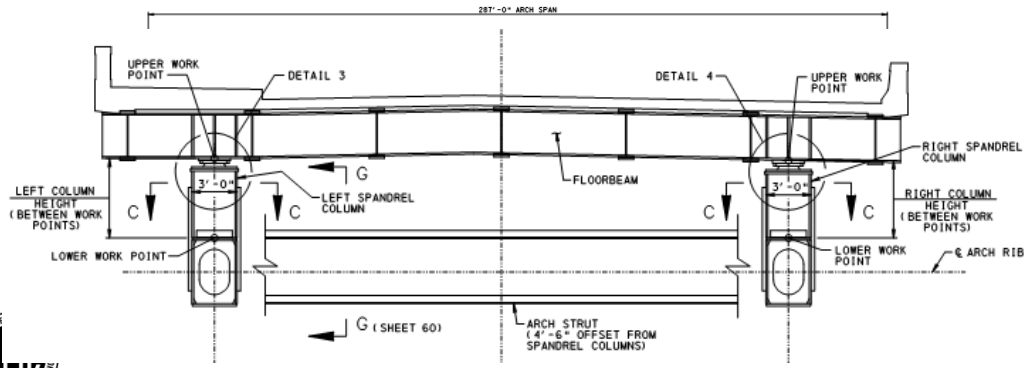
Notes:
Compute the lengths of members for fabrication for geometric shape of truss per notes on this sheet applied to the Elevation of Truss dimensions on Sheet No. 105 with the corrections indicated above applied to these lengths. + indicates lengthening. – indicates shortening.

Separate assemblies: 1) Top chord with web members and 2) Bottom chord with web members

73

Bridge Fit – Arches, Cable Stayed

- **Arches and Cable Stay Bridges**
  - Relationship between main structure camber and floorsystem / bracing camber and fit



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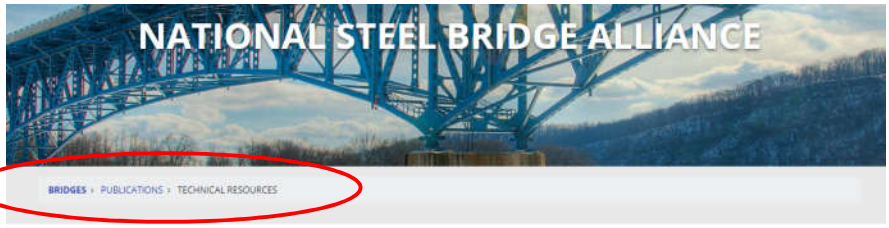
Bridge Fit – What if I have questions!?!?



IN THIS SECTION

- AASHTO/NSBA Collaboration
- Steel Bridge Design Handbook
- Modern Steel Construction Articles
- Technical Resources

Technical Resources

- AISC/PCI Quality Systems White Paper
- A Primer on Weathering Steel
- Advances in High Performance Steels for Highway Bridges
- Bolted Field Splices for Steel Bridge Flexural Members - Overview and Design Examples
  - Release Version 2.00
  - This document address the updates to the splice connection incorporated into the 8th Edition AASHTO LRFD Specification. Complete with 3 examples, the document guides an engineer through how to design a bolted splice connection from start to finish. Utilize the document in conjunction with the updated NSBA Splice for a complete splice design.
- Edge/Corner Primer of Steel Members and its Effect on Zinc Rich Primer Performance
- I-287 Viaducts Over the Saw Mill River and Bronx Parkways
- Reducing Time for Steel Bridge Construction
- Skewed and Curved Steel I-Girder Bridge Fit (Standalone Summay)
  - The standalone summary is a 6 page overview that introduces the concept of "fit condition", why specifying fit is important, and provides recommendations as to which fit condition is best based upon bridge geometry.
- Skewed and Curved Steel I-Girder Bridge Fit (Full Document)
  - The full document addresses the research that was performed in making the recommendations for fit conditions.
- Steel Bridge Construction: Myths & Realities (AISI D432-07)
- Short Span Steel Bridge Alliance Standards
- Mid-Atlantic States Structural Committee for Economic Fabrication (SCEF) Standards
- TxDOT Preferred Practices for Steel Bridge Design Fabrication and Erection

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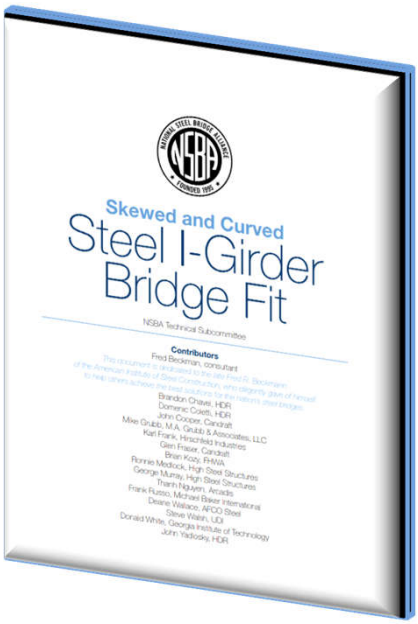
Bridge Fit – What if I have questions!?!?

Table 3 **Recommended Fit Conditions for Straight I-Girder Bridges (including Curved I-Girder Bridges with L/R in all spans ≤ 0.03)**[1]

Square Bridges and Skewed Bridges up to 20 deg Skew			
	Recommended	Acceptable	Avoid
Any span length	Any		None
Skewed Bridges with Skew > 20 deg and $I_z \leq 0.30$ +/-			
	Recommended	Acceptable	Avoid
Any span length	TDLF or SDLF		NLF
Skewed Bridges with Skew > 20 deg and $I_z > 0.30$ +/-			
	Recommended	Acceptable	Avoid
Span lengths up to 200 ft +/-	SDLF	TDLF	NLF
Span lengths greater than 200 ft +/-	SDLF		TDLF & NLF

Table 4 **Recommended Fit Conditions for Horizontally Curved I-Girder Bridges ($(L/R)_{MAX} > 0.03$)**[1]

Radial or Skewed Supports			
	Recommended	Acceptable	Avoid
$(L/R)_{MAX} \geq 0.2$	NLF [2,3]	SDLF [4]	TDLF
All other cases	SDLF [5]	NLF	TDLF



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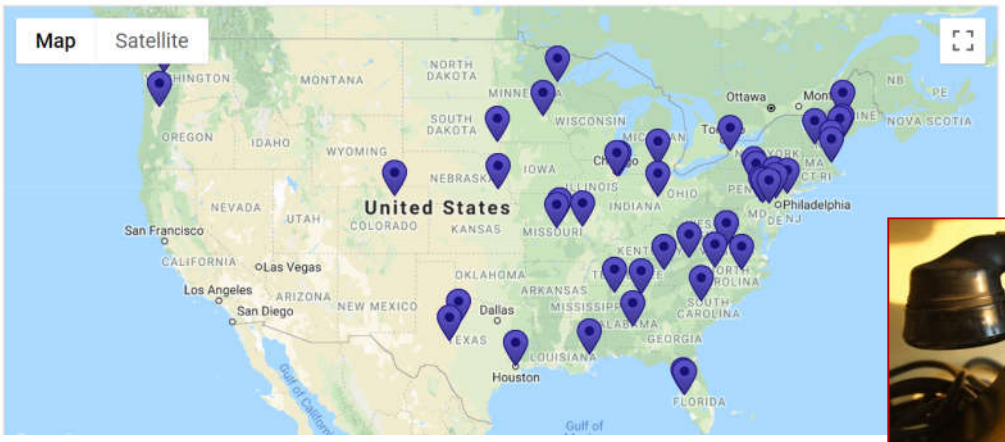
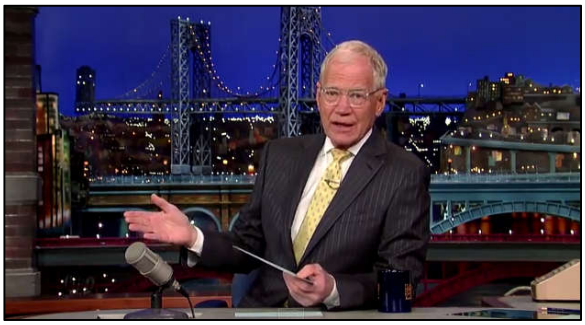
Bridge Fit – What if I have questions!?!?

