
Photo: 2024 Prize Bridge Merit Award, Medium Span - Rt. 34B over Salmon Creek Bridge – Photo Credit: NYSDOT

Steel Bridge Best Practices for Designers

2026 Indiana DOT Bridge Design Conference - February 17, 2026

Brandon Chavel, PhD, PE

AISC/NSBA Vice President of Bridges

Smarter.
Stronger.
Steel.

Steel Bridge Best Practices for Designers

Presentation Outline

- **AASHTO LRFD Bridge Design Specifications**
  - Steel Design
- **NSBA Resources**
  - How these can be used to simplify design
- **Design and Detailing Best Practices**
  - Girders
  - Cross-frames

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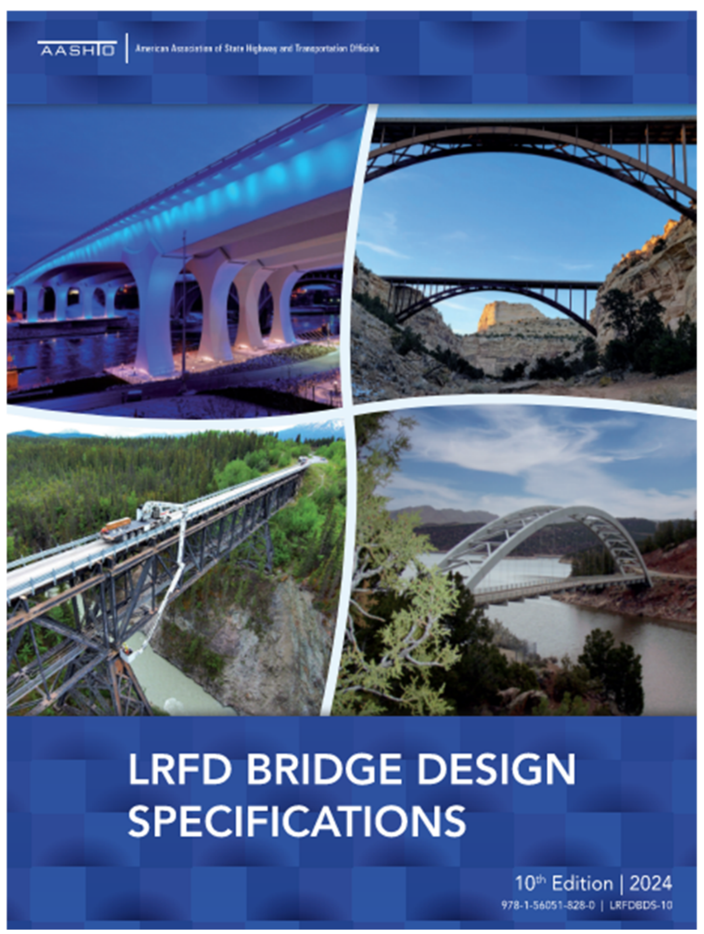
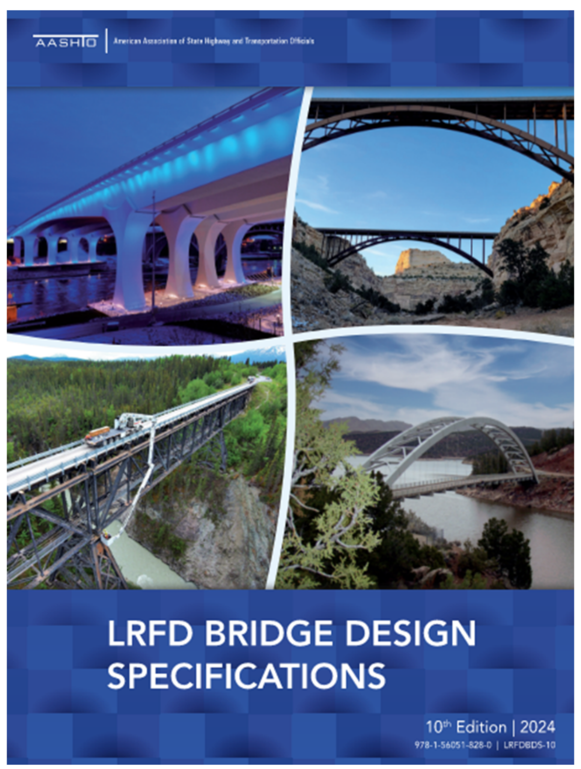
AASHTO LRFD Bridge Design Specifications

- For steel I-girder bridges, we have heard:
  - Too big.....
  - Too difficult to follow.....
  - Too difficult to design.....



AASHTO LRFD Bridge Design Specifications

- But, please keep in mind:



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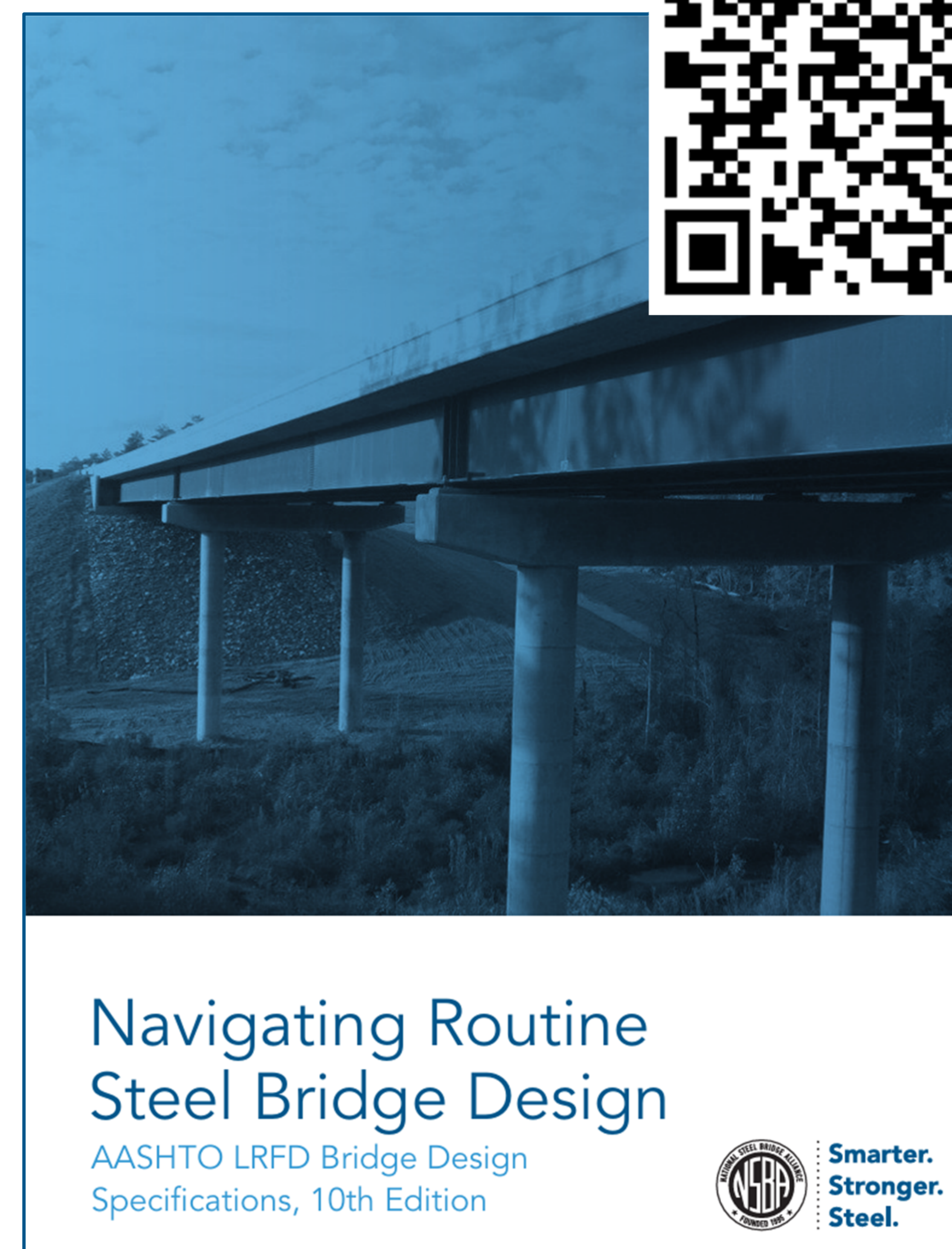
Question 1

- **Q: How can I simplify the AASHTO LRFD BDS 10th edition for Steel Girder Bridge Design?**

Navigating Routine Steel Bridge Design

Design Guide

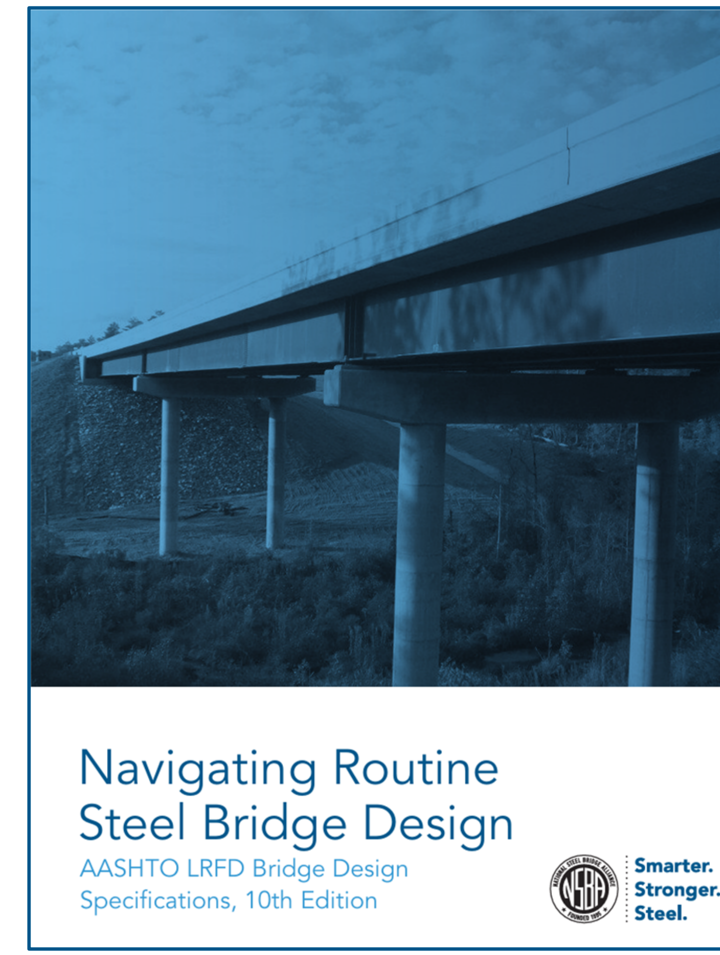
- **Purpose:**
  - Address complexity of AASHTO LRFD Bridge Design Specification.
  - Make routine steel I-girder bridge design an easier and simpler.
  - Consistent with the AASHTO LRFD Bridge Design Specifications, 10th Edition

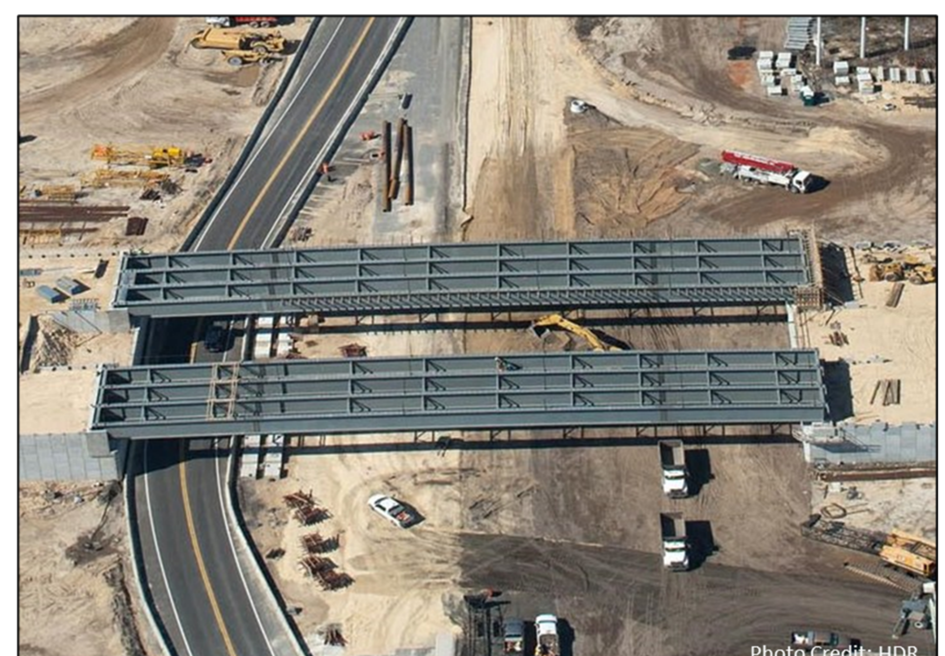


Navigating Routine Steel Bridge Design

Design Guide

- **Applies to:**
  - Straight girders, straight deck, little or no skew
  - Constant width, constant depth
  - Spans < 200’
  - Stringer-type cross-section with at least 4 girders
  - Contiguous truss-type cross-frames or solid diaphragms
  - Composite concrete deck
  - LINE GIRDER ANALYSIS





Navigating Routine Steel Bridge Design

• General Flow of Design Tasks

GENERAL FLOW OF DESIGN TASKS

Listed below are the general Design Tasks associated with the typical flow of design of a routine steel I-girder bridge superstructure. The list of Design Tasks is presented in roughly the typical order that they occur in the superstructure design process. However, as noted below, some topics apply to several Design Tasks. And, of course, the process of designing a bridge typically involves some degree of iteration; the initial results of later Design Tasks may suggest that revising part of the design which occurred earlier in the process might be beneficial. When iterating through a design in this manner, the designer is reminded that all steps of the design process should be checked to see if the revision of one part of the design might affect other parts. Each task/topic below is hyperlinked to its associated Design Task Quick Links page.

