Photo: 2020 Prize Bridge National Winner – Manning Crevice (Idaho) – Photo Credit: Ken Saindon

Tools and Resources for Steel Bridge Design

Vin Bartucca – Steel Bridge Specialist Northeast

Smarter. Stronger. Steel.

Who is the NSBA?

National Steel Bridge Alliance, a Division of AISC

- Technical Institute & Trade Association
- Not-for-profit: working for the advancement of steel bridge design and construction
- Services: free resources, forums, AASHTO/NSBA collaboration, preliminary design & evaluation tools, continuing education

Meet the **NSBA**

Bridge Steel Specialists

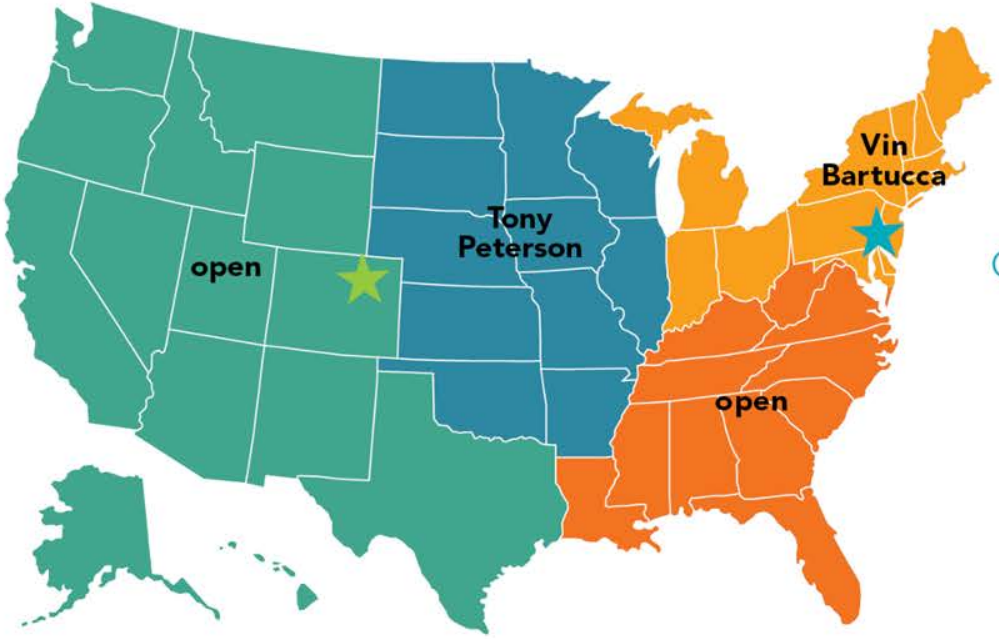
Western Market
open

Central Market
Tony Peterson

Southeast Market
open

Northeast Market
Vin Bartucca

Steel Solutions Center
Travis Hopper



Leadership Team

Senior Director of Market Development
Jeff Carlson ★

Chief Bridge Engineer
Chris Garrell ★

STEEL SOLUTIONS CENTER

The Steel Solutions Center is your gateway to nearly 100 years of steel knowledge, and it's just a phone call or email away.

aisc.org/askaisc

solutions@aisc.org

866.ASK.AISC

- answer your technical questions about structural steel design.
- help you understand NSBA's technical publications.
- help you reduce project risk by connecting decision-makers with AISC bridge-member fabricators for price and schedule information.
- provide conceptual solutions for steel girder and beam bridges, including framing plan and girder spacing concepts, preliminary girder sizes, and steel tonnage estimates.

Photo: 2020 Prize Bridge Merit Winner, Major Span – Portageville Bridge Replacement (New York) – Photo Credit: John Kucko

Upcoming Events

WORLD STEEL BRIDGE SYMPOSIUM

AT NASCC: THE STEEL CONFERENCE

HENRY B. GONZALEZ CONVENTION CENTER | MARCH 20–22, 2024

SAN ANTONIO

NSBA NATIONAL STEEL BRIDGE ALLIANCE FOUNDED 1995

Notable Events at WSBS – San Antonio

Basics of Curved Girder Design Workshop

Industry Roundtable

2024 Bridge of the Year

Are Resources Available to Help Design Steel Girder Bridges? --- YES THERE ARE!!!

Learning Objectives

Objective 1

AASHTO/NSBA Collaboration

Objective 2

Design & Technical Resources Available

Objective 3

FHWA References Available

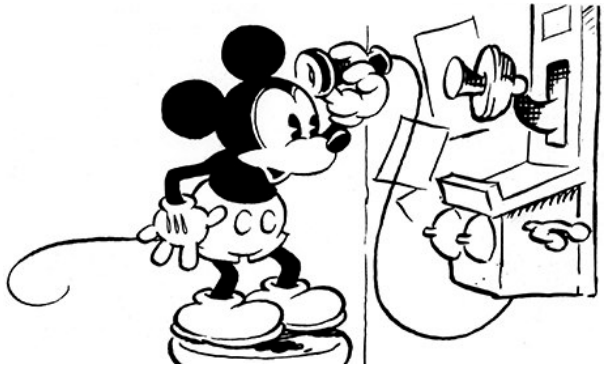
Presentation Outline

- Available References
  - AASHTO/NSBA Collaboration
  - NSBA Design & Technical Resources
  - FHWA Steel Bridge Handbook
  - Other FHWA Technical References
- Summary