Certified Company Search



#1 –



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#1 – Bearing Pad Elevations

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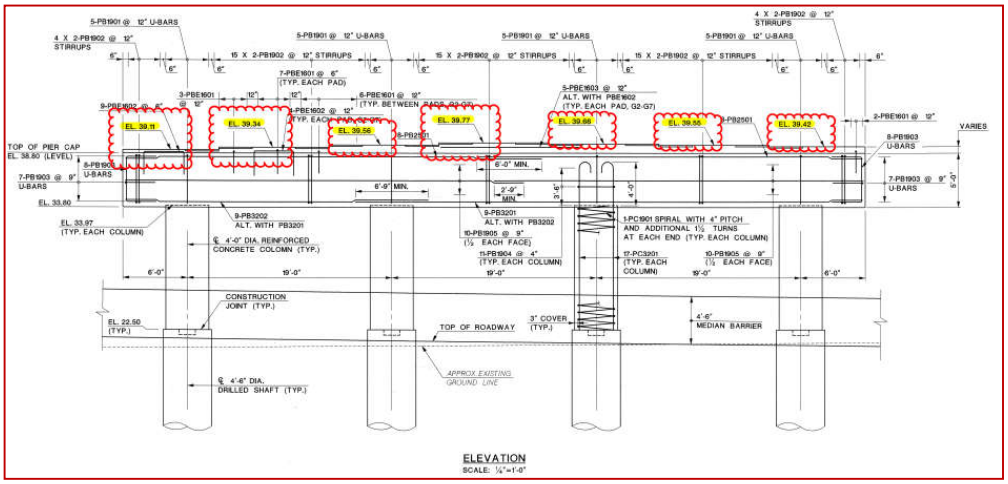
Bearing Pad Elevations

- **Anecdotally, the #1 discrepancy in bridge contract plans**



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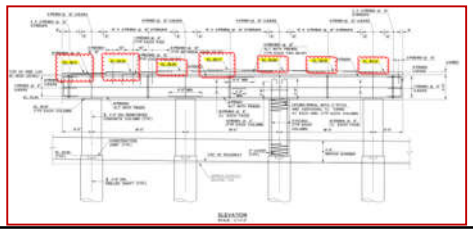
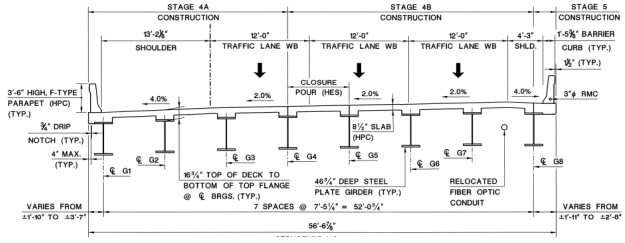
Bearing Pad Elevations

- **Why does the Fabricator care?**
  - ➢ "Just put steel at elevations provided . . . "
  - – Essentially, Detailers perform a verification of structure geometry
  - – Provides assurance that structural steel geometry is in conformance with contract plans



Bearing Pad Elevations

- **Detailer checks geometry by working from top of roadway down to bearing pads**
  - – Deck elevations } Or Bottom of Slab
  - – Deck thickness
  - – Haunch thickness
  - – Girder depth
  - – Bearing depth



Yields ⇒ Bearing Pad Elevations

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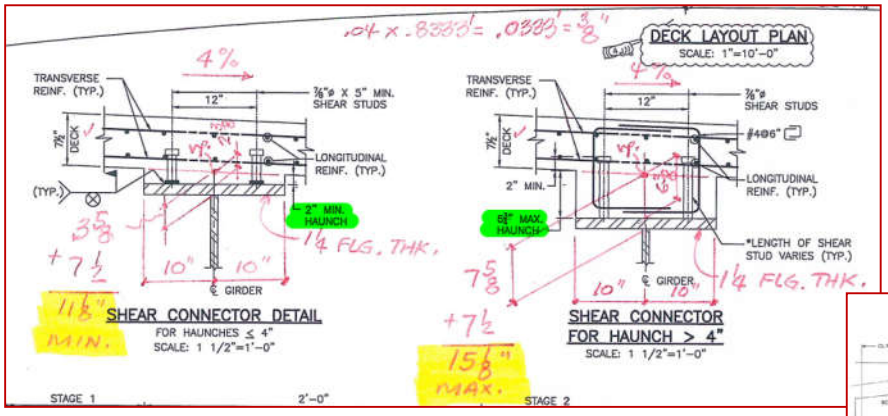
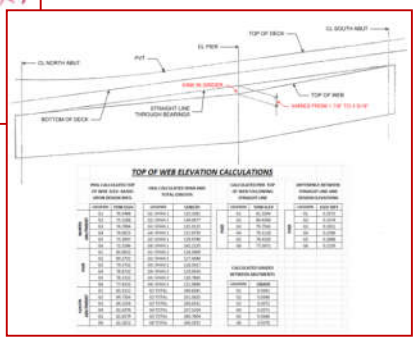
Bearing Pad Elevations





83

Bearing Pad Elevations

- **If a discrepancy, Detailer is unsure whether it's a:**
  - Bust in roadway geometry
  - Bust in concrete haunches
  - Bust in cambers
  - Bust in bearings
  - Bust in bearing pad elevations

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Bearing Pad Elevations

- **If a discrepancy, Detailer is unsure whether it's a:**
  - Bust in roadway geometry
  - Bust in concrete haunches
  - Bust in cambers
  - Bust in bearings
  - Bust in bearing pad elevations

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Bearing Pad Elevations

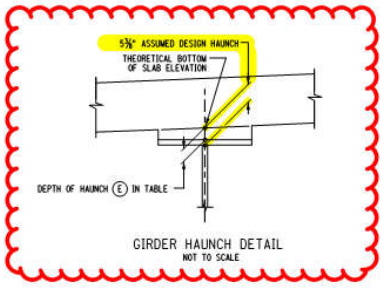
- **If a discrepancy, Detailer is unsure whether it's a:**
  - Bust in roadway geometry
  - Bust in concrete haunches
  - Bust in cambers
  - Bust in bearings
  - Bust in bearing pad elevations
- **Leads to an RFI, and essentially stoppage**

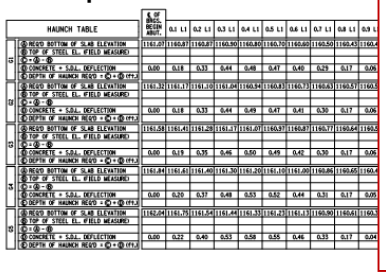
Why? Potential impact to steel material order

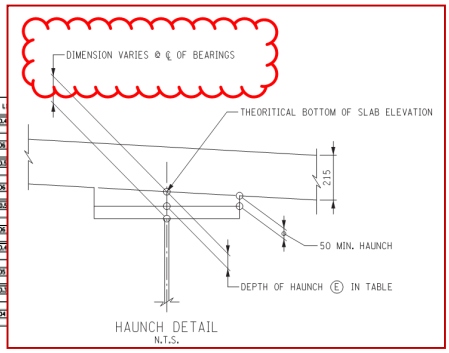
86

Bearing Pad Elevations

- **Suggestions for avoiding the discrepancy**
  - Include basic roadway geometry with structure
  - Clearly define deck slab and haunches
    - Constant haunch – state so
    - Variable haunch – provide







Common Design Issues Slowing Bridge Projects

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Common Design Issues Slowing Bridge Projects

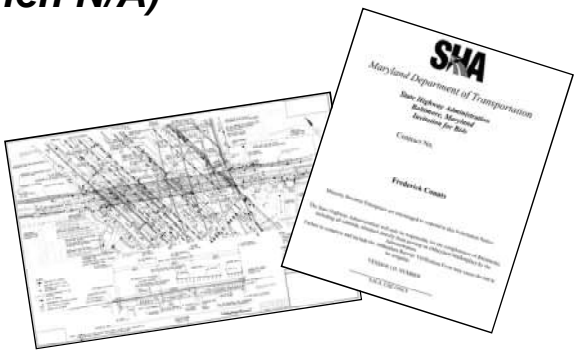
#5 – Primary Member, FCM and CVN Designation