General Flow of Design Tasks:

1. General Considerations
2. Deck Design
3. Resistance Factors and Load Modifiers
4. Load Combinations and Load Factors
5. Live Load Force Effects - Introduction
6. Live Load Force Effects - Flexure
7. Live Load Force Effects - Shear
8. Other Load Effects and Factors Affecting Load Effect Calculations
9. Girder Flexure Design – General
10. Girder Flexure Design – Constructibility
11. Girder Flexure Design – Service Limit State
12. Girder Flexure Design – Fatigue and Fracture Limit State
13. Girder Flexure Design – Strength Limit State
14. Girder Shear Design
15. Stiffener Design
16. Shear Connector Design
17. Splice Design
18. Cross-Frame/Diaphragm Design

Topics Which May Apply to Several Design Tasks:

- Bolted Connection Design
- Welded Connection Design
- Connection Design – Miscellaneous Checks

Navigating Routine Steel Bridge Design

- Splice Design
- Design Task Quick Links pages

SPLICE DESIGN

Quick links to applicable AASHTO LRFD BDS provisions, with Discussion

Design field splices (if present), considering the following:

- Bolted field splices of flexural members
  - General considerations (6.13.6.1.3a)
  - Flange splices (6.13.6.1.3b)
  - Web splices (6.13.6.1.3c)
- Welded splices (6.13.6.2)
- Minimum thickness requirements (6.7.3)

Determine flange sizes and locations of welded shop splices, considering the following:

- Welded splices (6.13.6.2)
- Minimum thickness requirements (6.7.3)

Quick links to helpful industry design guidelines, references, and examples

For more explanation and examples of field splice design, see:

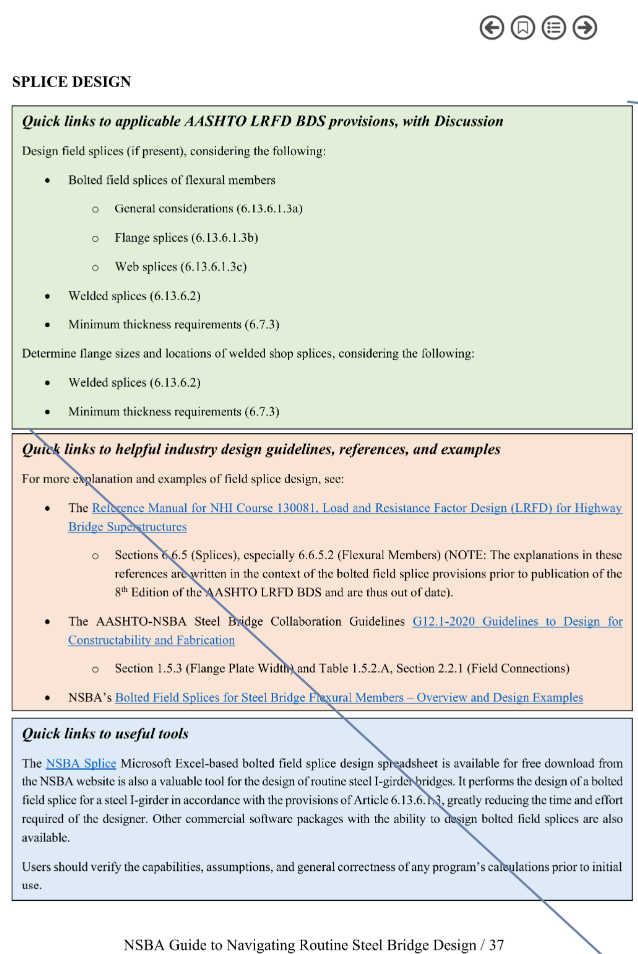
- The Reference Manual for NHI Course 130081, Load and Resistance Factor Design (LRFD) for Highway Bridge Superstructures
  - Sections 6.6.5 (Splices), especially 6.6.5.2 (Flexural Members) (NOTE: The explanations in these references are written in the context of the bolted field splice provisions prior to publication of the 8th Edition of the AASHTO LRFD BDS and are thus out of date).
- The AASHTO-NSBA Steel Bridge Collaboration Guidelines G12.1-2020 Guidelines to Design for Constructability and Fabrication
  - Section 1.5.3 (Flange Plate Width) and Table 1.5.2.A, Section 2.2.1 (Field Connections)
- NSBA's Bolted Field Splices for Steel Bridge Flexural Members – Overview and Design Examples

Quick links to useful tools

The NSBA Splice Microsoft Excel-based bolted field splice design spreadsheet is available for free download from the NSBA website is also a valuable tool for the design of routine steel I-girder bridges. It performs the design of a bolted field splice for a steel I-girder in accordance with the provisions of Article 6.13.6.1.3, greatly reducing the time and effort required of the designer. Other commercial software packages with the ability to design bolted field splices are also available.

Users should verify the capabilities, assumptions, and general correctness of any program's calculations prior to initial use.

Navigating Routine Steel Bridge Design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NSBA Guide to Navigating Routine Steel Bridge Design / 37

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6.13.6.1.3 Flexural Members

6.13.6.1.3a General

Determination of applicability, *All Routine Steel I-girder Bridges*: Applicable.

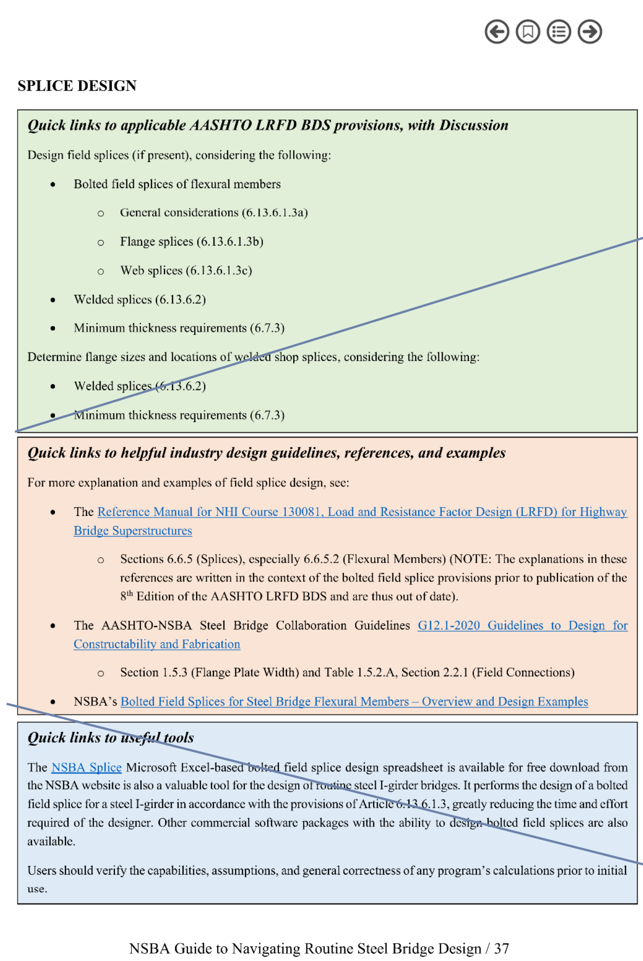
Discussion:

A splice is defined as a group of bolted connections (or a welded connection) sufficient to transfer the moment, shear, axial force or torque between two structural elements joined at their ends to form a single, longer element. Bolted splices are typically used to connect member sections together in the field; hence, the term "field splice" is often used. The provisions of this Article cover general provisions for the design of bolted field splices for members subject to flexure, and hence, are applicable to the routine steel I-girder bridges covered by this Guide.

Bolted beam or girder field splices generally include top flange splice plates, web splice plates and bottom flange splice plates. In addition, if the plate thicknesses on one side of the joint are different than those on the other side, filler plates are used to match the thicknesses within the splice (see the Discussion of Article 6.13.6.1.4 in this Guide). For the flange splice plates, there is typically one plate on the outside of the flange and two smaller plates on the inside of the flange; one on each side of the web. For the web splice plates, there are two plates; one on each side of the web, with at least two rows of high-strength bolts over the depth of the web used to connect the splice plates to the member.

As required by Articles 6.13.6.1.3b and 6.13.6.1.3c, bolted flange and web splice connections are

Navigating Routine Steel Bridge Design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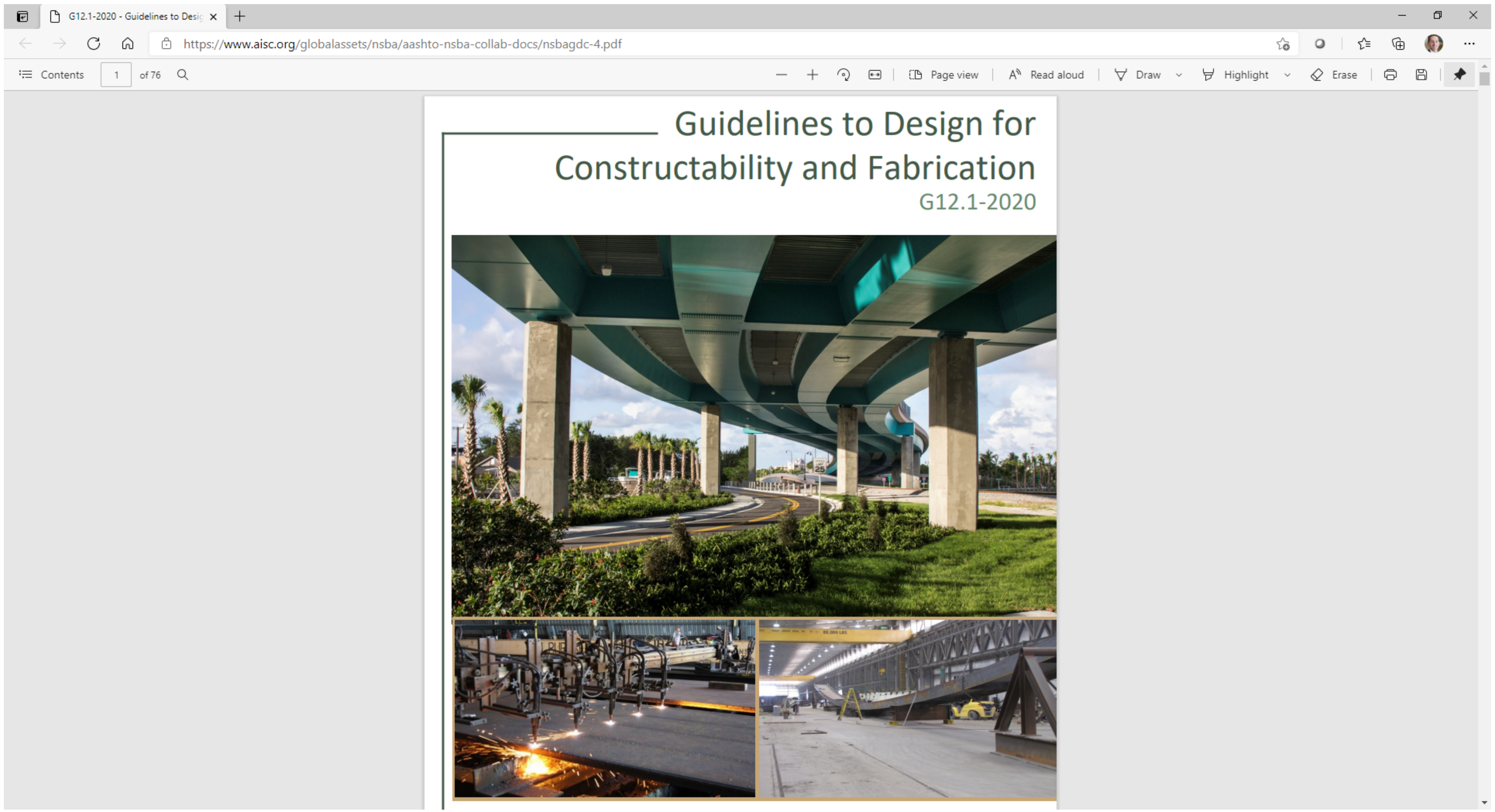