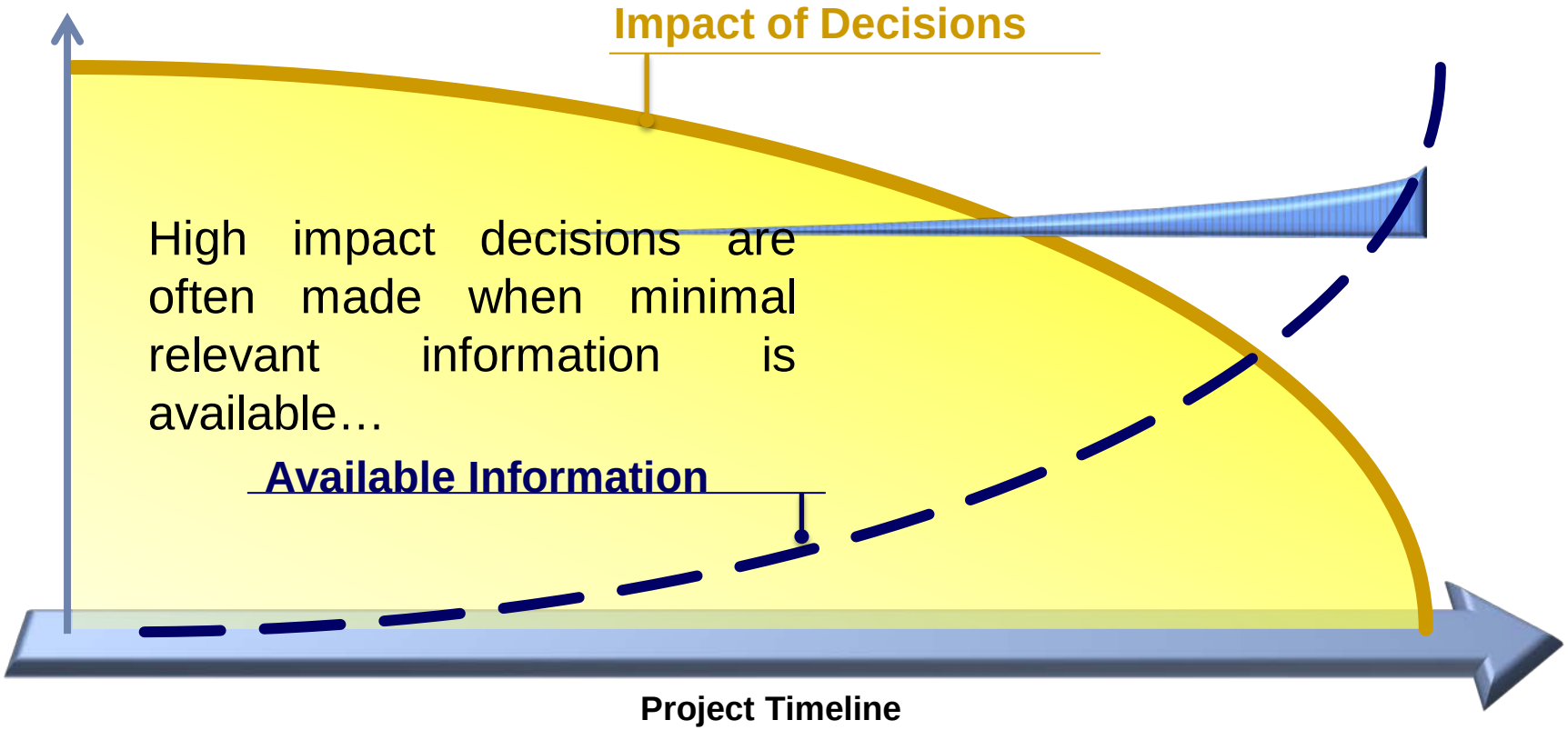
Knowledge Base

Before we get started…

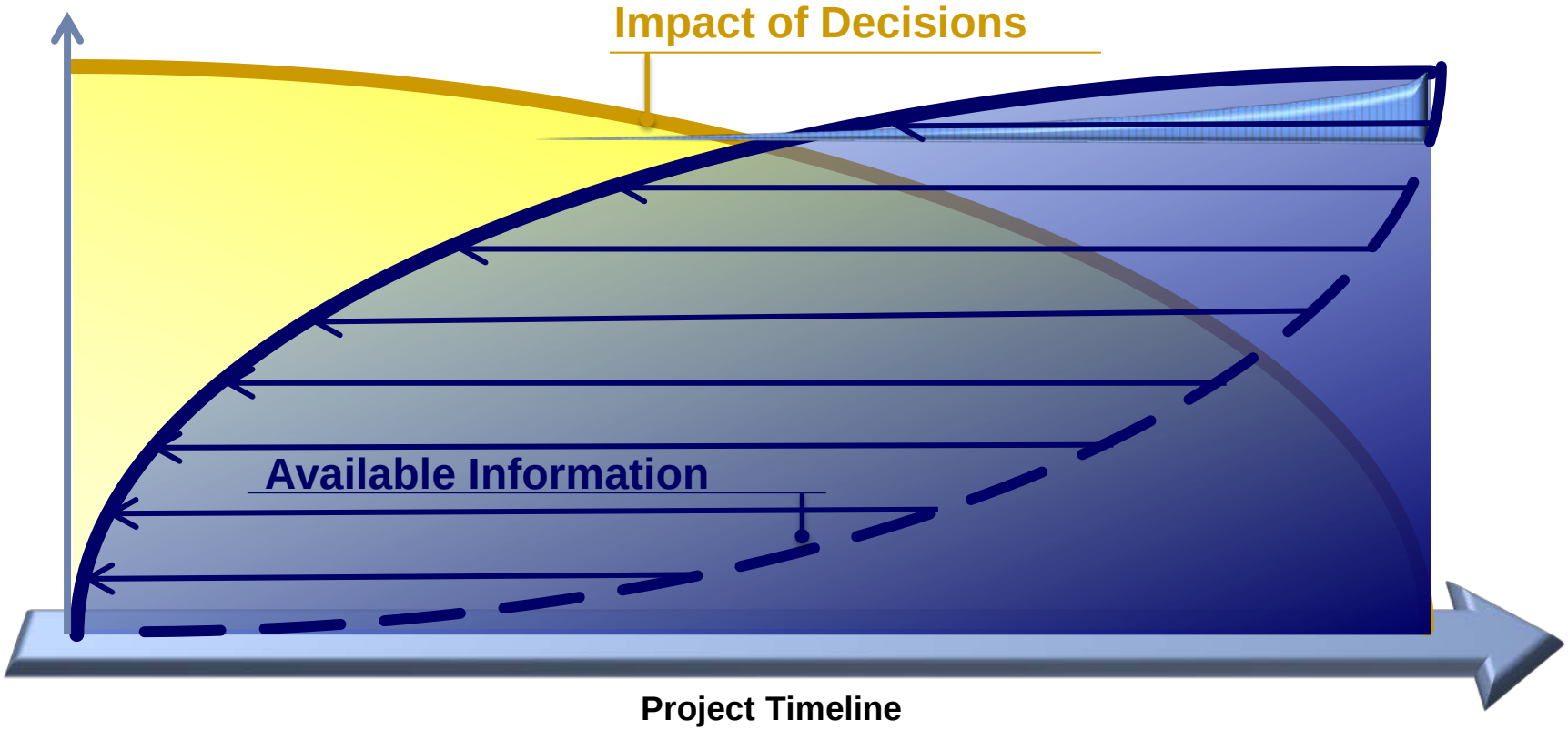
Guidelines and such are no substitute for talking with the experienced engineers in your office, colleagues, fabricators, erectors, or NSBA!!!!



Right Information at the Right Time



Right Information at the Right Time



AASHTO/NSBA Collaboration

Smarter.
Stronger.
Steel.

AASHTO/NSBA Steel Bridge Collaboration

- Provides a forum where professionals can work together to improve and achieve the quality and value of steel bridges through standardization of design, fabrication and erection.
- Over 20 years!
- **Specifications and Guidelines**
  - Specifications:
    - Written in “spec language”
    - Can be adopted as a contract document
  - Guidelines:
    - Written as a reference
  - Consensus of the steel industry
- ALL ARE FREE!!!