#4 – Details of Stiffeners and Connection Plates

#3 – Use of Standard Details *(When N/A)*

#2 – Bridge Fit

#1 – Bearing Pad Elevations



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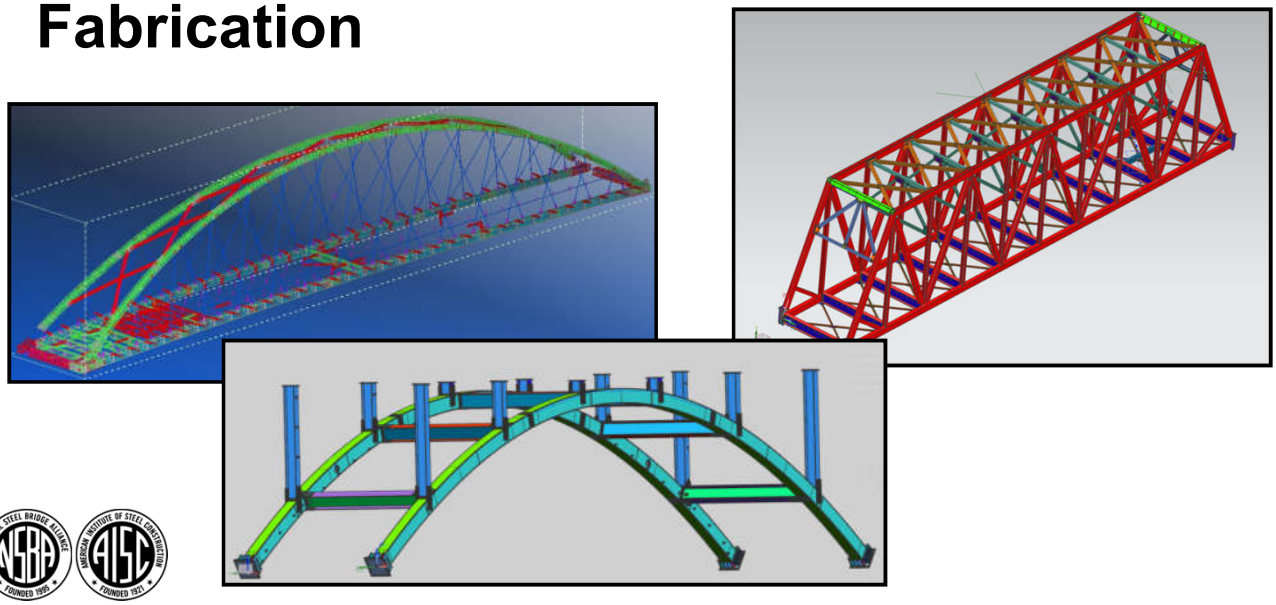
Part II: BIM for Bridges in Structural Steel Fabrication



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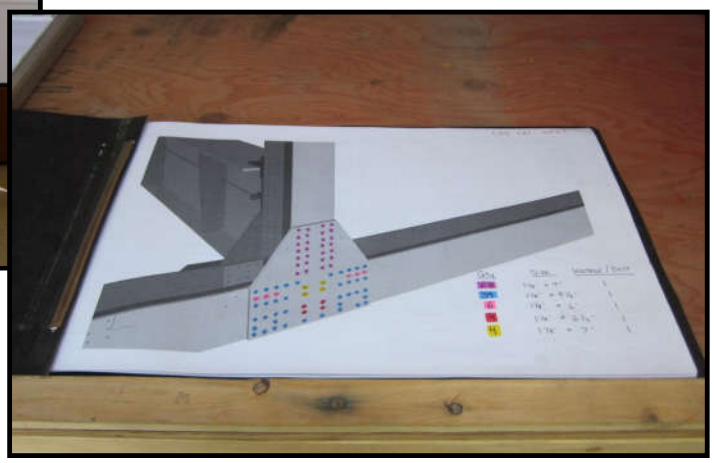
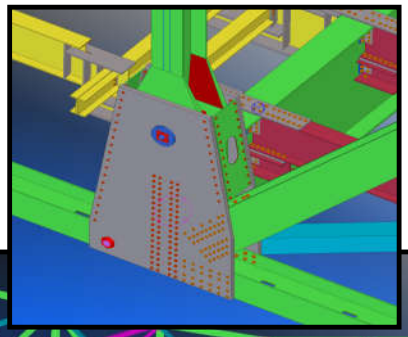
Traditional BIM in Bridge Fabrication



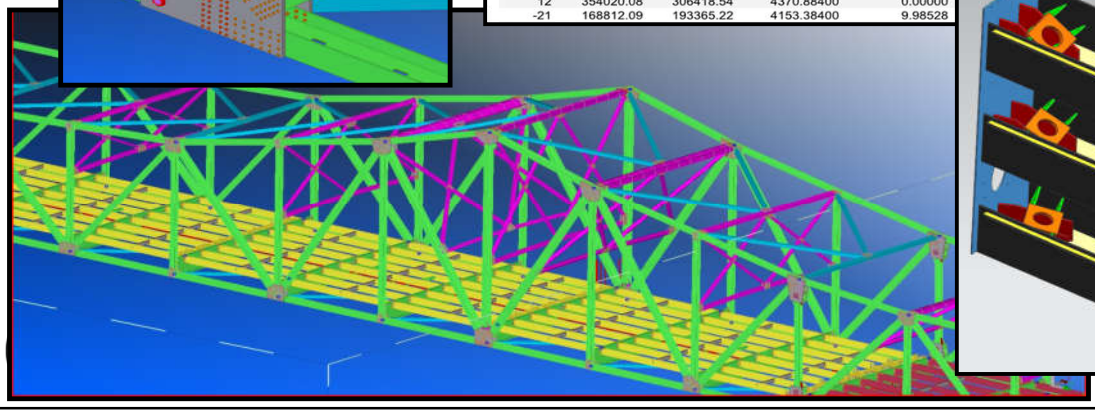
91

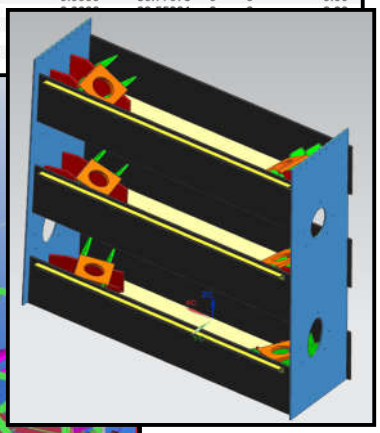
Current BIM in Bridge Fabrication



Coordinate Base — Seq # 14 — Metric

Pt	North	East	Station	Top of Roadway Elevation	Cross Slope	Azimuth	Gdr Line	Point Type	Extension
1	0.00	0.00	3895.77200	0.00000	0.0000	57.82763	0	0	0.00
2	576166.51	368725.73	4602.40400	0.00000	0.0000	7.40792	0	0	0.00
3	679699.39	-427571.92	0.00000	0.00000	0.0000	0.00000	0	0	0.00
4	745175.98	390699.97	4772.83600	0.00000	0.0000	7.40792	0	0	0.00
5	930300.71	427407.92	4961.70400	0.00000	0.0000	15.02321	0	0	0.00
6	561962.76	1799839.39	0.00000	0.00000	0.0000	0.00000	0	0	0.00
7	169507.80	192519.65	4153.38400	0.00000	0.0000	39.44646	0	0	0.00
8	199011.71	215660.82	4190.88400	0.00000	0.0000	36.77075	0	0	0.00
9	235794.10	241574.63	4235.88400	0.00000					
10	273970.20	265387.55	4280.88400	0.00000					
11	313420.15	287024.84	4325.88400	0.00000					
12	354020.08	306418.54	4370.88400	0.00000					
-21	168812.09	193365.22	4153.38400	9.98528					





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The Power is in the "I" – the Info