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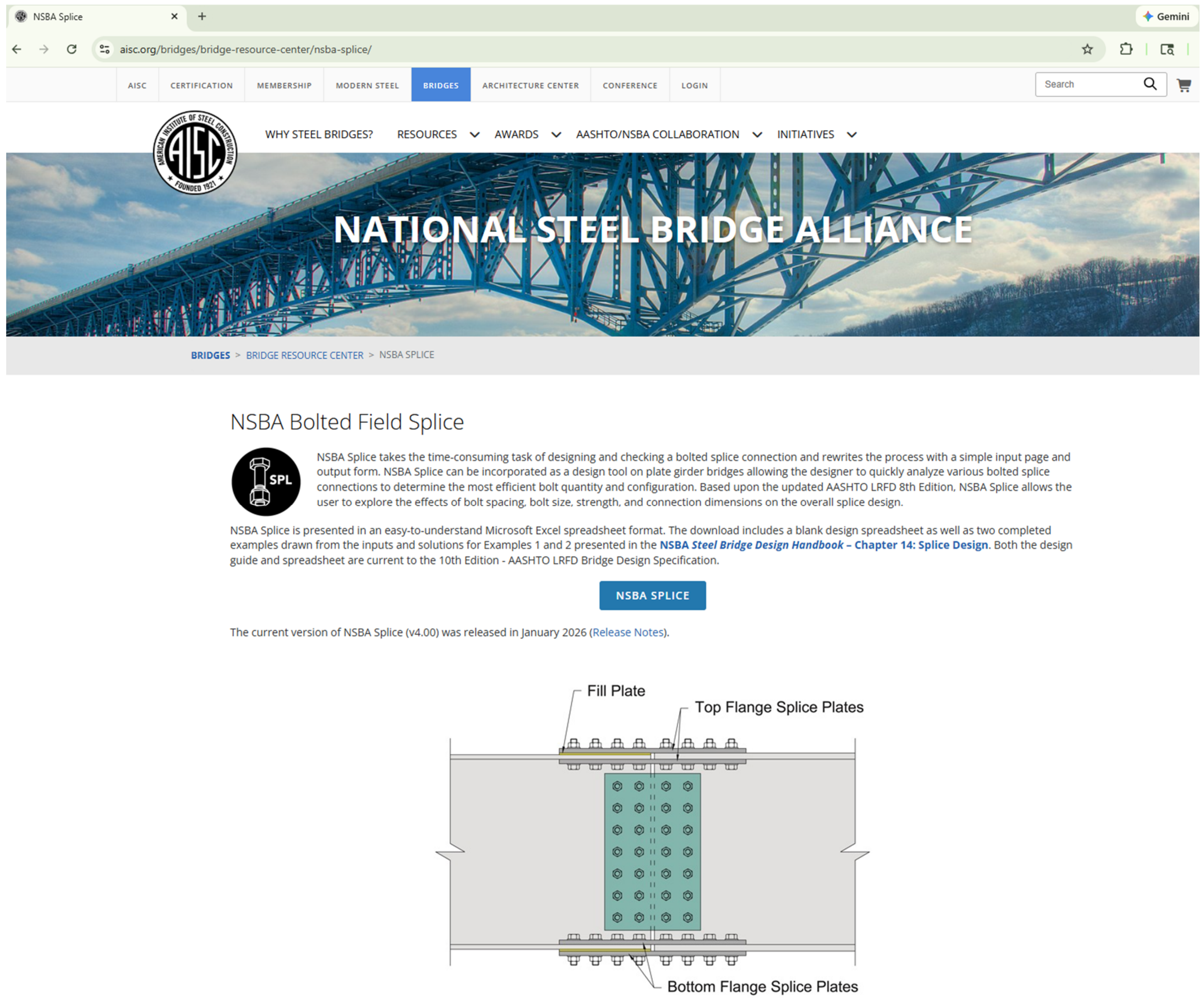


Question 2

- Q: Are there any steel girder standards that I can follow? Maybe to at least start my design? Or, to quickly assess alternatives?

Standard Plans for Steel Bridges

Streamlined and Standardized Design

- **Purpose:**
  - Provide optimized designs for 1, 2, 3, and 4 span plate girder bridges.
  - Ensure cost-efficient and reflect standard plate sizes available from domestic mills.
  - Nearly 300 bridge designs
    - Spans range from 80ft to 300ft
    - Girder spacings = 8ft, 10ft, 12ft, 14ft

- **Industry Feedback**:
  - Use has increased significantly
  - Final design starting point (straight & curved)
  - Design build initial estimating

aisc.org/standard-bridge-plans

Standard Designs for Straight I-Girder Bridges

What is in there???

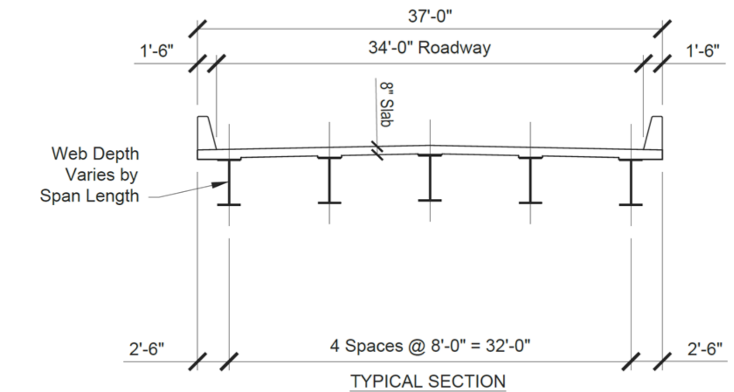
- **Single Span Bridges:**
  - 80 ft to 300 ft spans
  - Link Slab Details
- **2-Span Continuous Bridges:**
  - Equal Spans
  - 100 ft to 250 ft spans
- **3-Span Continuous Bridges:**
  - End span = 78% of center span
  - Center spans = 150 ft to 300 ft
- **4-Span Continuous Bridges:**
  - End span = 78% of center span
  - Two center spans = 150 ft to 300 ft

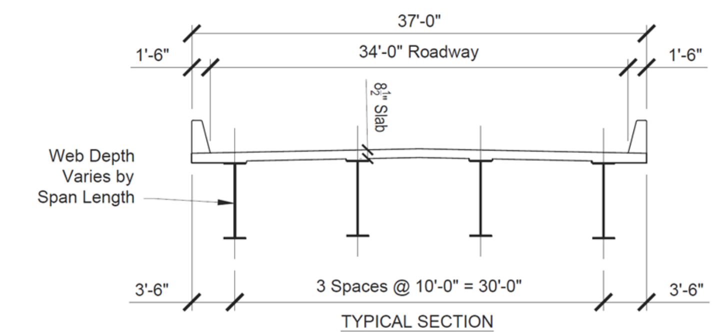
3-span

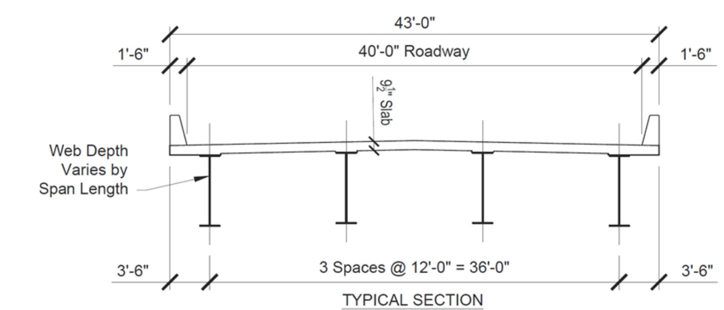
Span, ft. End-Int.-End
117-150-117
129-165-129
141-180-141
153-195-153
164-210-164
176-225-176
188-240-188
199-255-199
211-270-211
223-285-223
234-300-234

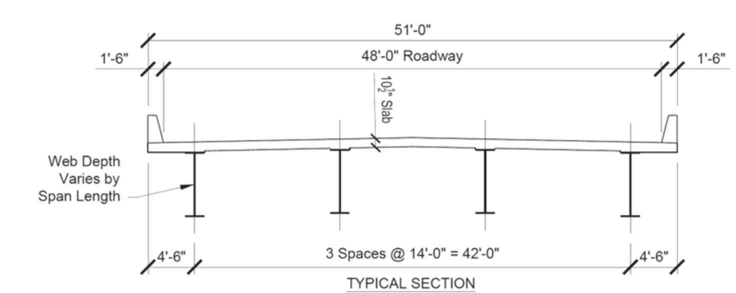
4-span

Span, ft. End-Interior
117-150
129-165
141-180
153-195
164-210
176-225
188-240
199-255
211-270
223-285
234-300



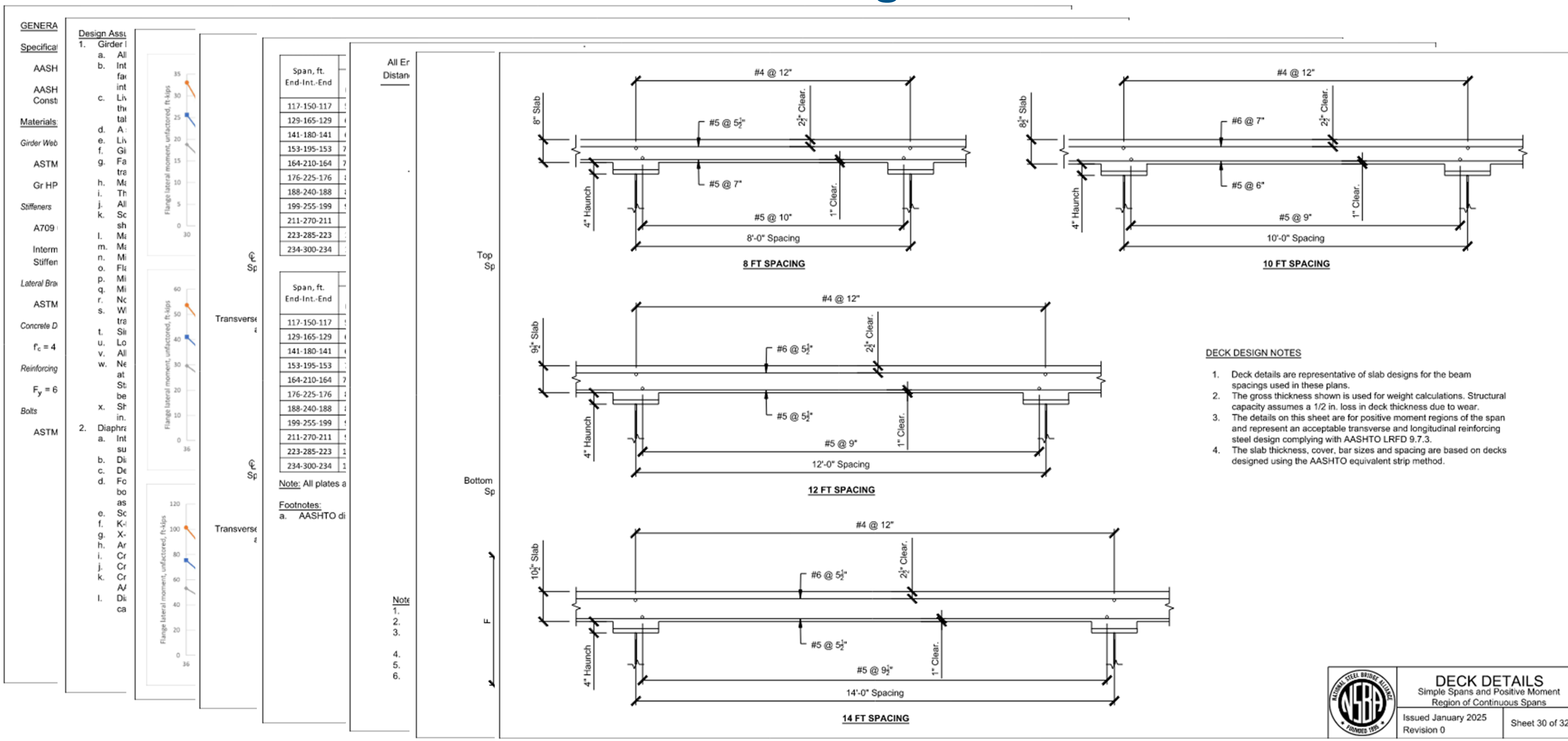






Standard Plans for Steel Bridges

Streamlined and Standardized Design



Standard Plans for Steel Bridges

Example – starting a new design

- **Designer:** Josh Allen
- **Bridge Layout**
  - 3-spans => 200’-250’-200’
  - 6 girders
  - Girder Spacing: 11 ft
  - Deck Overhang: 3.5 ft