AASHTO/NSBA Steel Bridge Collaboration

Recent AASHTO Approved Documents

- S10.1 – Steel Bridge Erection
- G14.2 – Guidelines for Field Repairs and Retrofits of Steel Bridges
- S8.3 - Hot Dip Galvanizing Guide Specification

- Free! - www.aisc.org/nsba

Note about plate availability

- G12.1 – Constructability, Section 1.4

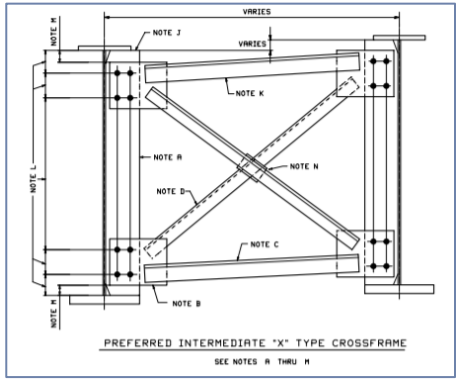
Next Meeting

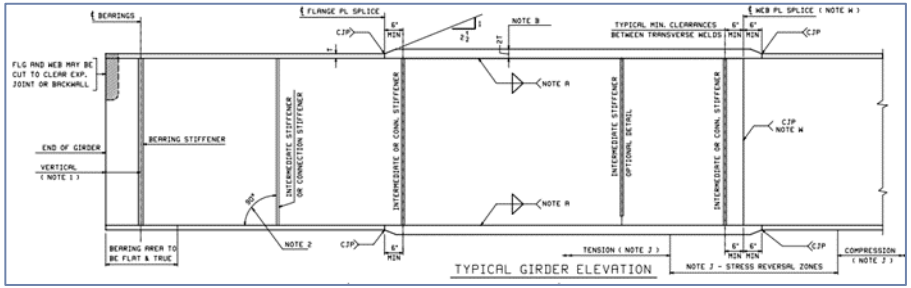
- **Spring April 16-18 Providence RI**

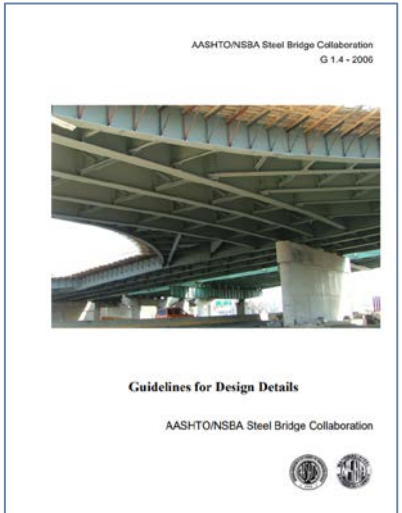
AASHTO/NSBA Steel Bridge Collaboration

Guidelines for Design Details (G1.4-2006)

- Collection of sample design details that allow for the economical fabrication and erection of bolted splices, cross frames, and stiffeners.
- When in doubt regarding a specific design detail, this should be the engineer's first reference



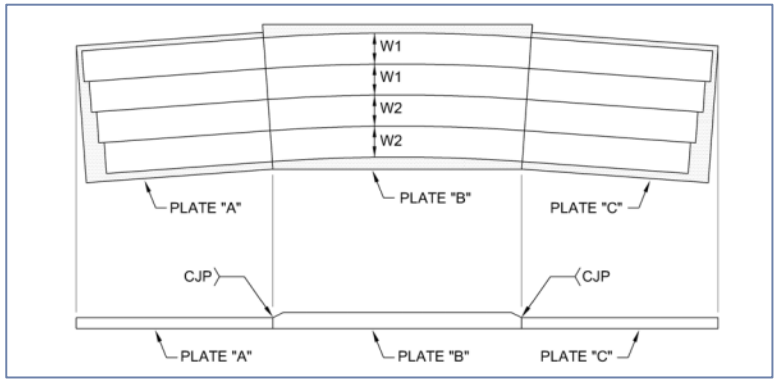


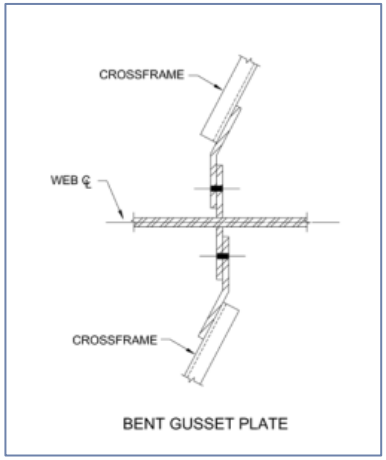


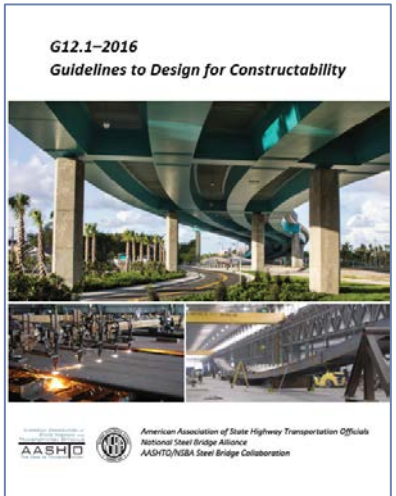
AASHTO/NSBA Steel Bridge Collaboration

Guidelines for Design for Constructability (G12.1-2020)

- Provides engineers with design and detailing recommendations to help make steel girder type bridges more easily fabricated and constructible.
- Refer to this guideline for a better understanding of certain details can affect fabrication, and for general guidance to make better informed decisions during design.







AISC's Need For Speed Initiative

Standard Designs for Straight I-Girder Bridges – In Progress

- **Motivation:**
  - Steel provides great flexibility in design.
  - Engineers are routinely confronted with repetitive design decisions regarding material thickness and sizes for the routine steel I-girder bridges.
- **Objective:** Develop bridge standards
  - 1, 2, 3, and 4 span arrangements.
  - Optimize and standardize web, flange, stiffener, and field splice plate sizes from typical mill plate widths and thicknesses.
  - Provide cost-efficient diaphragm and cross-frame standards.
- **Status:**
  - Single span standards completed and awaiting posting.
  - Two, three, and four-span standards will be posted on a rolling release into the beginning of 2024.