Mark	Radius	Width	Detail_Length	Adjust_Length	Order_Length	Thickness
1160245A_G10O-b1	144	12	109.5625	0.015	113	1
1160245A_G10O-b2	144	12	111	0.015	114	1
1160245A_G10O-b3	0	12	220.773	0.0287	222	1
1160245A_G10O-t1	144	12	9			
1160245A_G10O-t2	144	12	1			

```
INPUT BY:   GPS
CHECKED BY: MJA
 50
   ,'YES'
   ,   2,  10,  10,'EQUAL   '
 51,'FEET   '
   ,   2,   1,   5
       , 0.0000, 0.0900, 0.1600, 0.2100, 0.2300, 0.2200, 0.1900, 0.1400, 0.0800
       , 0.0300, 0.0000, 0.0200, 0.0800, 0.1200, 0.1900, 0.2200, 0.2300, 0.2100
       , 0.1600, 0.0900, 0.0000
   ,   1,   2
       , 0.0000, 0.0900, 0.1600, 0.2100, 0.2400, 0.2300, 0.1900, 0.1400, 0.0800
       , 0.0300, 0.0000, 0.0200, 0.0800, 0.1200, 0.1900, 0.2200, 0.2400, 0.2100
       , 0.1600, 0.0900, 0.0000
   ,   1,   3
       , 0.0000, 0.0900, 0.1600, 0.2100, 0.2400, 0.2300, 0.1900, 0.1400, 0.0800
       , 0.0300, 0.0000, 0.0200, 0.0800, 0.1300, 0.1900, 0.2200, 0.2400, 0.2200
       , 0.1600, 0.0900, 0.0000
   ,   1,   4
       , 0.0000, 0.0900, 0.1600, 0.2100, 0.2400, 0.2300, 0.1900, 0.1400, 0.0800
       , 0.0300, 0.0000, 0.0200, 0.0800, 0.1300, 0.1900, 0.2200, 0.2400, 0.2100
       , 0.1600, 0.0900, 0.0000
   ,   0
 52,'FEET   '
   ,   5,   1,   2,   3,   4,   5
       , 0.0000, 0.0200, 0.0400, 0.0500, 0.0500, 0.0500, 0.0400, 0.0300, 0.0200
       , 0.0100, 0.0000, 0.0000, 0.0200, 0.0300, 0.0400, 0.0500, 0.0500, 0.0500
       , 0.0400, 0.0200, 0.0000
   ,   0
 53,'YES'
 60,  60, 104,'LEFT  ',   4
 61,  20, 1.1510, 1.1094,   0,   0, 0.0000,0,  21, 0.0677, 1.1094,   0,   0, 0.0000,0
                                                 677, 1.1094,   0,   0, 0.0000,0
                                                 677, 1.1094,   0,   0, 0.0000,0
                                                 510, 1.1094,   0,   0, 0.0000,0
                                                 510, 1.1094,   0,   0, 0.0000,0
                                                 510, 1.1094,   0,   0, 0.0000,0
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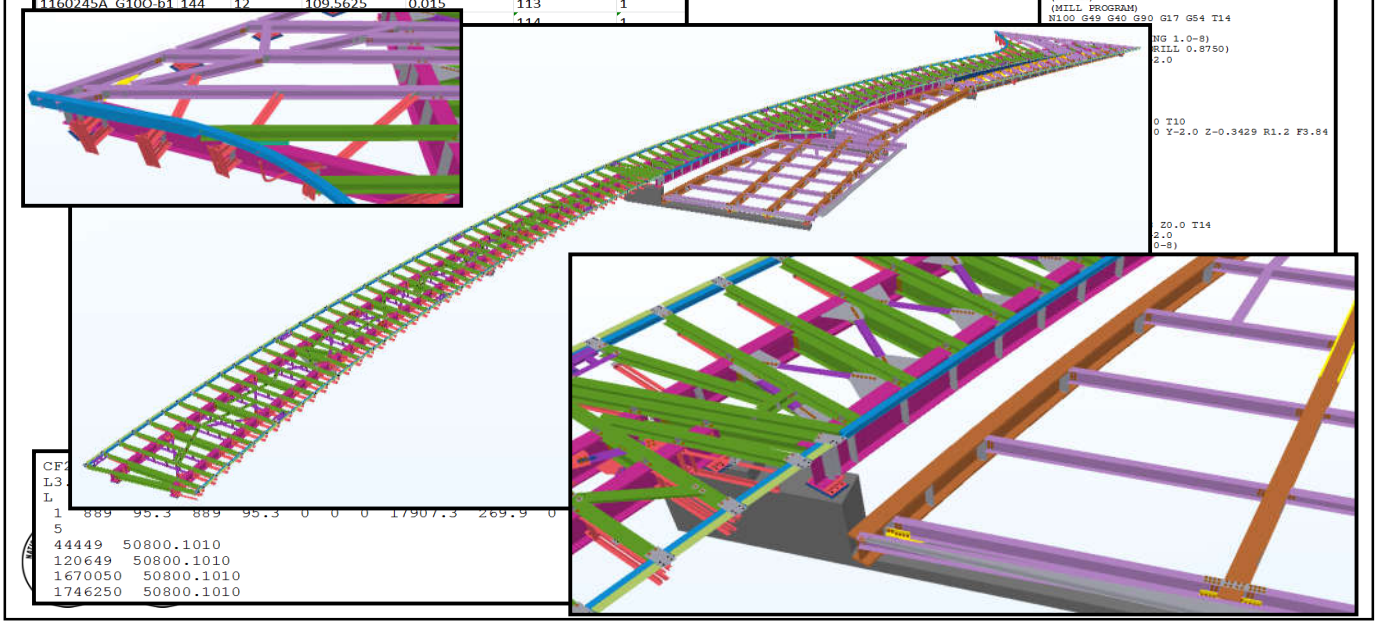
```
CF2-A   1160083A DWG:4
L3.5X3.5X0.4
L
 1  889  95.3  889  95.3  0  0  0  17907.3  269.9  0  0  0  0  0  0  0  0
 5
 44449  50800.1010
 120649  50800.1010
 1670050  50800.1010
 1746250  50800.1010
```