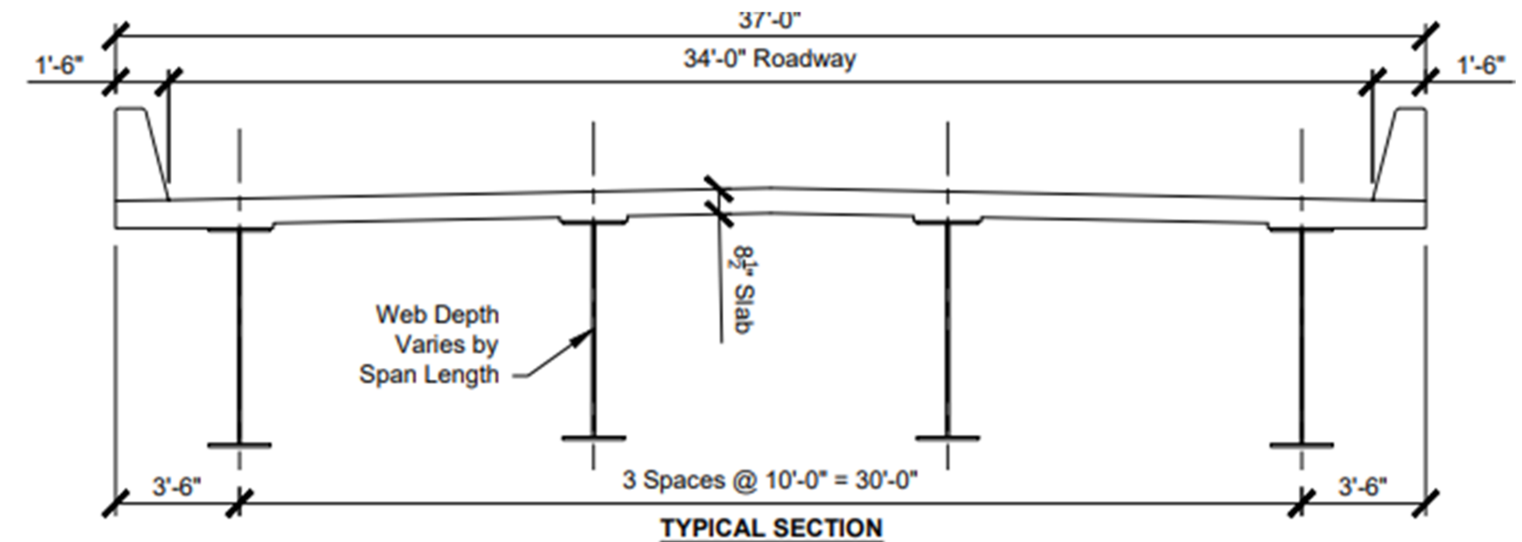
Where does Josh start?

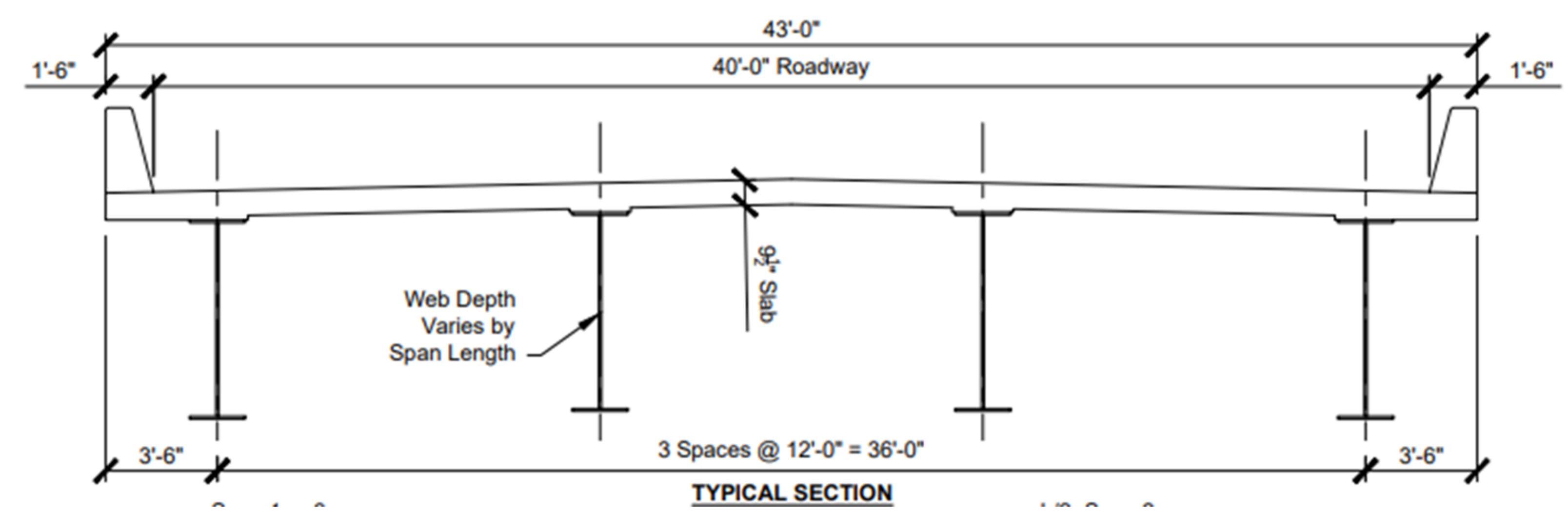
Standard Plans for Steel Bridges

Selecting a girder spacing to use

- **Bridge Layout**
  - 3-spans => 200’-250’-200’
  - 6 girders
  - Girder Spacing: 11 ft
- **Standard Plans**
  - Girder Spacings for 10ft and 12ft

Let’s Look at the 12ft Girder Spacing





Standard Plans for Steel Bridges

Selecting a span arrangement

- **Bridge Layout**
  - 3-spans => 200’-250’-200’
  - 6 girders
  - Girder Spacing: 11 ft

- **Standard Plans**
  - 188’-240’-188’
  - 199’-255’-199’

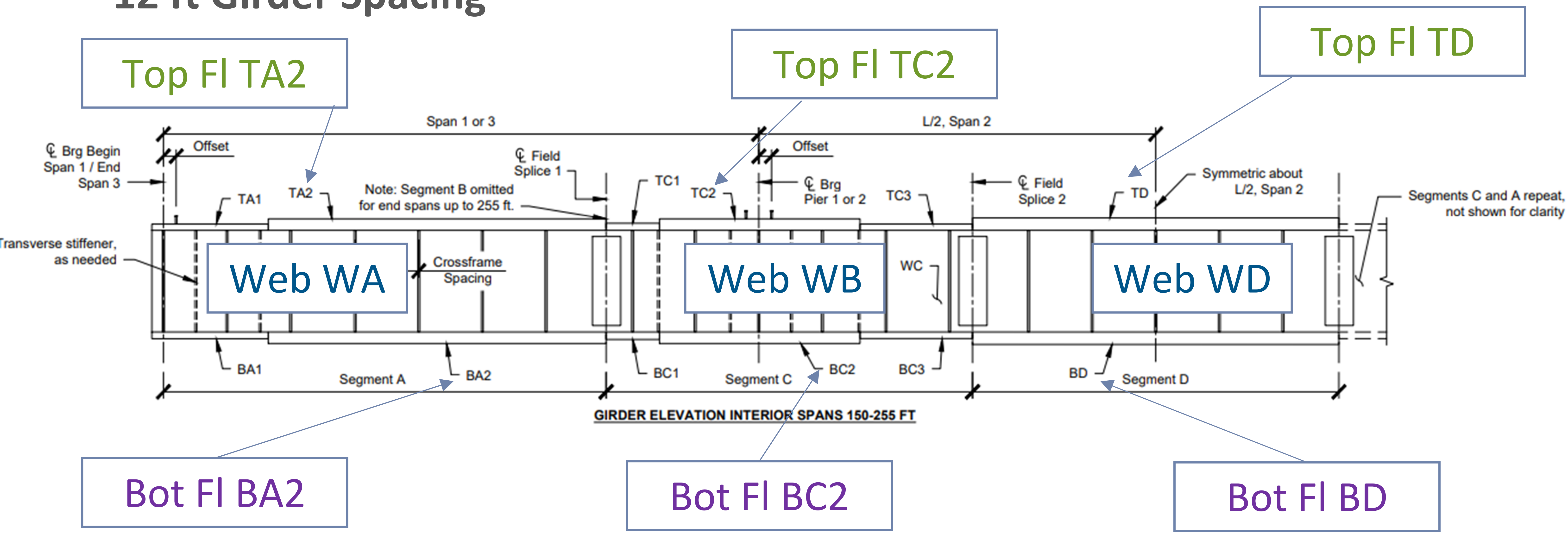
Let’s Look at the 199’ - 255’ - 199’

Span, ft. End-Int.-End
117-150-117
129-165-129
141-180-141
153-195-153
164-210-164
176-225-176
188-240-188
199-255-199
211-270-211
223-285-223
234-300-234

Standard Plans for Steel Bridges

Girder Elevation

- 12 ft Girder Spacing



Standard Plans for Steel Bridges

Typical presentation of flange and web sizes

- 12 ft Girder Spacing | 200'-255'-200'

Span, ft. End-Int.-End	SEGMENT A				
	WA (in. x in. x ft.)	TA1 (in. x in. x ft.)	TA2 (in. x in. x ft.)	BA1 (in. x in. x ft.)	BA2 (in. x in. x ft.)
117-150-117	54 x 0.625 x 79	---	16 x 1 x 79	---	22 x 1.5 x 79
129-165-129	62 x 0.625 x 89	---	16 x 1 x 89	---	22 x 1.5 x 89
141-180-141	66 x 0.625 x 98	---	18 x 1 x 98	22 x 1.25 x 49	22 x 1.5 x 49
153-195-153	74 x 0.625 x 106	---	18 x 1 x 106	24 x 1 x 65	24 x 1.25 x 41
164-210-164	78 x 0.625 x 113	---	18 x 1 x 113	24 x 1 x 57	24 x 1.25 x 56
176-225-176	82 x 0.75 x 122	18 x 1 x 61	18 x 1.25 x 61	22 x 1 x 61	22 x 1.5 x 61
188-240-188	88 x 0.75 x 130	---	20 x 1 x 130	24 x 1 x 70	24 x 1.25 x 60
199-255-199	94 x 0.75 x 138	---	20 x 1 x 138	24 x 1 x 84	24 x 1.25 x 54
211-270-211	98 x 0.75 x 51	20 x 1 x 51	---	24 x 1 x 51	---
223-285-223	102 x 0.75 x 51	22 x 1 x 51	---	24 x 1 x 51	---
234-300-234	108 x 0.75 x 54	24 x 1 x 54	---	24 x 1.25 x 54	---

Plate sizes in Segment A
(End span)

Web = 0.75" x 94" x 138'
Top Fl (TA2) = 1" x 20" x 138'

Bot Fl (BA1) = 1" x 24" x 84'
Bot Fl (BA2) = 1.25" x 24" x 54'

Standard Plans for Steel Bridges

Modify Standard Plans for actual and check loads

- **Recall our Bridge Layout**
  - 3-spans => 200’-250’-200’
  - 6 girders
  - Girder Spacing: 11 ft
  - Deck Overhang: 3.5 ft

- **From the Standard Plans**
  - 3-spans => 199’-255’-199’
  - Girder Spacing: 12 ft
  - Deck Overhang: 3.5 ft

Therefore, for my analysis:

- *Cut out the 5’ from the center span positive moment segment*
- *Add 1’ to the end span segment at the abutment side*
- *Remember my girder sizes are for 12 ft girder spacing…. Actual is 11 ft*
- *Analyze the design in my favorite program….*
- *Do not make large changes…. if satisfies design checks, STOP!!*

Standard Plans for Steel Bridges

Compare solutions and analyze for actual loads

- **From Standards – Girder Weights**
  - 10ft Girder Spacing = 147 tons (D_{web} = 92”)
  - 12ft Girder Spacing = 154 tons (D_{web} = 94”)

- **Analysis and Design**
  - Run my analysis and design checks:
  - Everything passes!
  - What next?
    - LEAVE IT ALONE!!! STOP!!
  - Making adjustments, we may save about 1%-2% of the steel……

Josh is happy with his design!