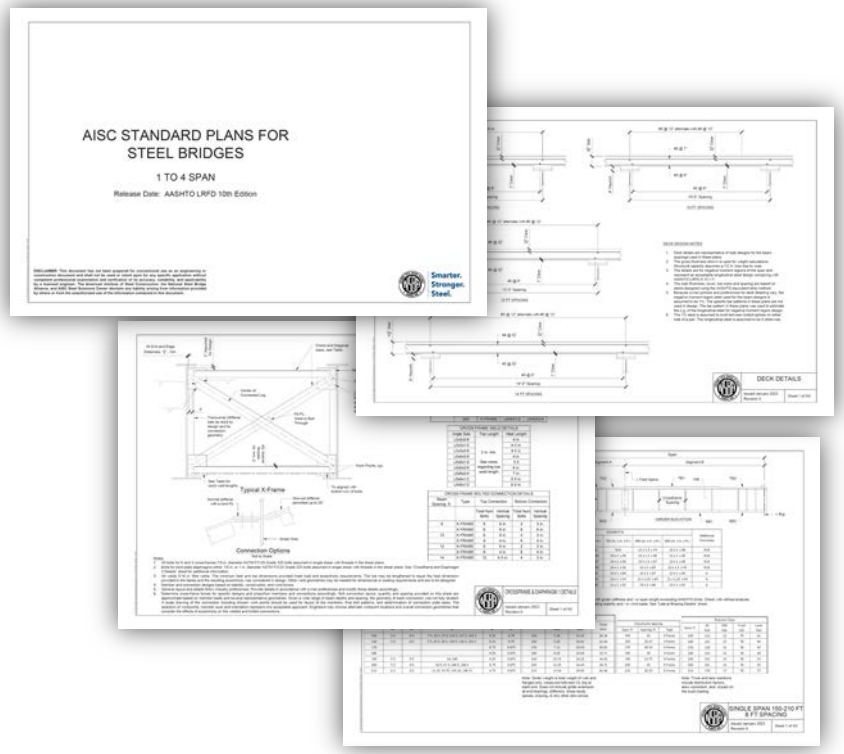
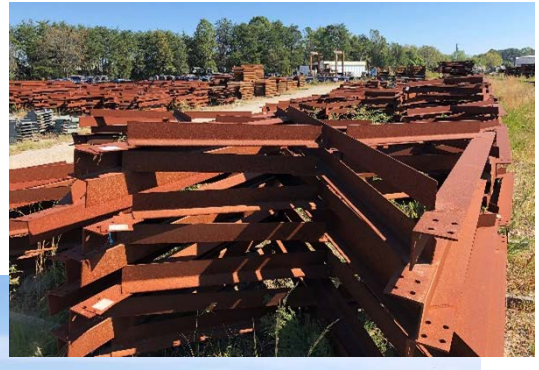


Photo: 2020 Prize Bridge Merit Winner, Major Span – Portageville Bridge Replacement (New York) – Photo Credit: John Kucko

Material Availibility

Material Availbility

- MYTH – Contractor is always waiting for steel…..
  - Completed girders and cross-frames stored on-site



Achieving Speed From Design to Delivery

Material Procurement - Plate

Material Availability

- Steel Plate Lead times – typically in 8-10 week range
- Smaller quantities probably in stock at Service Centers

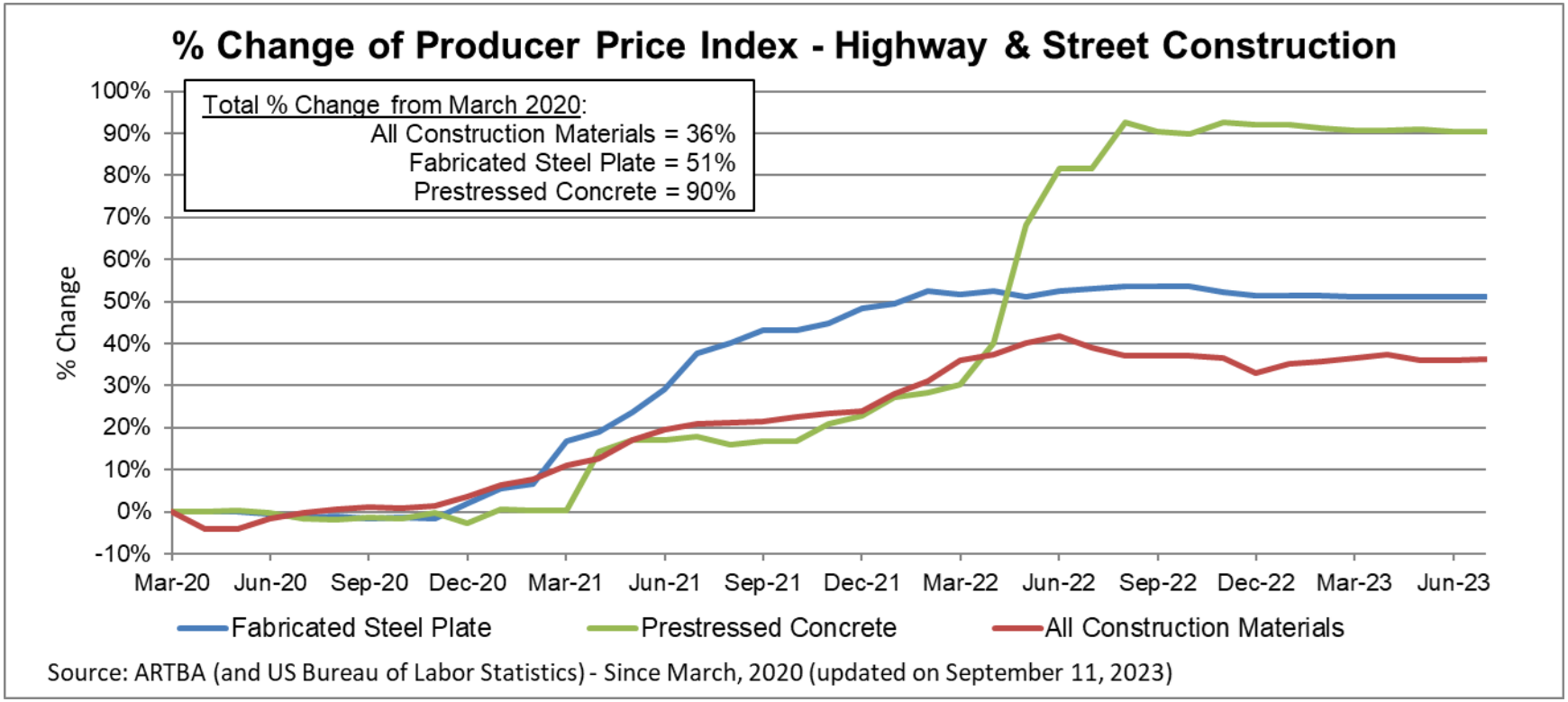
Material Availability

- Capacity continues to improve, becoming stronger
- Balanced Approach to Bid Letting helps capacity
- New Nucor Kentucky Plate Mill
  - Increases plate capacity (Adds approx. 120,000 tons overall steel products)
  - Improved lean processes
  - Improved sustainability

Material Availability – Emergency Situations

- I-95 Penn Bridge
- Emergency Situations differ for lead times
- Website and document for handling emergency projects