```
(M2-MA)
(MILL PROGRAM)
N100 G49 G40 G90 G17 G54 T14
N105 T14 M11
N110 (TAP DRILLING 1.0-8)
N115 (7/8 DIA. DRILL 0.8750)
N120 G00 X2.0 Y-2.0
N125 / T0 M06
N130 M08
N135 G04 P2000
N140 M38
N145 S480 M03
N150 G45 H14 Z2.0 T10
N155 G98 G81 X2.0 Y-2.0 Z-0.3429 R1.2 F3.84
N160 Y-10.0
N165 X18.0
N170 Y-2.0
N175 G80
N180 G00 Z2.0
N185 M05
N190 M09
N195 T10 M11
N200 G00 G91 G28 Z0.0 T14
N205 G90 X2.0 Y-2.0
N210 (TAPPING 1.0-8)
N215 (1 DIA. TAP 1.0-8)
N220 G49 T14 M06
N225 M08
N230 G04 P2000
N235 M38
N240 S305 M03
N245 G45 H10 Z2.0 T0
N250 G98 G84 X2.0 Y-2.0 Z-0.625 R1.2 F38.2
N255 Y-10.0
N260 X18.0
N265 Y-2.0
N270 G80
N275 G00 Z2.0
N280 T0
N285 T0 M11
N290 M05
N295 M09
N300 G80
N305 G00 G91 G28 Z0.0 T10
N310 G49 G91 G28 X0.0 Y0.0 T10 M06
N315 T14
N320 T14 M06
N325 M30
(CYCLE TIME = 2.2 MINUTES)
```

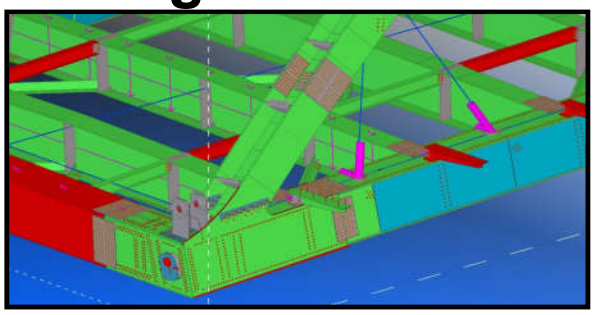
93

The Power is in the "I" – the Info



Current Uses of BIM for Bridges

- Generation of Shop Drawings, Fab Data & CAM Files
- Fabrication Planning
- Fit Verification and Clash Detection
- Quality Control/Assurance
- Steel Erection Planning
- Data Warehouse for Fabrication Documentation (RFIs, QC Data)
- PROJECT DATA for LIFE CYCLE!



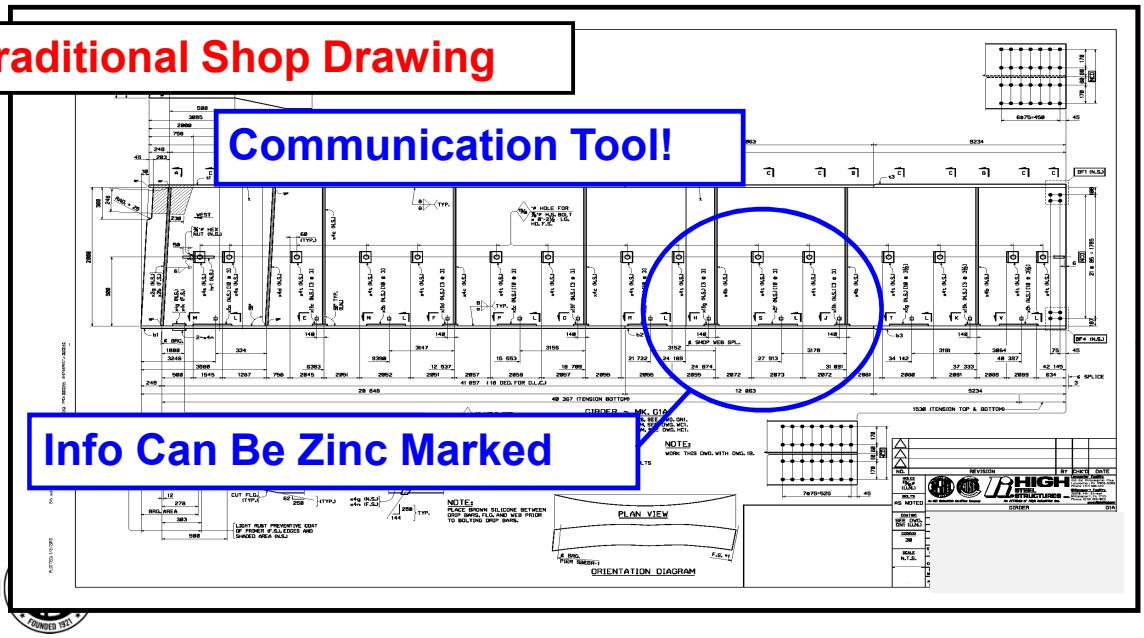
95

Current Use of BIM – Fabrication

Traditional Shop Drawing

Communication Tool!

Info Can Be Zinc Marked



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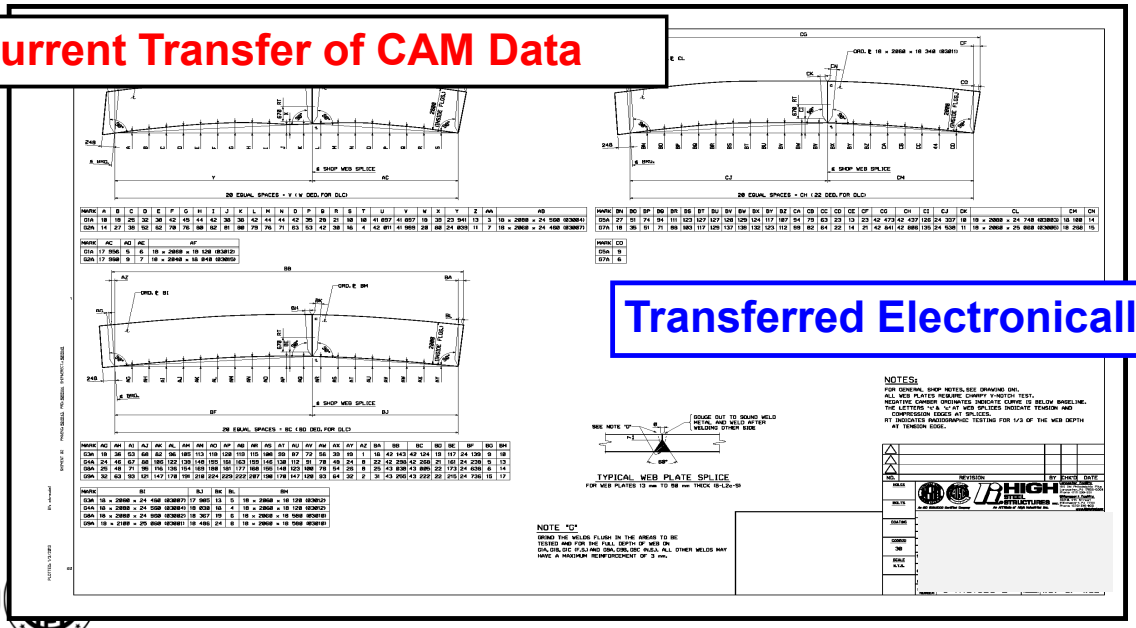
Current Use of BIM – Fabrication

Current Transfer of CAM Data

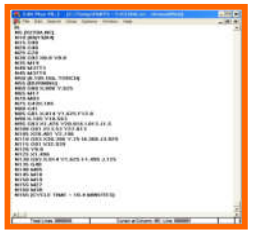


Transferred Electronically

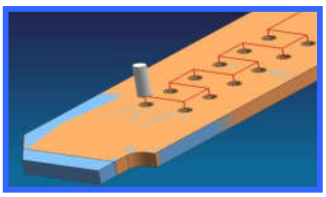
97

Current Use of BIM – Fabrication