Standard Plans for Steel Bridges

Streamlined and Standardized Design

- Examples demonstrating use when spans and/or spacing do not exactly match:
    1. Three-Span Bridge Matching a Standard Design
    2. Three-Span Bridge with a Thicker Slab
    3. Three-Span Bridge with a Non-Standard Beam Spacing and Matching Span Lengths
    4. Three-Span Bridge with Matching Beam Spacing but Non-Standard Span Lengths
    5. Three-Span Bridge with Unique Beam Spacing, Overhangs, and Span Lengths
    6. Three-Span Bridge with Unique Beam Spacing, Overhangs, and Span Lengths with a Skew Index > 0.3
    7. Preliminary Curved Girder Bridge

aisc.org/standard-bridge-plans

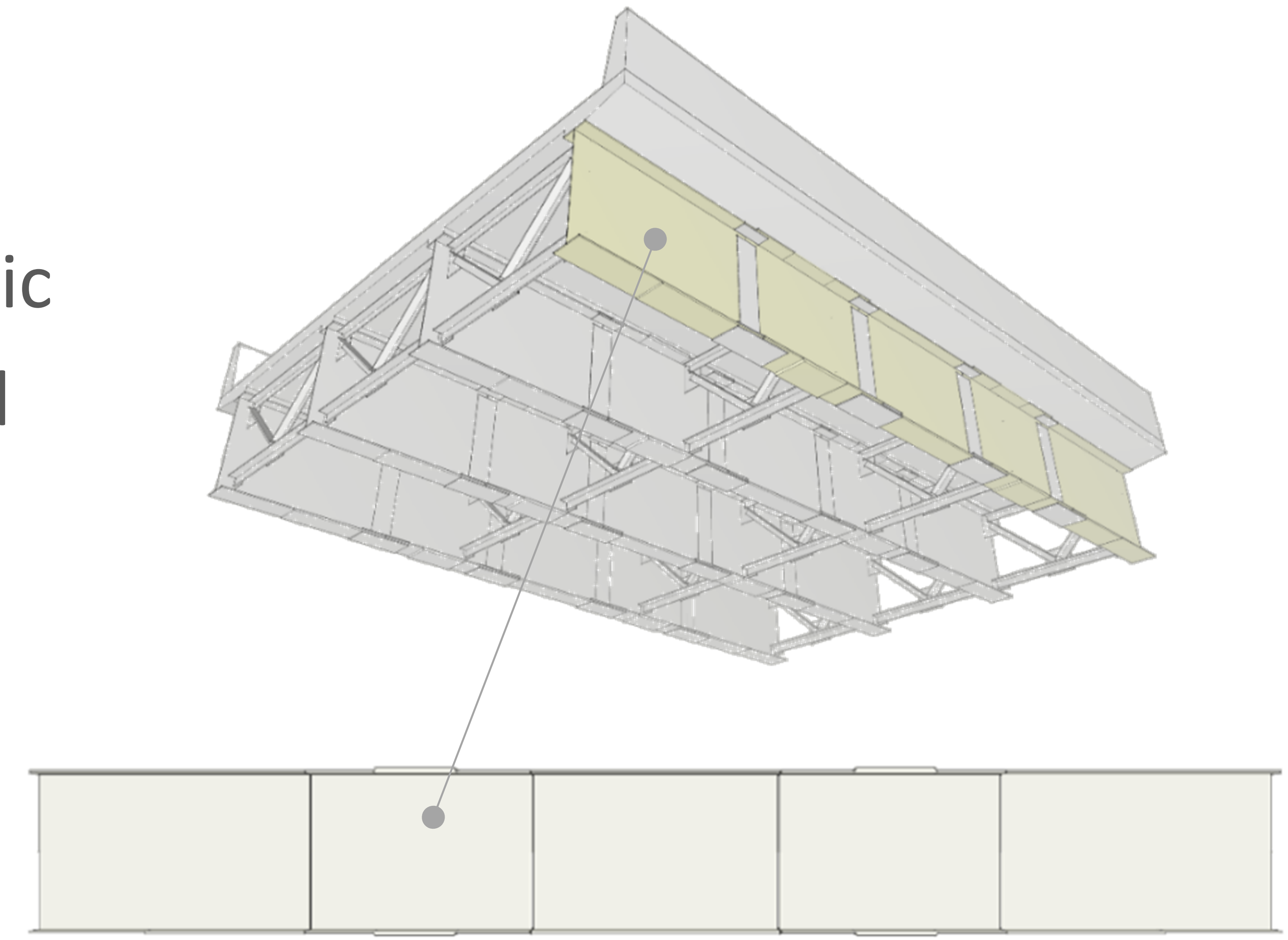
Question 3

- Q: Is there a simple analysis program I can use to quickly check different alternatives?

LRFD Simon

What LRFD Simon Is…

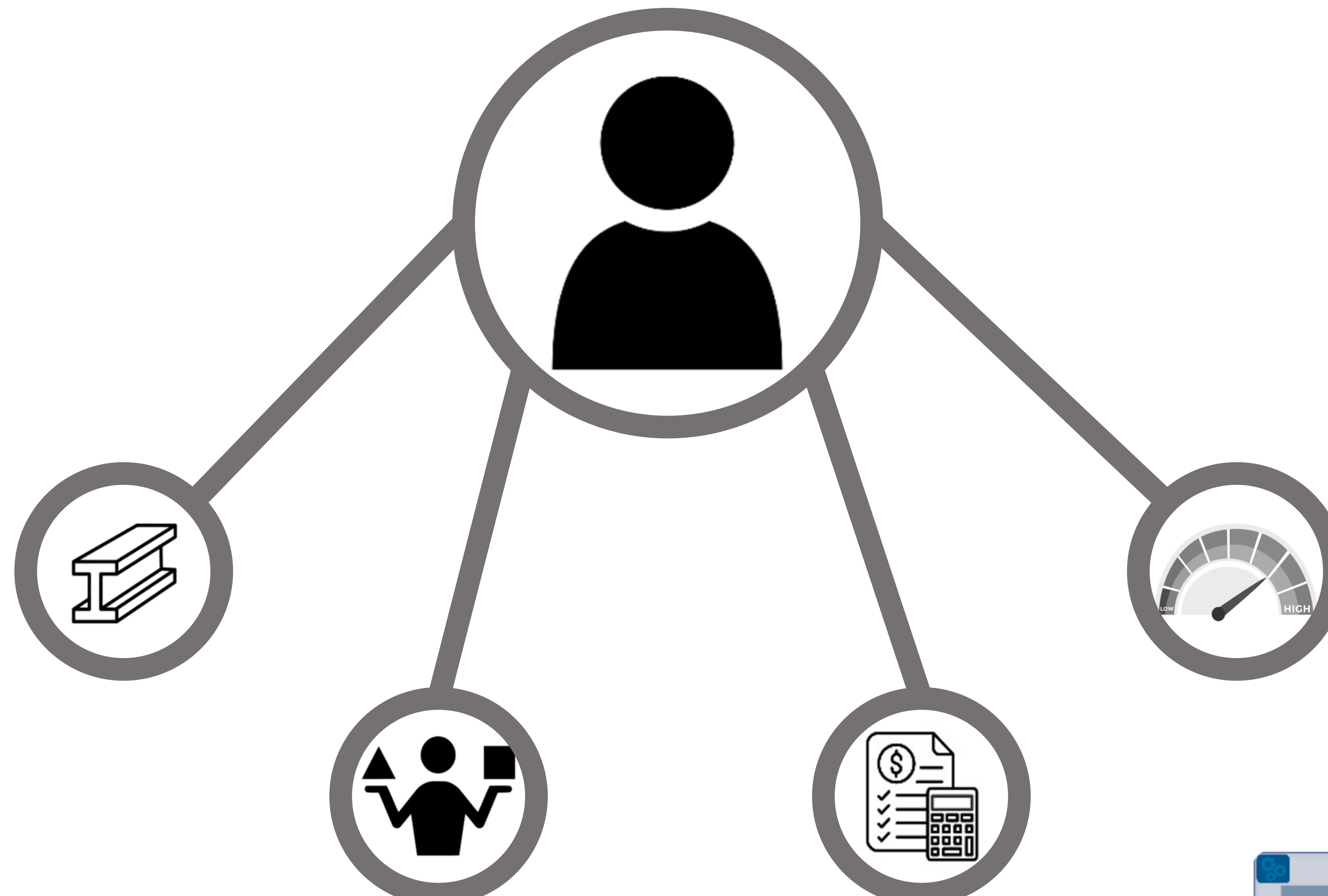
- Line-girder analysis and design tool
- Specification-driven and deterministic
- Transparent and engineer-controlled
- Fast and iteration-friendly
- AASHTO LRFD BDS 10th Editions
- FREE!!!!



LRFD Simon Fundamentals

Typical Use Cases

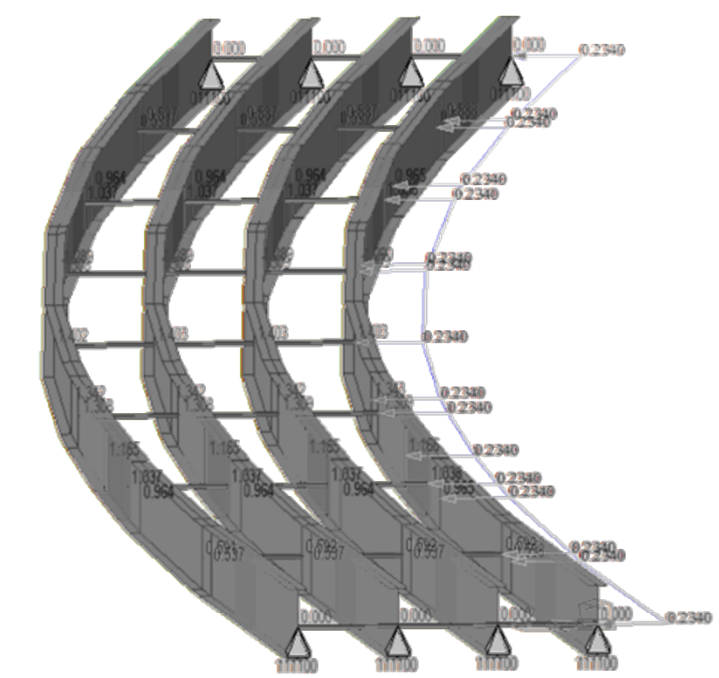
- Early girder sizing
- Comparing alternatives
- Cost and weight estimation
- Sensitivity checks

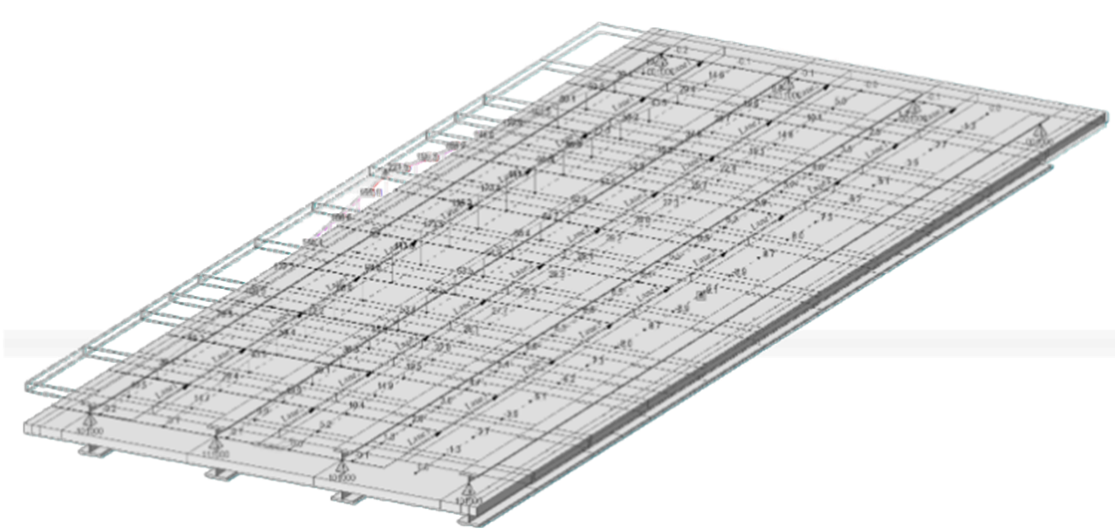


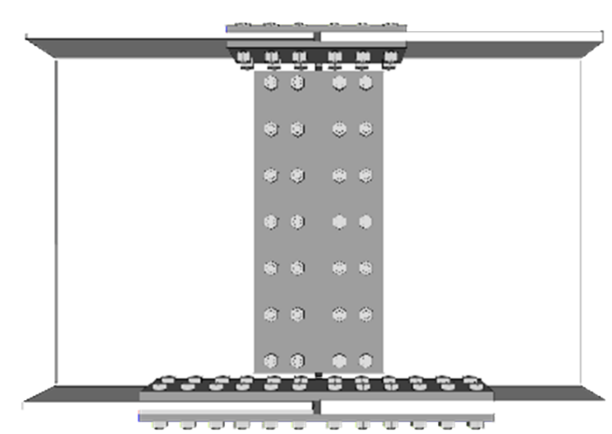
LRFD Simon

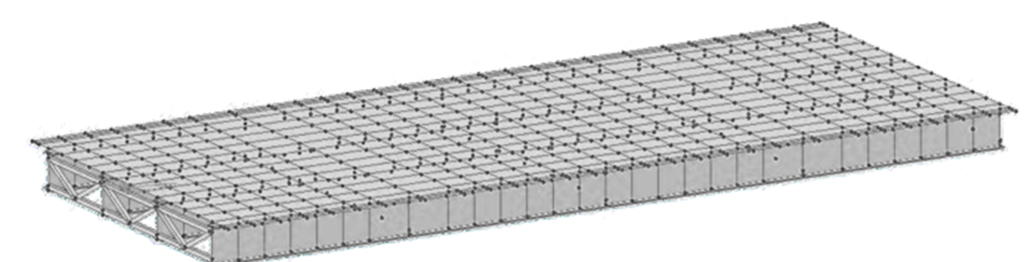
What LRFD Simon Is Not…

- Not a 3D bridge model
- Not for curved bridges
- Not for large skews
- Not for detailing or connections