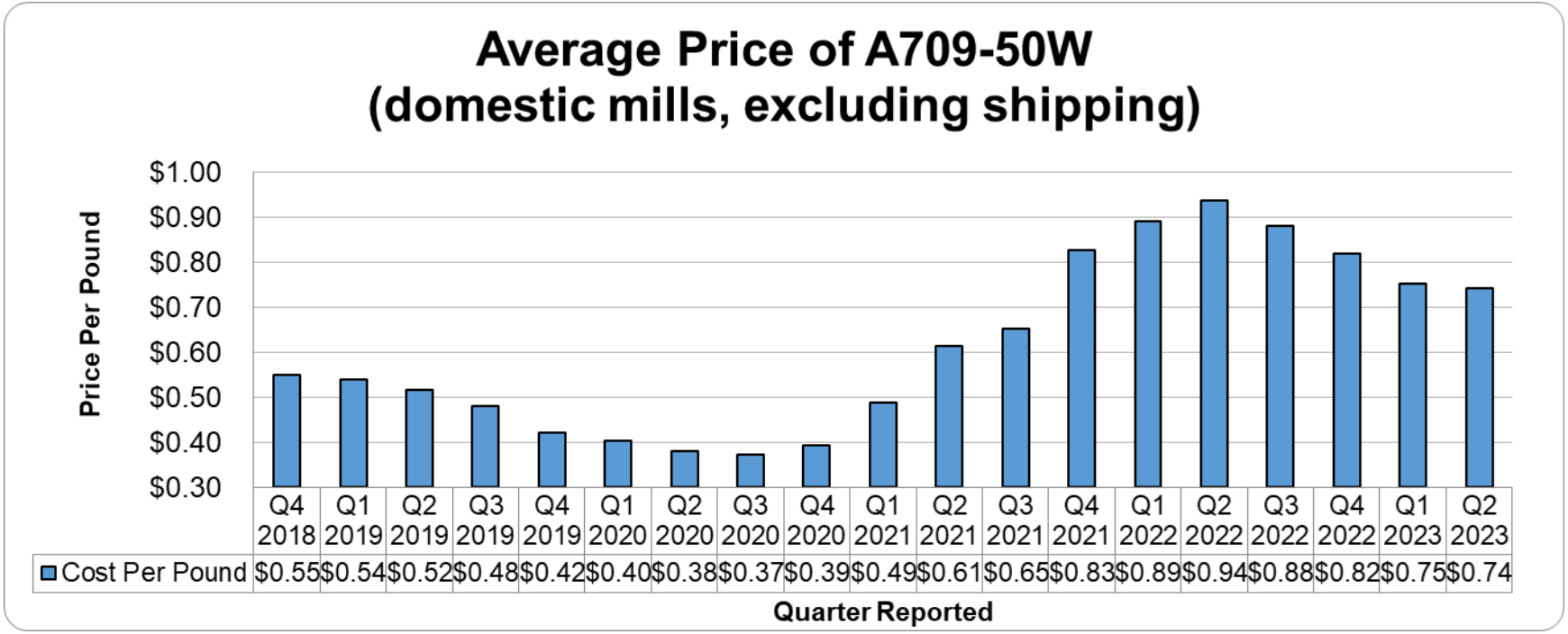
Historical Fabricated Steel Costs



Also available at artba.org/economics/materials-dashboard/

Average Mill Price of A709-50W

Size 1 ½ in. thick x 96 in. wide x 636 in. long



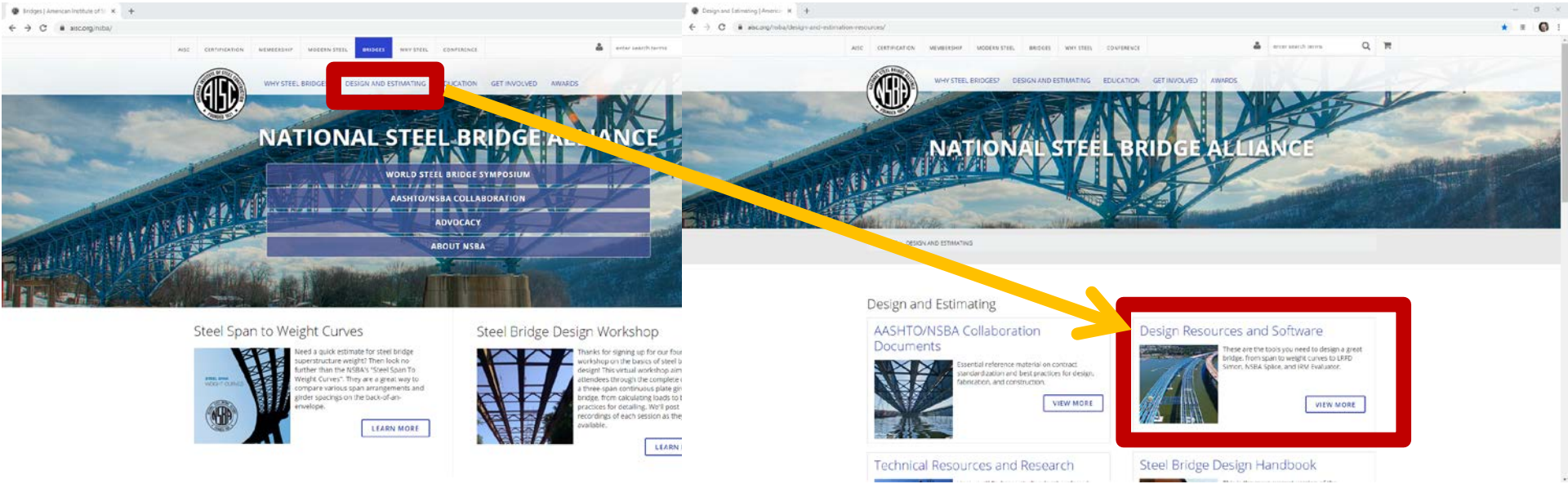
Raw material pricing presented in this chart is a small snapshot of a limited time and is not representative of long term historical and future trends.

NSBA Design & Technical Resources

Smarter.
Stronger.
Steel.