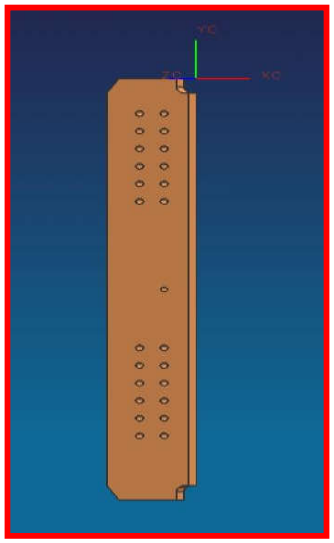
- ***Parametric 3D models created for girder parts***
- ***One associative part model shared by all disciplines***
- ***Reduces redundant efforts***



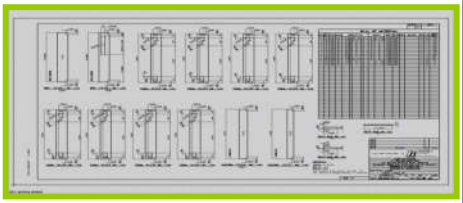
CNC Code



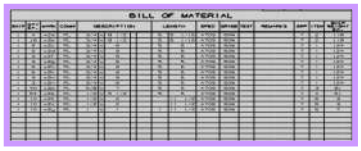
CAM Toolpath



Part Model



CAD Drawings



BOM

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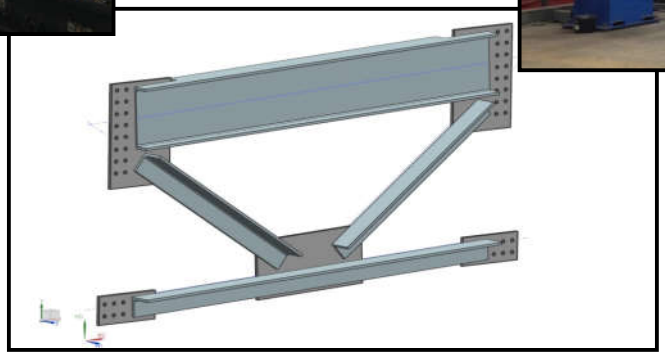
Current Use of BIM – Fabrication



Individual Components

Assembly

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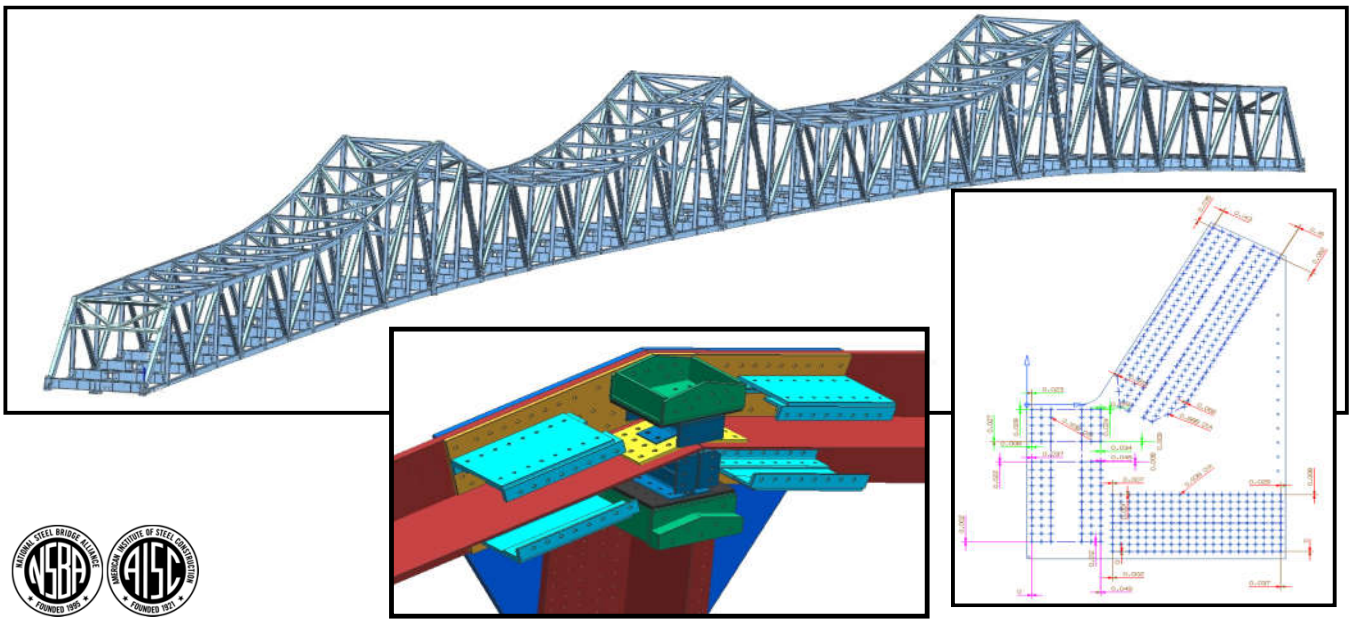
Current Use of BIM – Fit Verification

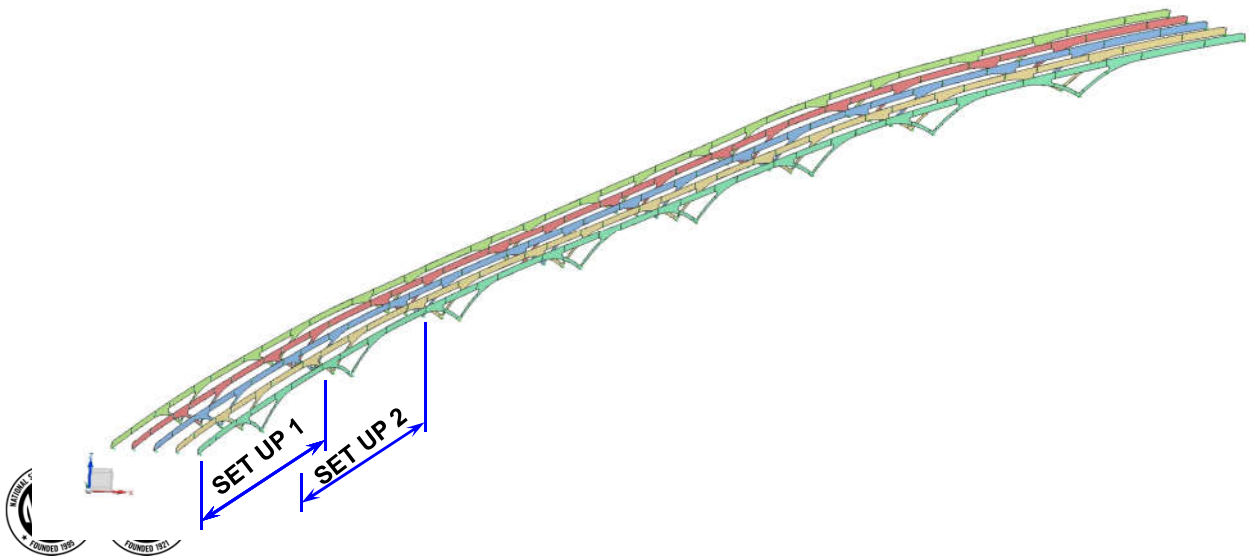
Traditional Assembly

- **Labor Intensive**
- **Time Consuming**
- **Costly**

Current Use of BIM – Fit Verification



Current Use of BIM – Fit Verification



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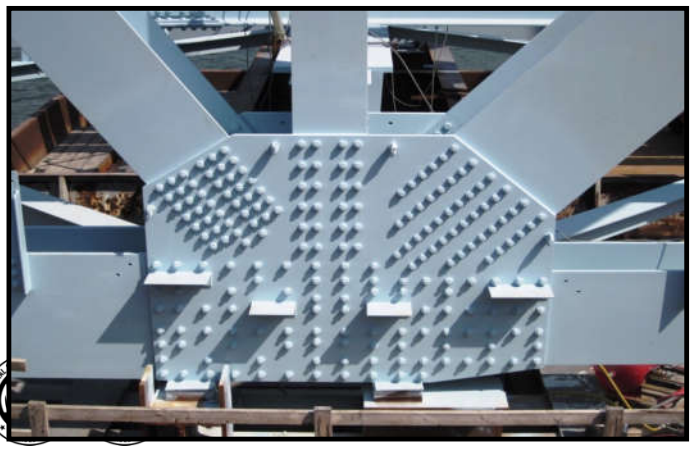
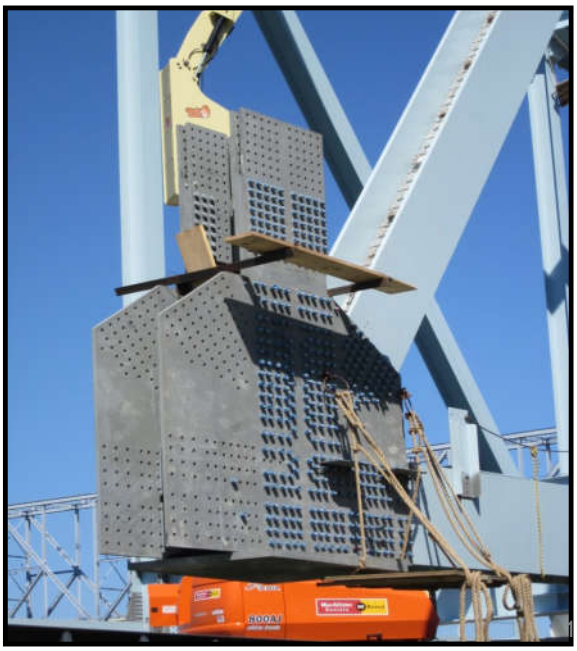
Current Use of BIM – Fit Verification

Physical Assembly avoids issues here, BUT
Virtual Assembly can achieve same result

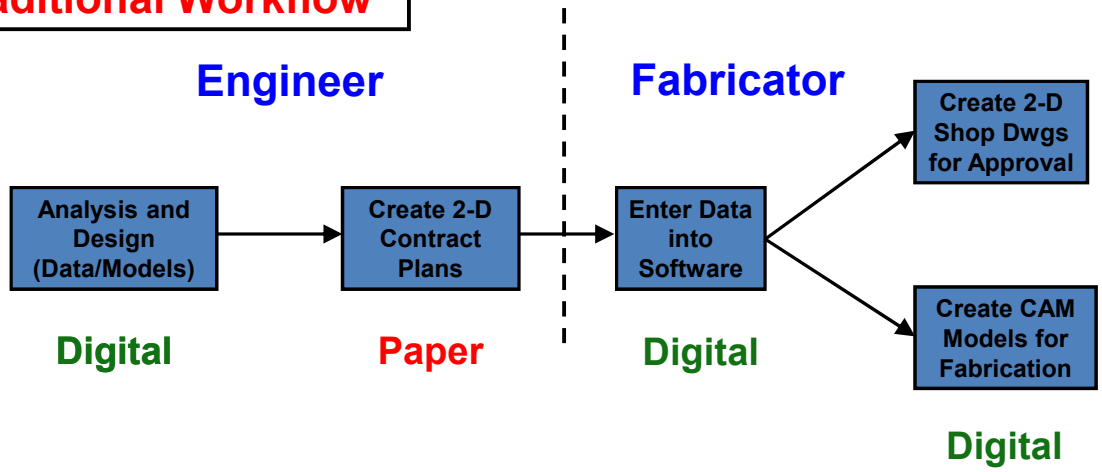




103

Potential Use of BIM – Info Sharing

Traditional Workflow



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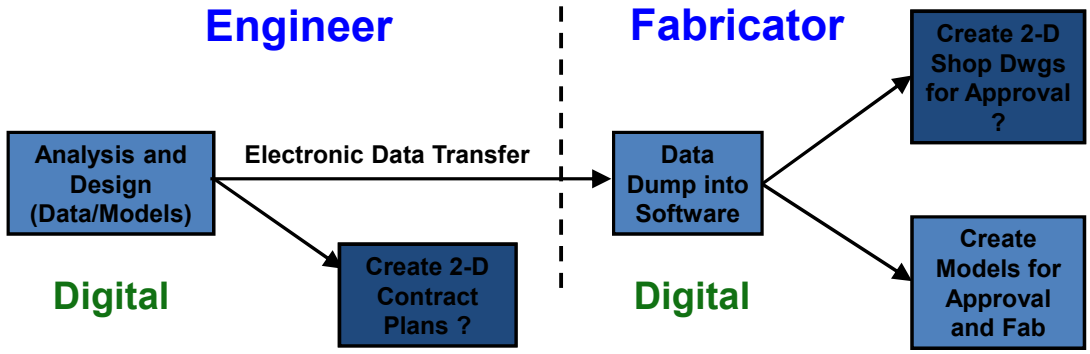
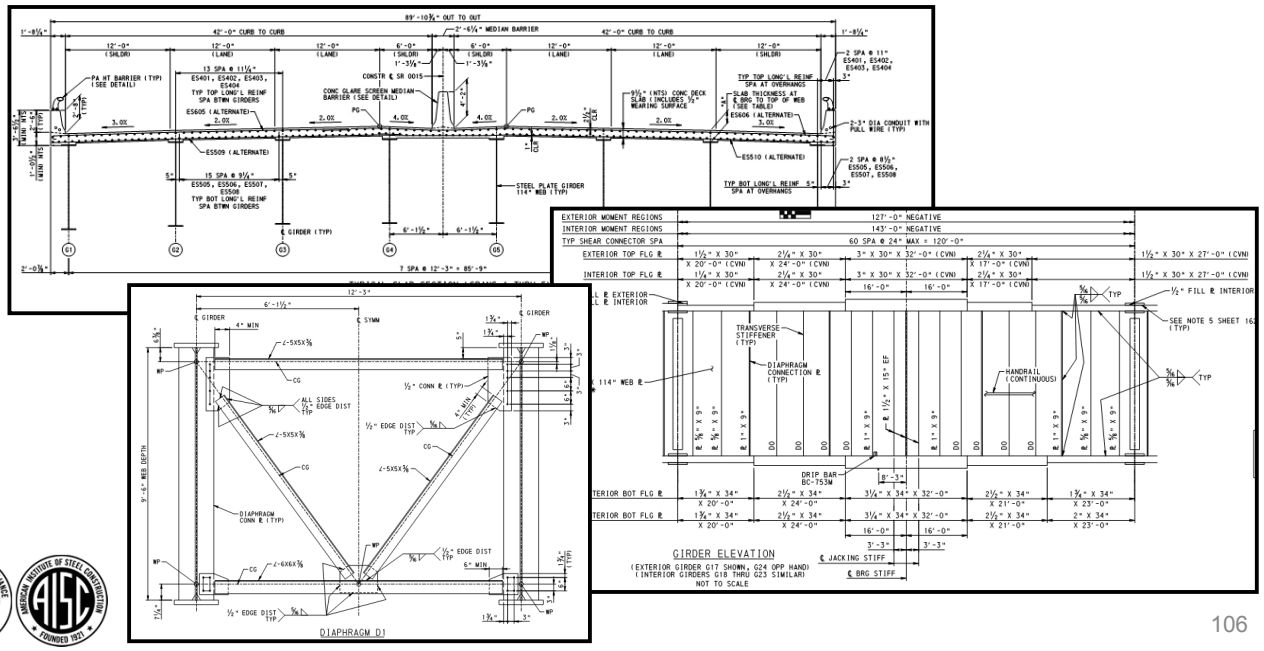
Potential Use of BIM – Info Sharing

Preferred Workflow



105

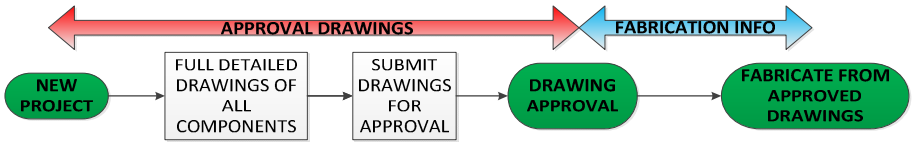
Potential Use of BIM – Info Sharing



106

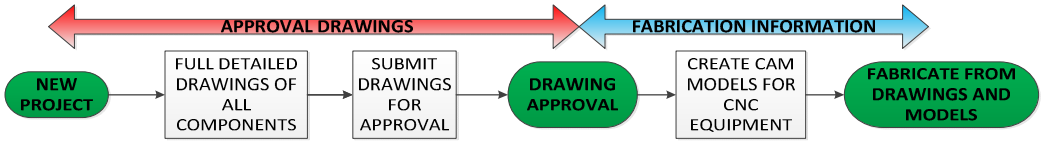
Potential Use of BIM – Fab Doc Review

SHOP DRAWING TO FABRICATION FLOW - TRADITIONAL



DRAWINGS GOVERN!