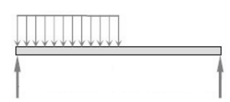
LRFD Simon

What LRFD Simon Is Not…

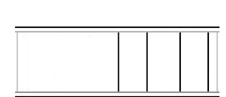
LRFD Simon Fundamentals

Inputs You Can Explore

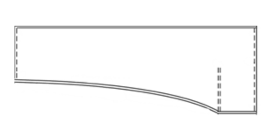

Simple span or up to 12 continuous spans

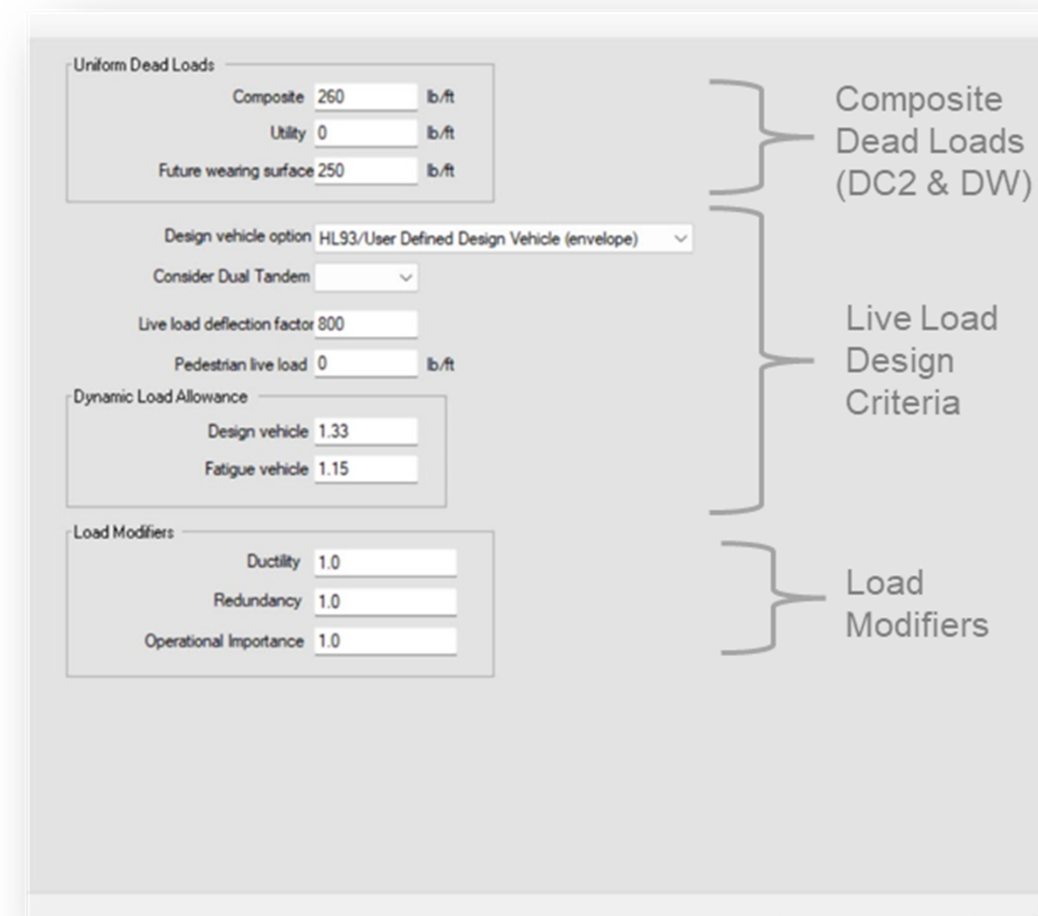

Partial or full-length dead loads


AASHTO or user-defined live loads


Stiffened or unstiffened webs


Homogenous or hybrid cross-sections


Parabolic or linear web haunches



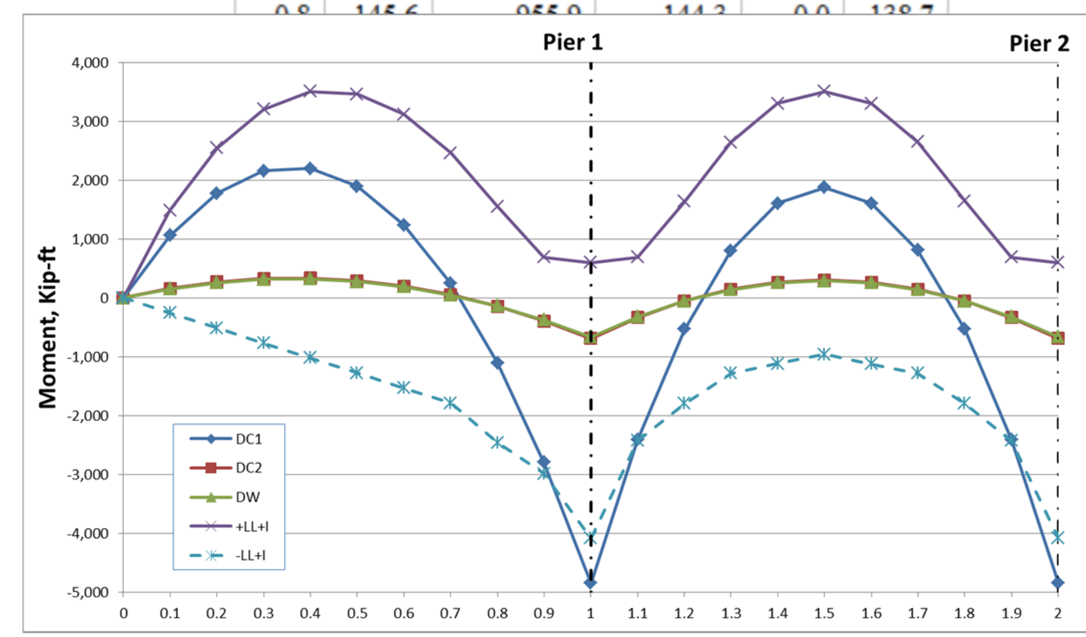
LRFD Simon Fundamentals

Outputs You Can Expect

- Moments/shears at tenth points
- Live load envelopes
- Deflections
- Performance ratios for all limit states
- Stiffener & shear connector design
- Bill of materials with estimated costs
- Automatically generated "best design" input file

Span: 1

Point	Girder	Other DC1	Comp DL	Utility	FWS
0.0	0.0	0.0	0.0	0.0	0.0
0.1	146.0	915.0	160.3	0.0	154.2
0.2	247.8	1534.4	269.7	0.0	259.3
0.3	305.4	1858.3	328.1	0.0	315.5
0.4	315.8	1886.6	335.5	0.0	322.6
0.5	276.0	1619.3	292.0	0.0	280.8
0.6	186.1	1056.5	197.5	0.0	189.9
0.7	45.9	198.1	52.1	0.0	50.1
0.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



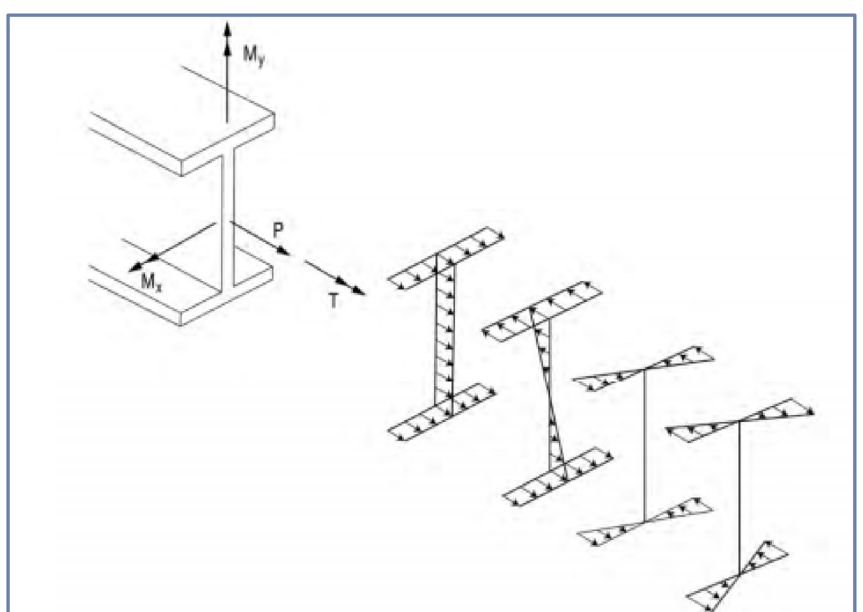
Question 4

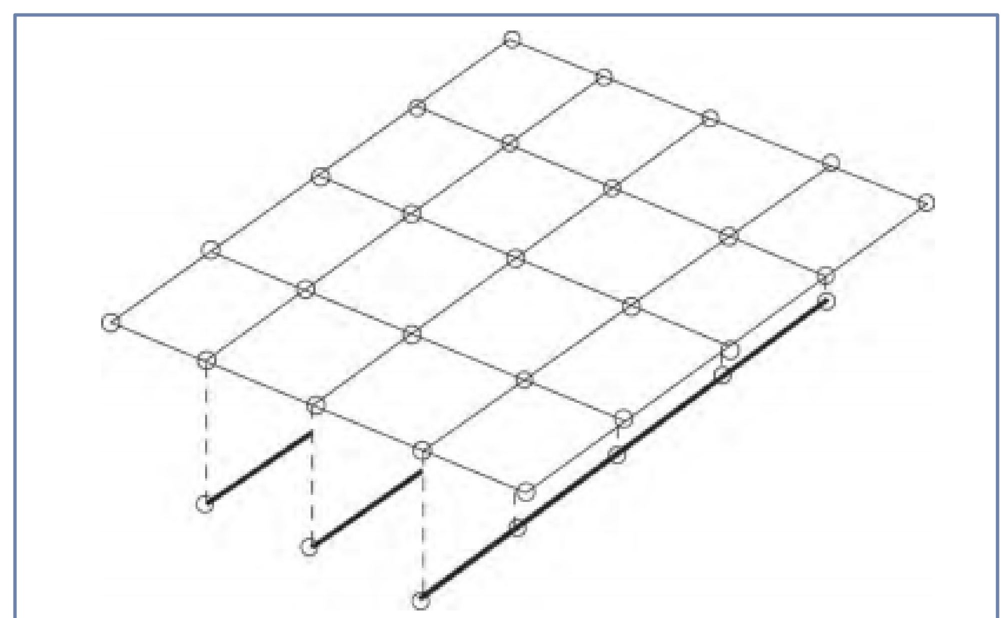
- Q’s: But how do I know what level of analysis is appropriate for my bridge? Can I use Line Girder for a skewed bridge?

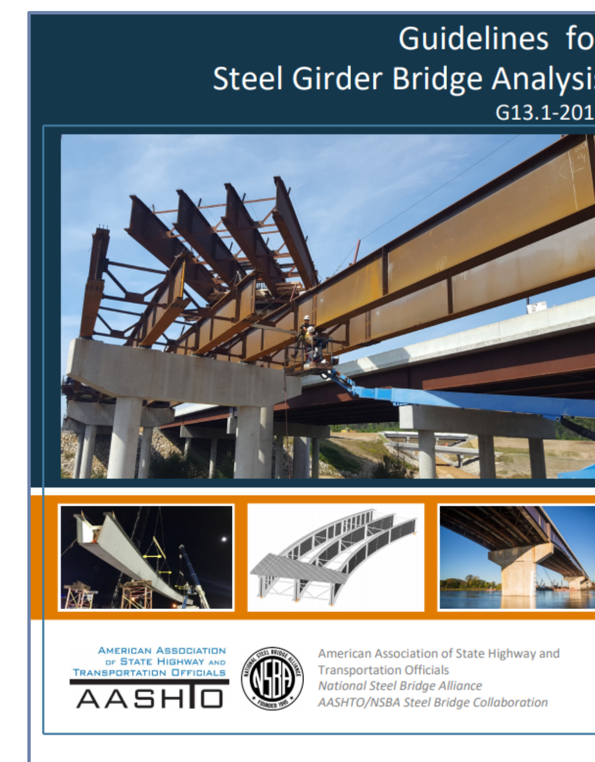
Guidelines for Steel Girder Bridge Analysis

AASHTO/NSBA Steel Bridge Collaboration

- G13.1-2019
  - Provides the most comprehensive presentation and discussion regarding analysis techniques associated with steel girder bridges.
  - Discussions for line girder (1D), 2D, and 3D analysis methods
  - Guidance to determine the appropriate level of analysis based on a bridge’s geometric aspects.