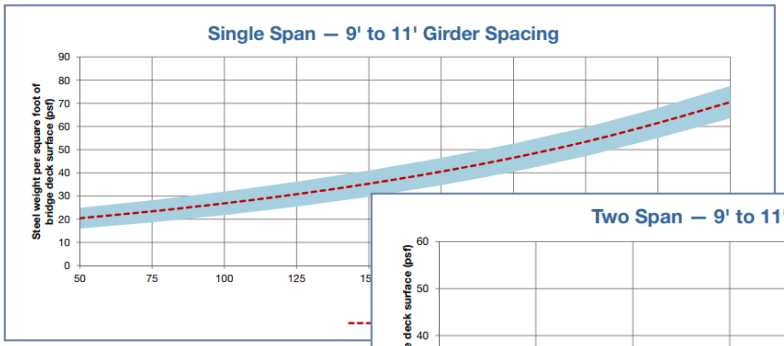
NSBA Design and Software

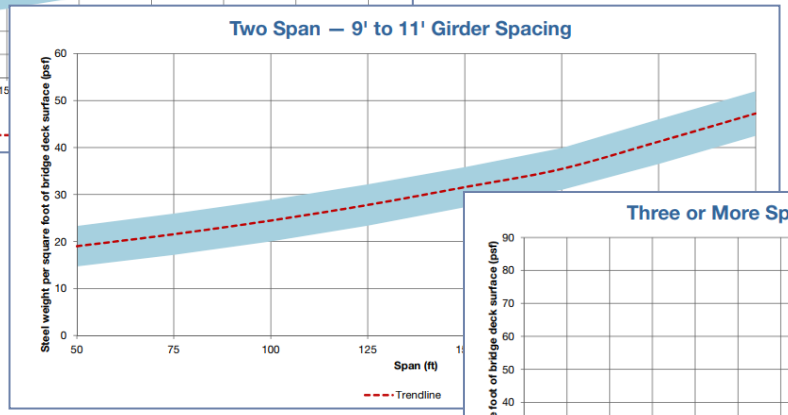
https://www.steelbridges.org/

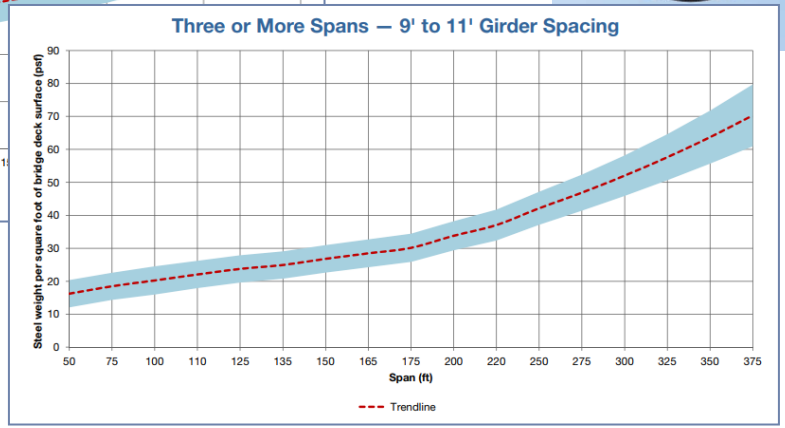


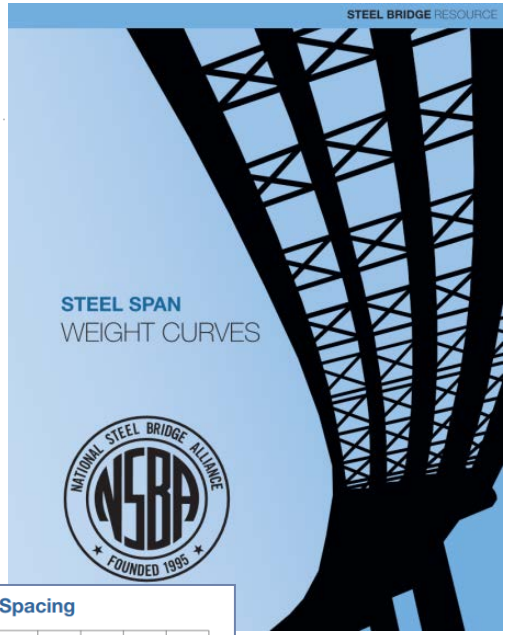
NSBA Design and Software

- **Steel Span to Weight Curves**



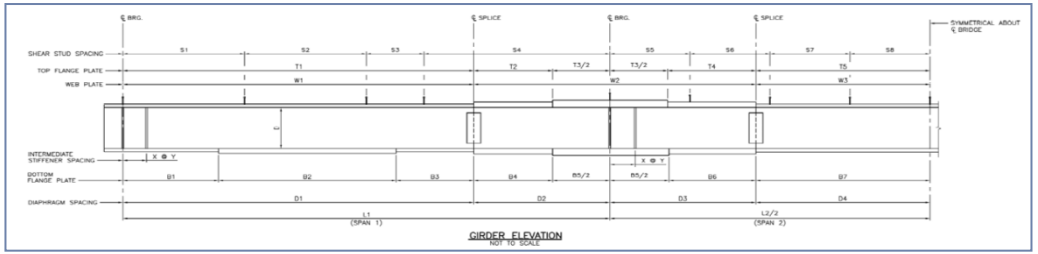






NSBA Design and Software

- **Continuous Span Standards**
  - **Assist Engineers During the TS&L Phase:**
    - Flange plate sizes and lengths
    - Web plate sizes and lengths
    - Diaphragm spacing
    - Stiffener locations
    - Girder weights
    - Shear connector spacing
    - Camber tables



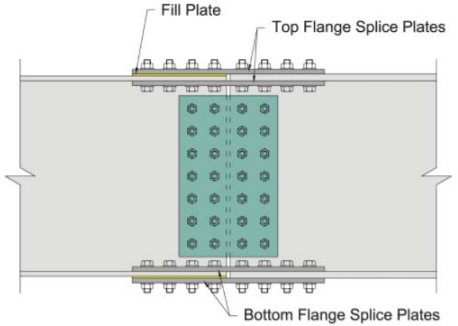
NSBA Design and Software

SIMON Analysis Software

- Line girder analysis software that can be used to analyze straight and low skew plate girder and tub girder bridges.
- AASHTO LRFD 9th Edition

NSBA Splice Spreadsheet

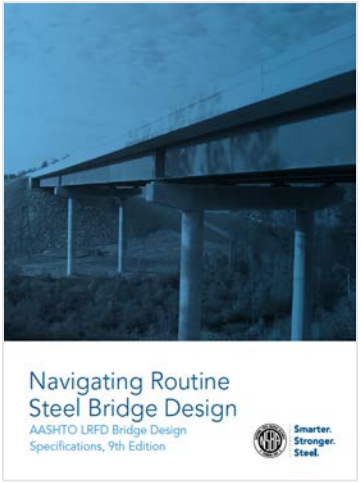
- SPREADSHEET!
- Allows the designer to quickly analyze various bolted splice connections to determine the most efficient bolt quantity and configuration.