SHOP DRAWING TO FABRICATION FLOW - WITH ADVENT OF CNC EQUIPMENT

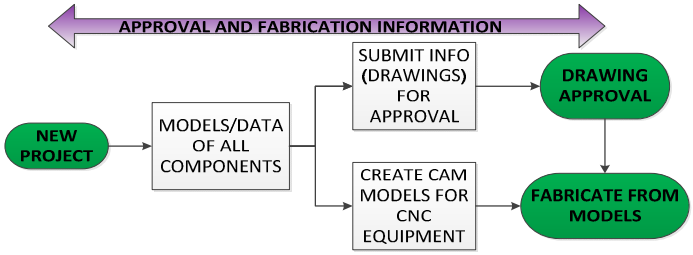


DRAWINGS GOVERN, BUT MODELS/DATA USED

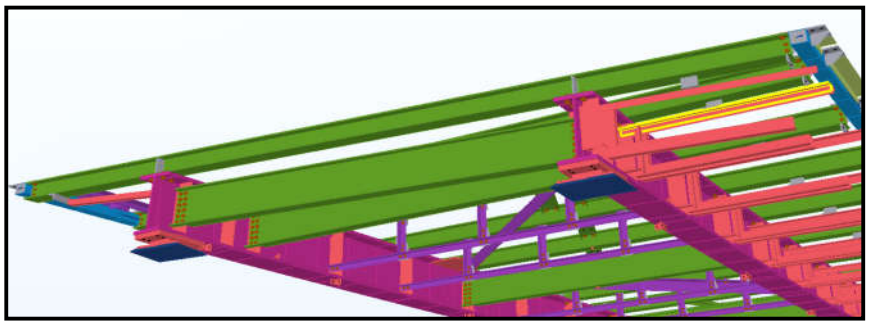
107

Potential Use of BIM – Fab Doc Review

SHOP DRAWING TO FABRICATION FLOW - WITH FULL UTILIZATION OF BrIM AND CNC EQUIPMENT



MODELS/DATA GOVERN!



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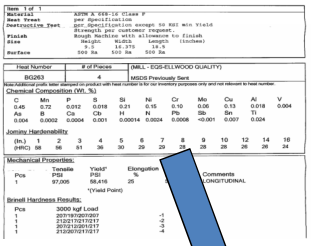
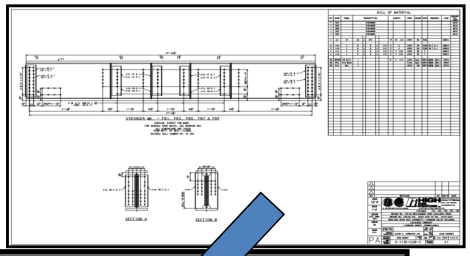
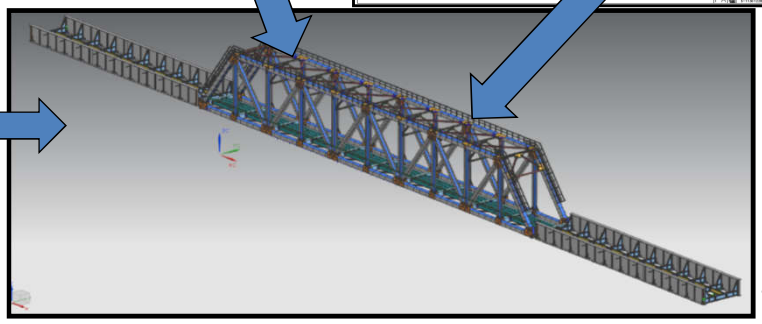
Potential Use of BIM – Data Storage

- **Project Info Warehouse**
  - Fabrication Details
  - RFIs
  - Fabrication QC Docs
  - As-Built Docs







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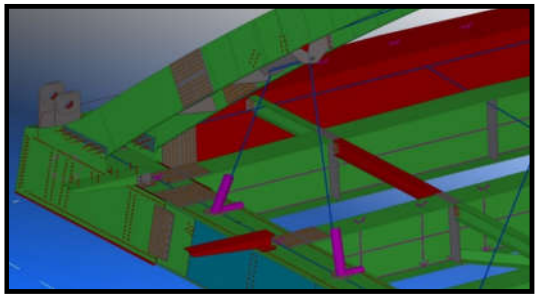
BIM Benefits in Bridge Fabrication

- **Optimizes Workflow thru Design – Detailing – Fabrication – Field**
- **Minimizes Errors due to:**
  - Manual Data Transfer
  - Detailing Misfits
- **Provides One Source for Data**
  - Shop Drawings / RFIs
  - Fabrication Documentation
  - QC Records
- **Eliminates Redundant or Manual Efforts**
  - Manual Programming and Fabrication Processes
  - Physical Assemblies for Fit Verification



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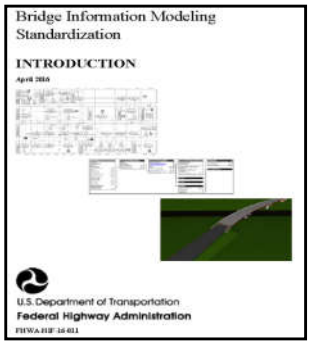
Where Do We Go From Here???

- **FHWA is setting a path for implementation of BIM**
  - Defined information exchange format in 2016
    - IFC file = Industry Foundation Classes
    - Standardized neutral data model/file that describes building and construction industry
    - Overseen and governed by buildingSMART International



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Where Do We Go From Here???