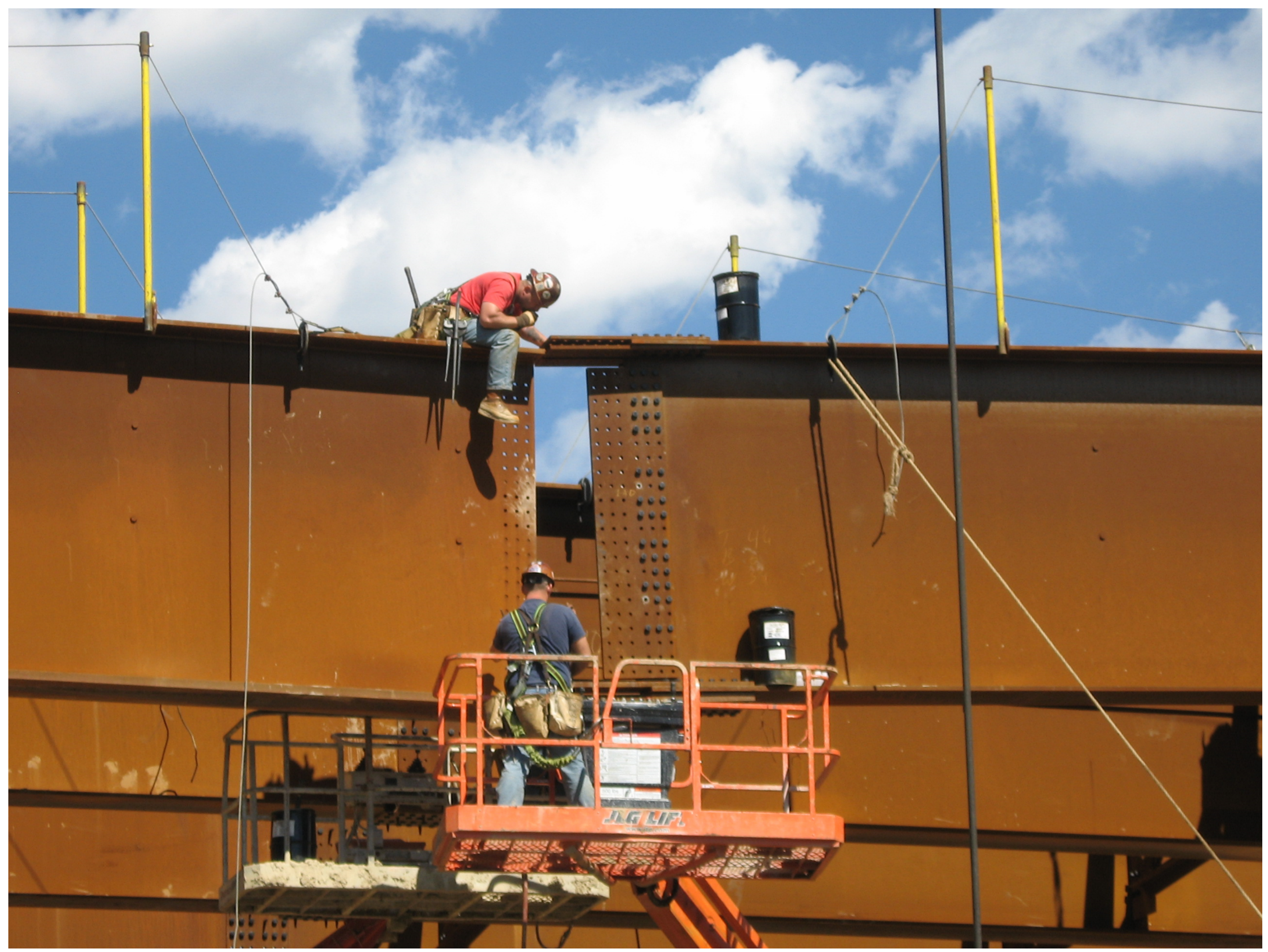






Question 5

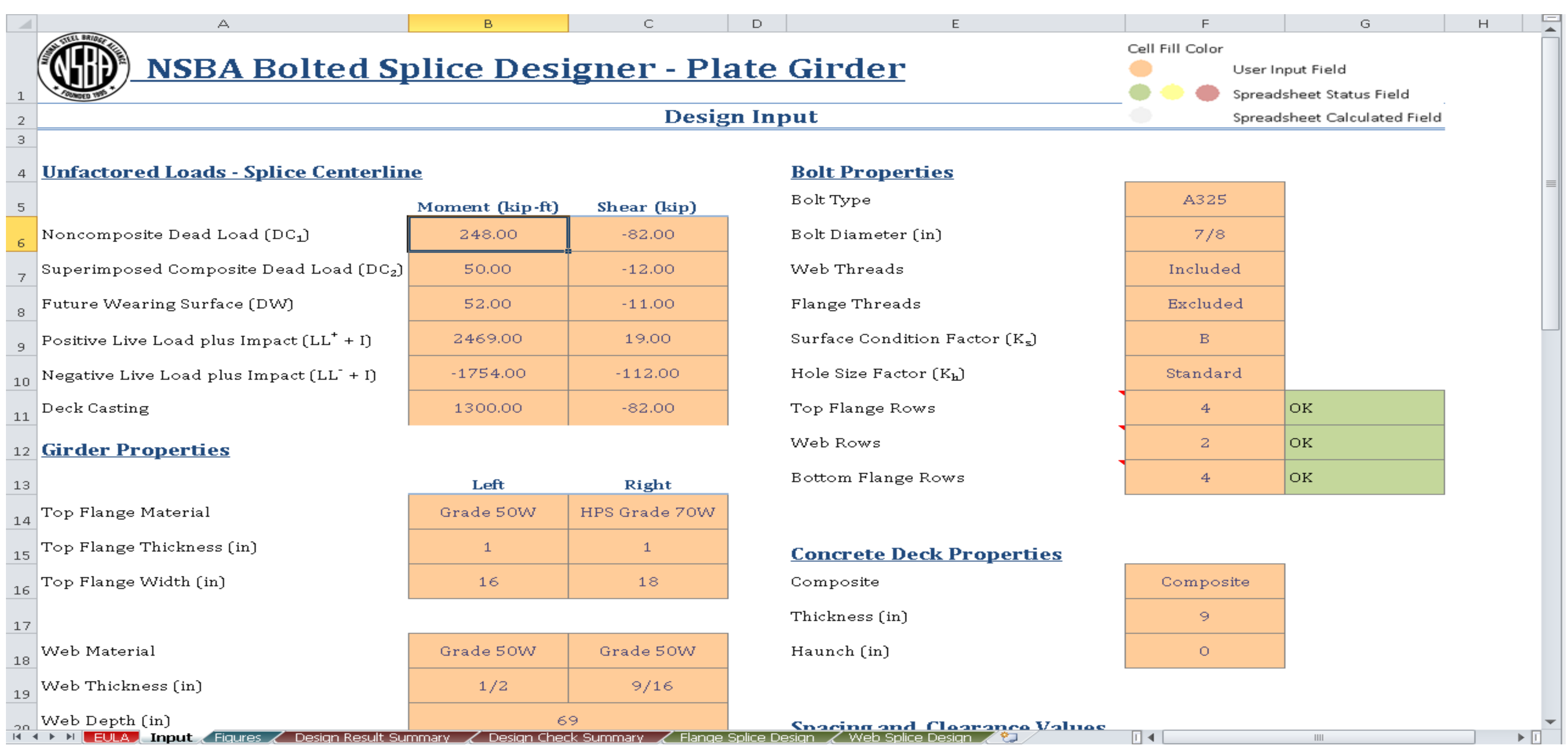
- Q: What about the design of the girder field splices and all those bolts???

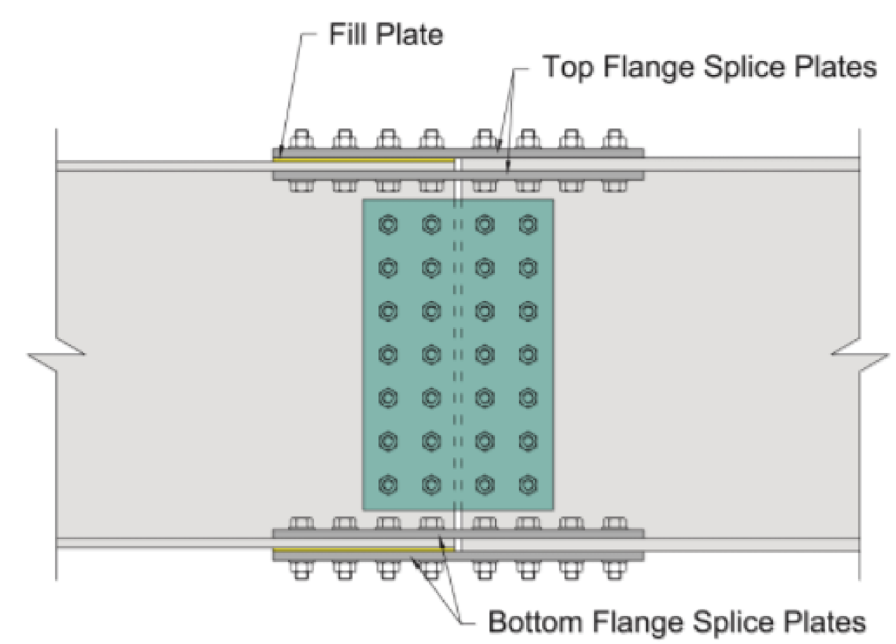


Girder Field Splice Design

Simplified Design

- NSBA Splice Spreadsheet
  - Allows the designer to quickly analyze various bolted splice connections to determine the most efficient bolt quantity and configuration.
  - Consistent with AASHTO LRFD BDS 10th Edition





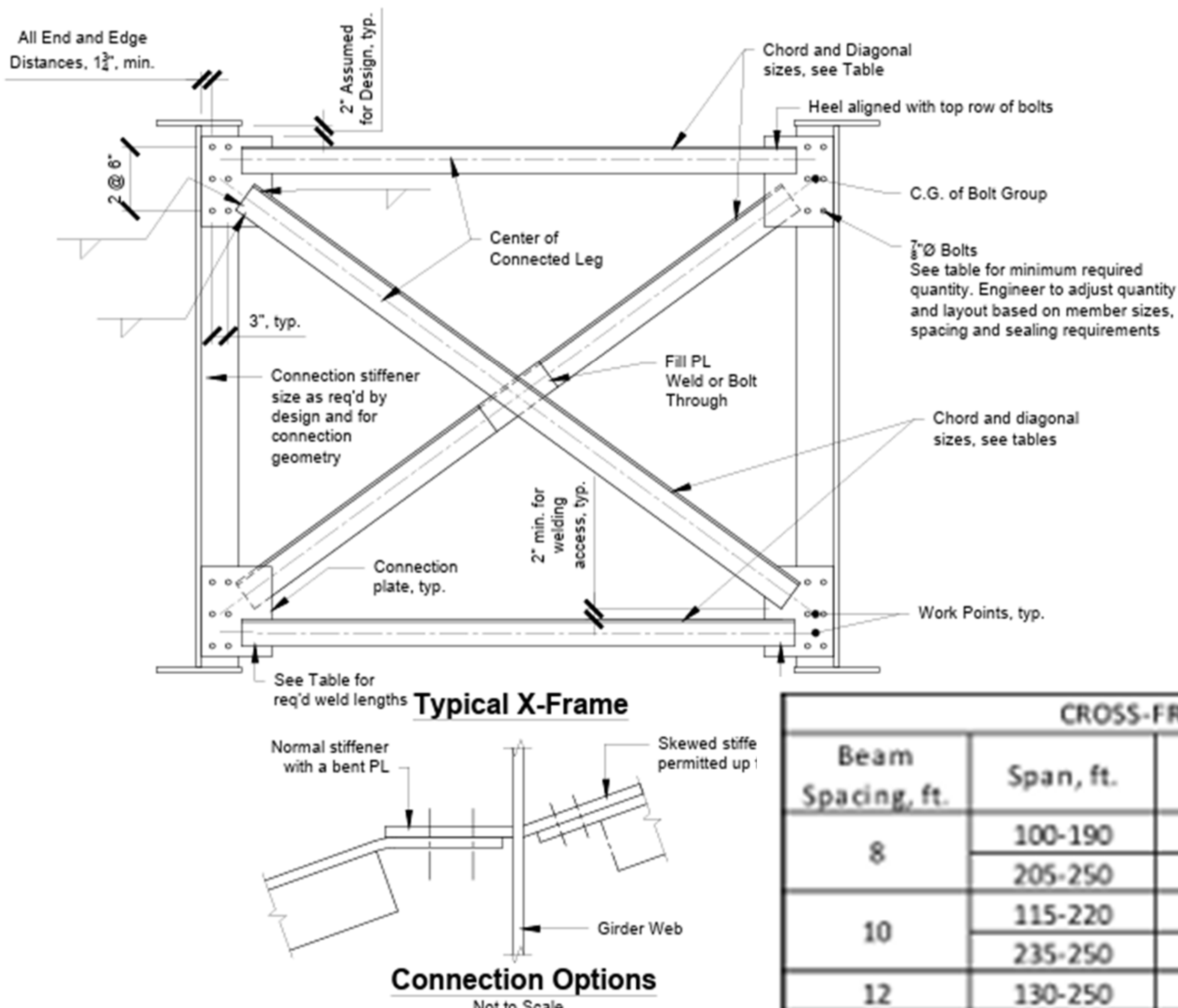
Question 6

- Q: Cross-frames look to be super-difficult…. Is there anything that can help me design or check them too?