Resources

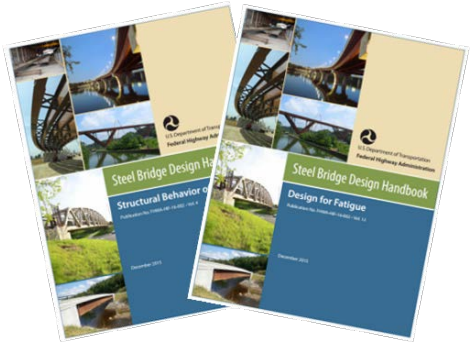
Guideline for Navigating Routine Steel Bridge Design

- for straight, low skew, <200’ span steel girder bridges (“routine”)
- Implement AASHTO LRFD BDS with greater efficiency and quality
  - https://www.aisc.org/nsba/



Steel Bridge Design Handbook Update

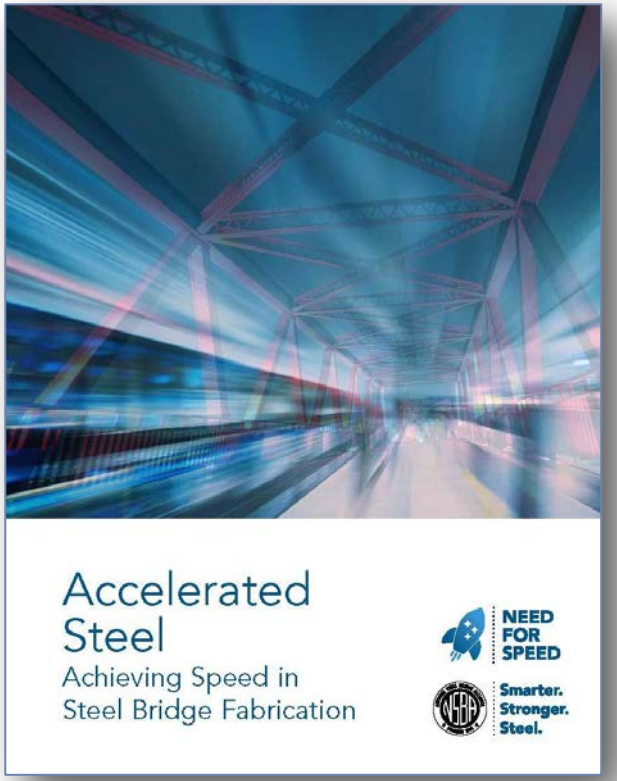
- FHWA handed back to NSBA
- Updated for AASHTO LRFD 9th Edition
  - https://www.aisc.org/nsba/



Designer Resources – Now Available

Achieving Speed in Steel Bridge Fabrication

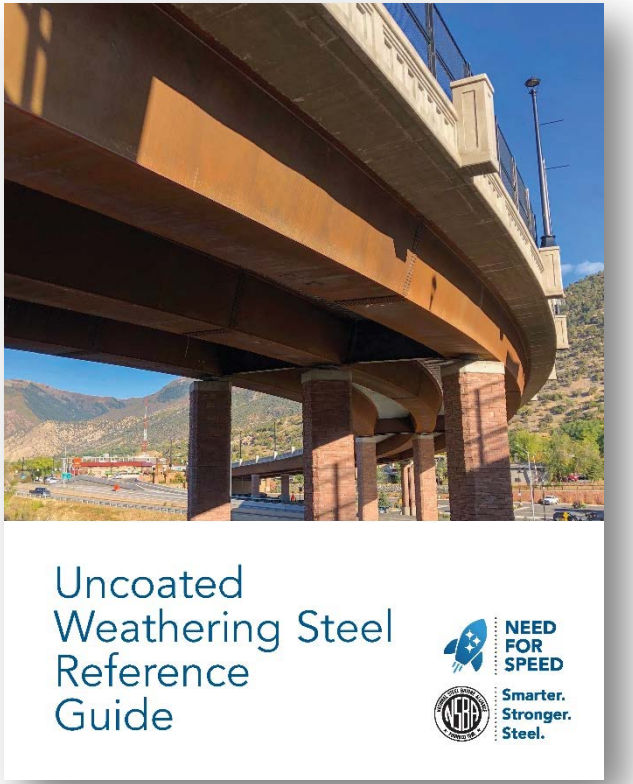
- Describe the best practices for executing the fabrication of a steel bridge project.
- **Major Chapters**
  - Shop drawing approval
  - Shop assembly
  - Quality control
  - Best practices on behalf of the owner
  - Best practices on the behalf of the designer
  - Best practices on design-build project
- **About this Version:** New document
- **Status**: aisc.org/fasterbridgefab



Designer Resources – Now Available

Uncoated Weathering Steel Reference Guide

- Reduce cost from fabrication & life cycle cost through long term maintenance costs
- **Major Chapters**
  - Benefits and Appropriate Use.
  - Design and Detailing Recommendations.
  - Fabrication and Construction Considerations
  - In-Service Inspection and Maintenance.
  - Preservation and Repair.
- **About this Version:** New document
- **Status**: aisc.org/uwsguide



Designer Resources – Now Available

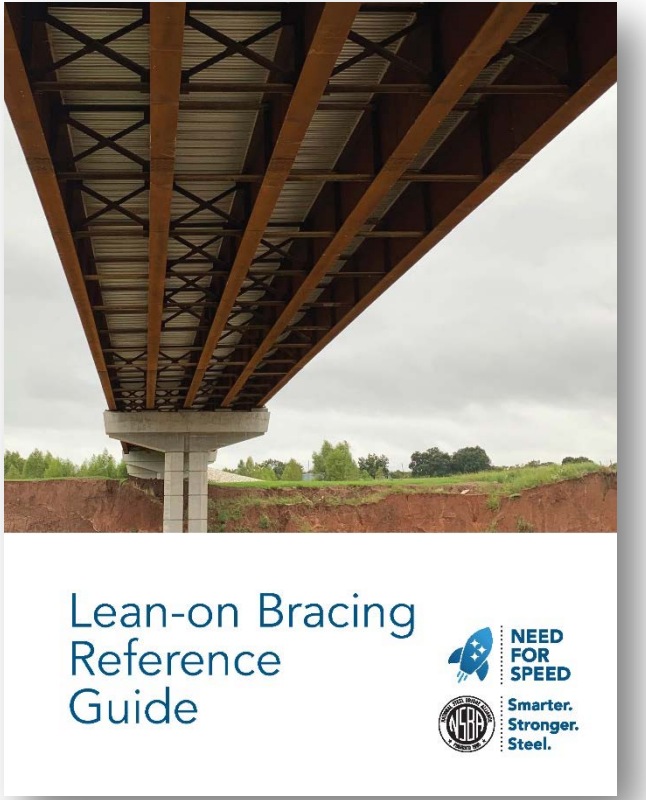
Single Coat IOZ Synthesis Study

- SIOZ is a cost-effective solution to corrosion protection in instances where weathering steel may not be appropriate.
- **Major Chapters**
  - Literature Review.
  - Survey of Current Bridge Inventory.
  - Field Assessment of In-Service Bridges.
  - Recommendations for Further Research.
- **About this Version:** New document
- **Status**: aisc.org/sioz-report

Designer Resources – Now Available

Lean-on Bracing Guide

- Easiest method for achieving cost effectiveness for straight steel I-girder bridges with little or no skew.
- **Major Chapters**
  - Stability Fundamentals.
  - Available Literature and Research.
  - Design Approach.
  - Fabrication and Erection Consideration.
  - Case Studies.
  - Design Examples - Two.
- **About this Version:** New document
- **Status**: aisc.org/leanonbracing