- **AASHTO T-19 Pooled Fund Study**
  - Defining the bridge data to be included in the IFC file
  - Current effort focused on data exchange from designer to fabricator
  - Industry task groups assisting (AASHTO/NSBA Steel Bridge Collaboration)

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Where Do We Go From Here???

- **Consider the benefits to you**
  - Owner, Engineer, Fabricator, GC, Erector
- **Prepare for the use of IFC files—it's coming!**
- **Participate in Industry Development**
  - AASHTO/NSBA Steel Bridge Collaboration

Remember, the Power is the INFO/DATA!!

(this drives any 3D representation)

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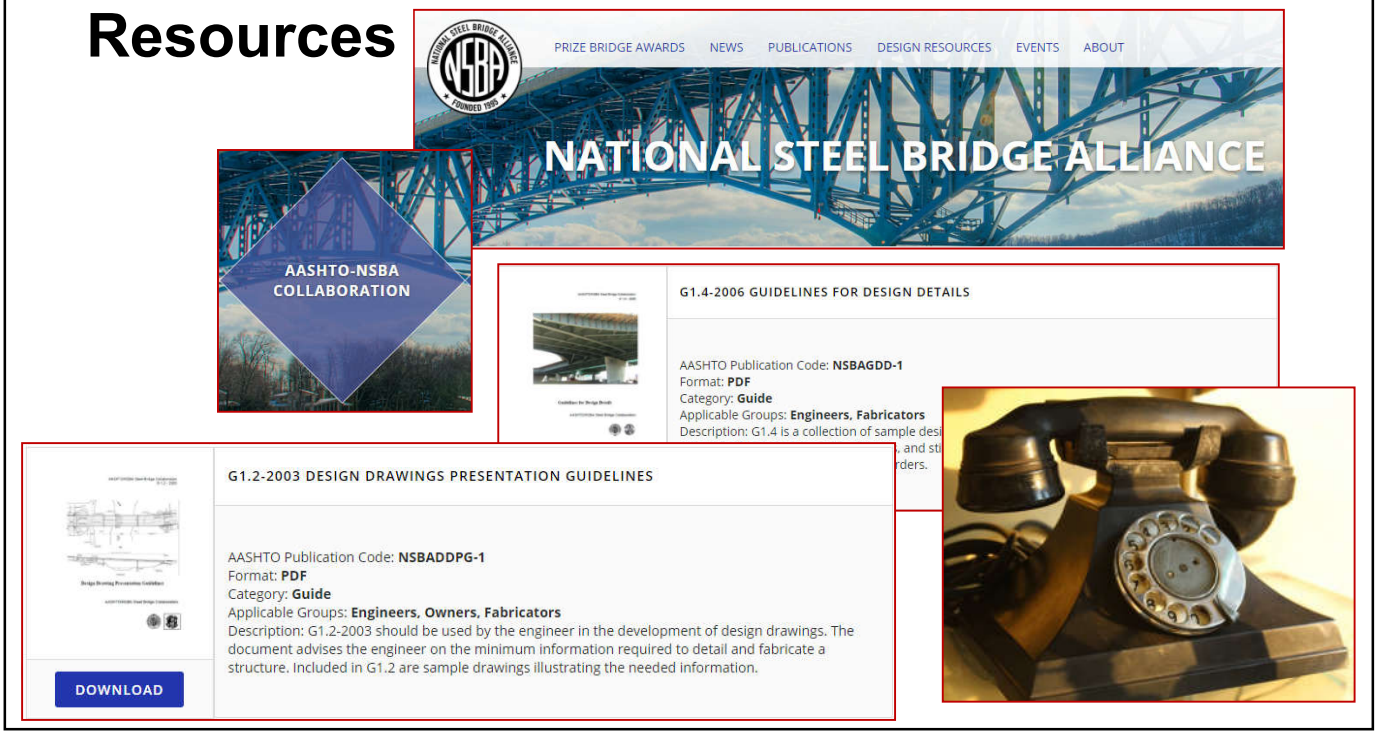
Resources



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The Hales Company

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An Affiliate of High Industries Inc.

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Questions?

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CEU / PDH Certificates

- You will receive an email on how to report attendance from: registration@aisc.org.
- Be on the lookout: Check your spam filter! Check your junk folder!
- Completely fill out online form. Don't forget to check the boxes next to each attendee's name!

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CEU / PDH Certificates

- Reporting site (URL will be provided in the forthcoming email).
- Username: Same as AISC website username.
- Password: Same as AISC website password.

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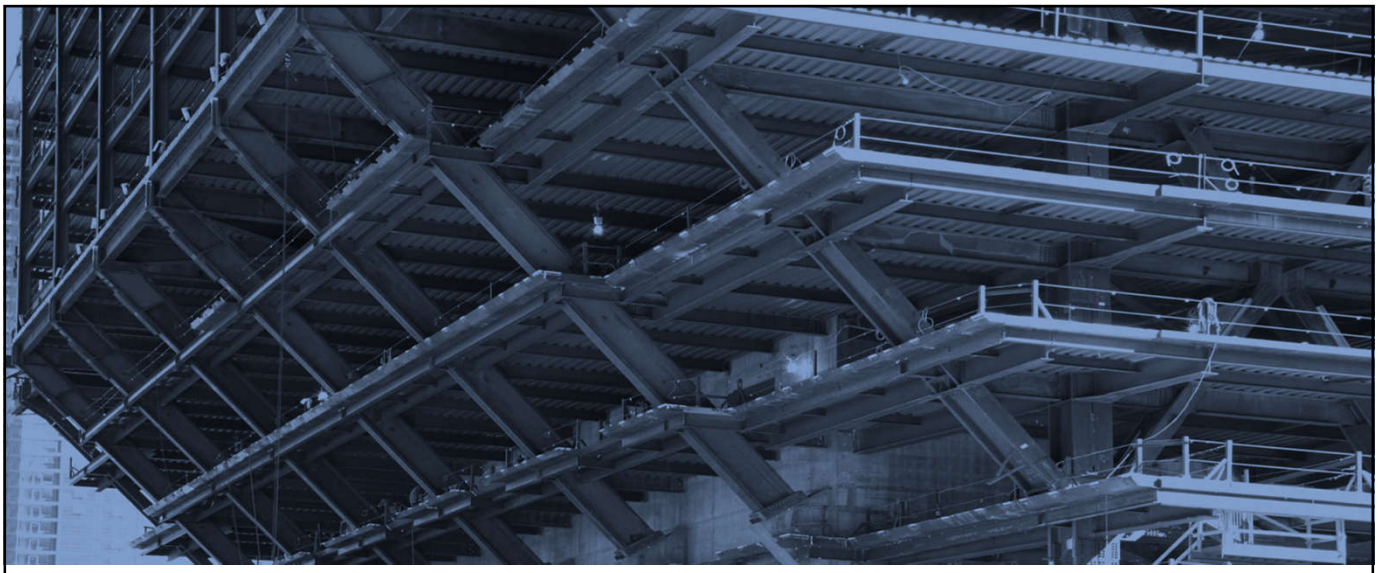

Thank you.

Smarter.
Stronger.
Steel.