Cross-frame Design and Detailing

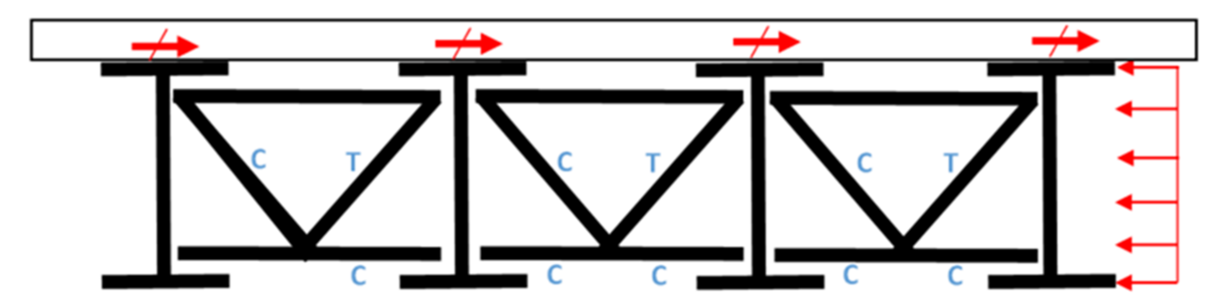
Keep them simple!!!

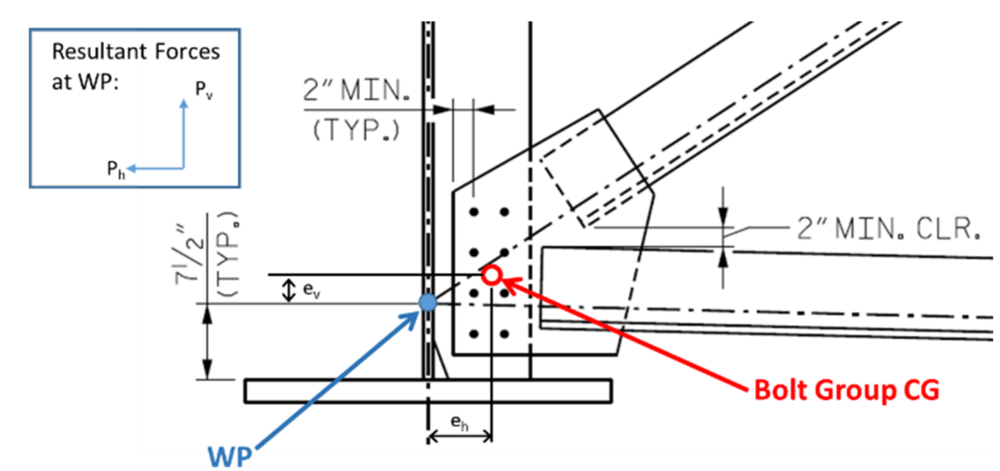
- Standard Plans for Steel Bridges



CROSS-FRAME MEMBER SIZES				
Beam Spacing, ft.	Span, ft.	Type	Chord	Diagonal
8	100-190	K-Frame	L5X5X3/8	L5X5X3/8
	205-250	X-Frame	L5X5X3/8	L5X5X3/8
10	115-220	K-Frame	L5X5X3/8	L5X5X3/8
	235-250	X-Frame	L5X5X3/8	L6X6X3/8
12	130-250	K-Frame	L6X6X3/8	L5X5X3/8
14	160-250	K-Frame	L8X6X1/2	L5X5X3/8

- AASHTO/NSBA Steel Bridge Collaboration
  - forthcoming guideline





Steel Bridge Best Practices for Designers

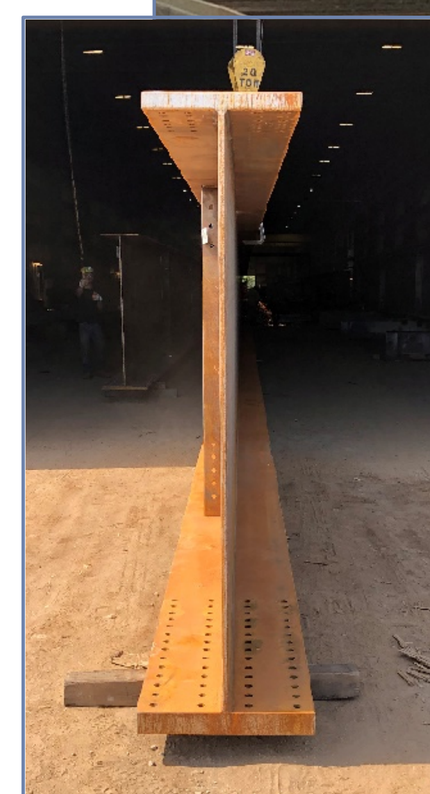
Presentation Outline

- AASHTO LRFD Bridge Design Specifications
  - Steel Design
- NSBA Resources
  - How these can be used to simplify design
- **Design and Detailing Best Practices**
  - Girders
  - Cross-frames

Design and Detailing Best Practices

- **Girders:**
  - Do not over analyze!
  - Use the appropriate level on analysis
  - Least weight is not most efficient
    - Consider handling and erection

  - Limits the number of different plate thicknesses
  - Keep flanges the same width within a field piece
  - Avoid longitudinal stiffeners
  - Provide camber values for:
    - Steel dead load
    - Weight of concrete deck
    - Loads applied to composite section (barriers)
    - Geometric camber



Design and Detailing Best Practices

- **Girders:**
  - Plate Girder Webs
    - ½″ minimum
    - Often thicker for shear design
  - Plate Girder Flanges
    - ¾″ minimum
    - Wider helps with lateral stability
  - Stiffeners and Connection Plates
    - ½″ minimum
    - Include cross-frame connection plates in shear checks

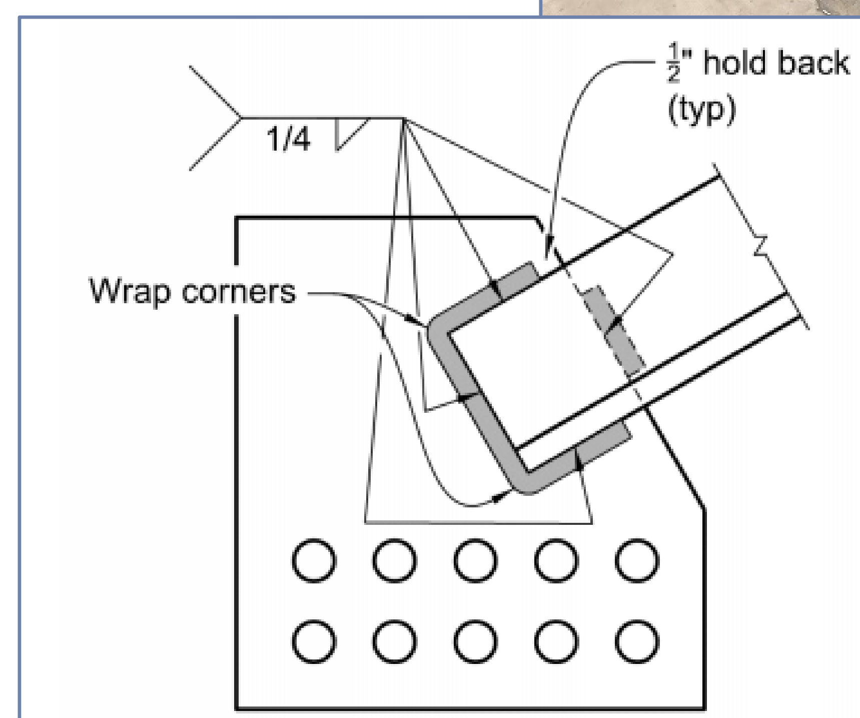
Design and Detailing Best Practices

- **Cross-frames:**
  - Line girder analysis, then design for:
    - Transfer of wind forces
    - Slenderness effects
    - Stability forces and stiffness
  - Refined analysis model, then design for:
    - All Applicable limit states
      - Dead, Live, Fatigue, Wind, etc.
    - Slenderness effects
    - Stability forces and stiffness

Design and Detailing Best Practices

- **Cross-frames:**
  - Angles preferred over WTs
    - Angles are produced at steel mills
    - WTs need to be cut/split from Wide Flange beams
  - Angles
    - Avoid 1/16” gages

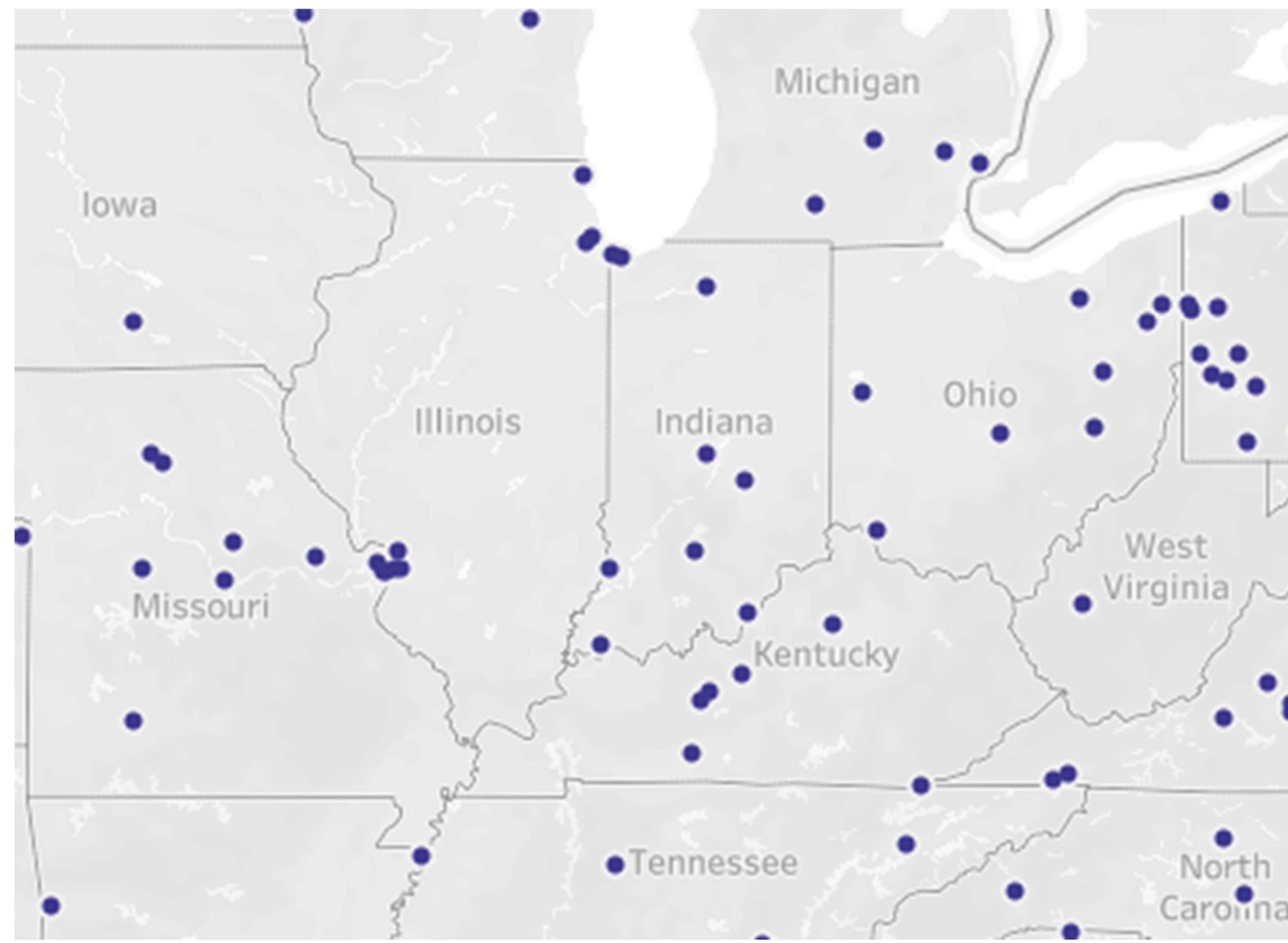
  - Correctly call-out welds



Graphics Credit: Annotated from the FHWA Bridge Welding Reference Manual
https://www.fhwa.dot.gov/bridge/steel/pubs/hif19088.pdf

Have questions, next week?

- Contact me at NSBA: chavel@aisc.org
- Or, contact a regional fabricator:



Steel Bridge Best Practices for Designers

Presentation Outline

- **AASHTO LRFD Bridge Design Specifications**
  - Steel Design
- **NSBA Resources**
  - How these can be used to simplify design
- **Design and Detailing Best Practices**
  - Girders
  - Cross-frames


Photo: 2024 Prize Bridge Merit Award, Medium Span - Rt. 34B over Salmon Creek Bridge – Photo Credit: NYSDOT

Thank you!

Brandon Chavel, PhD, PE
312.805.2137
chavel@aisc.org
www.aisc.org/nsba/

Smarter.
Stronger.
Steel.