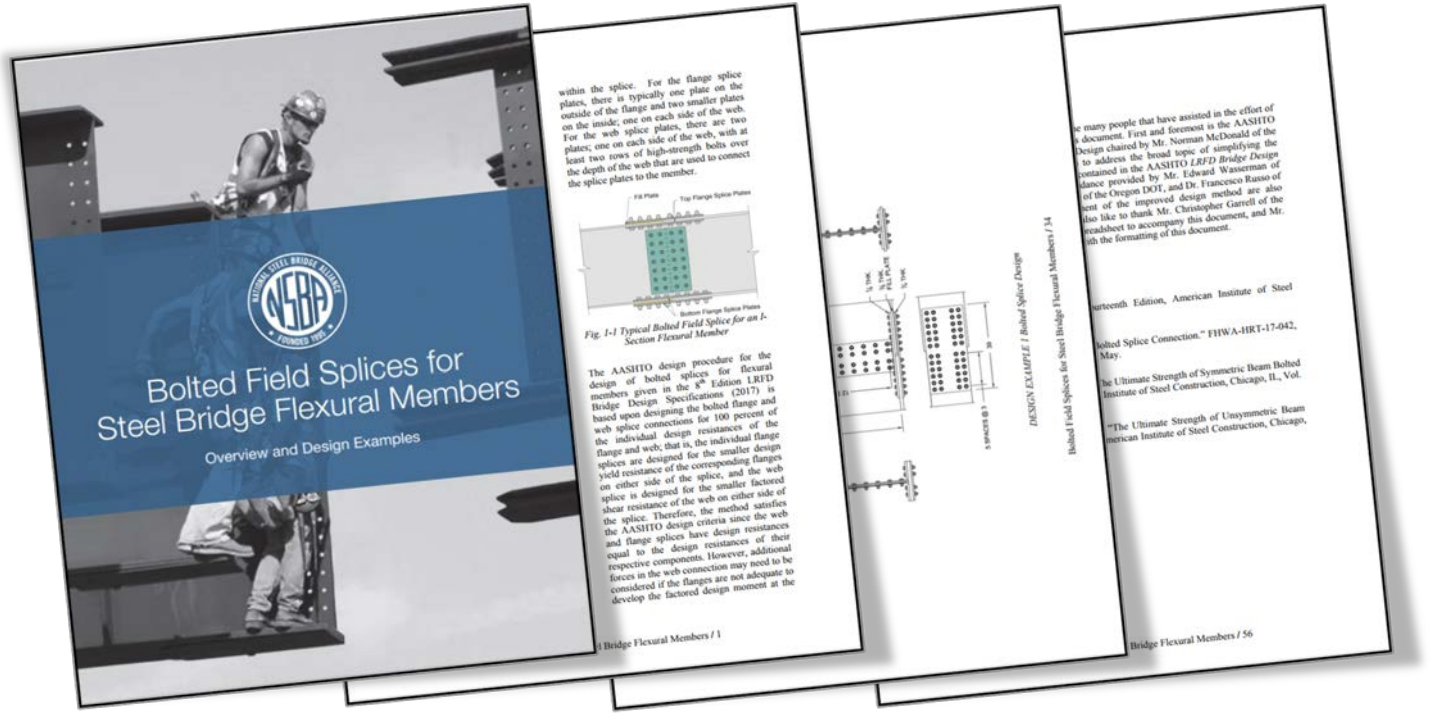


NSBA Technical Resources and Research

- Practical Steel Tub Girder Design
- A Fatigue Primer for Structural Engineers
- Moments, Shears, and Reactions
- Bolted Field Splices
- FHWA Bridge Welding Reference Manual

NSBA Technical Resources and Research

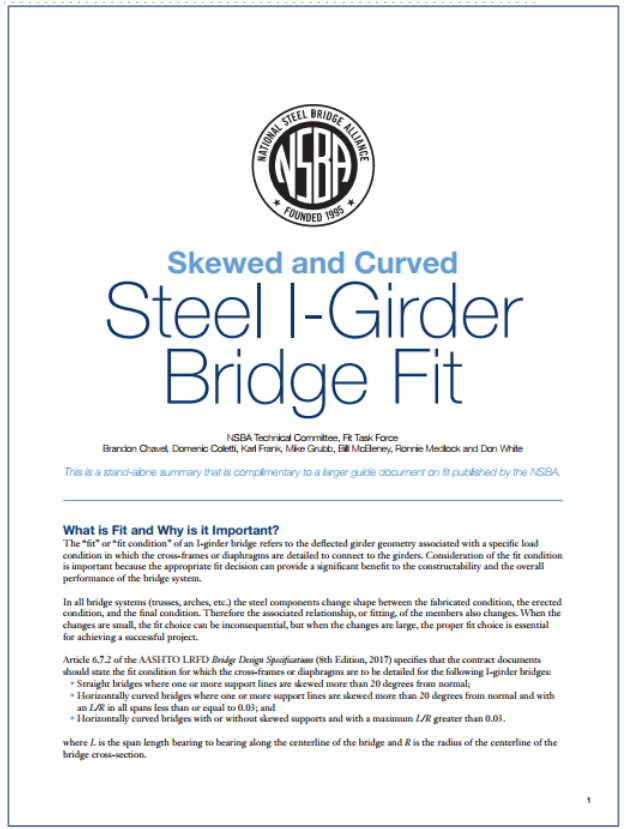
Bolted Field Splices – AASHTO LRFD 9th Edition



NSBA Technical Resources and Research

Skewed and Curved Steel I-Girder Bridge Fit

- **Standalone Summary (6 pages)**
- **Full Document (47 pages)**
  - Explains Fit Conditions
    - No Load Fit
    - Steel Dead Load Fit
    - Total Dead Load Fit
  - Provides Recommended Fit Conditions for
    - Skewed Bridges
    - Curved Bridges
    - Curved Bridges with Skewed Supports



Skewed and Curved

Steel I-Girder Bridge Fit

NSBA Technical Committee, Fit Task Force
Brandon Chavel, Domenic Coletti, Karl Frank, Mike Grubb, Bill McElwee, Ronnie Medlock and Don White

This is a stand-alone summary that is complimentary to a larger guide document on fit published by the NSBA.

What is Fit and Why is it Important?

The "fit" or "fit condition" of an I-girder bridge refers to the deflected girder geometry associated with a specific load condition in which the cross-frames or diaphragms are detailed to connect to the girders. Consideration of the fit condition is important because the appropriate fit decision can provide a significant benefit to the constructability and the overall performance of the bridge system.

In all bridge systems (trusses, arches, etc.) the steel components change shape between the fabricated condition, the erected condition, and the final condition. Therefore the associated relationship, or fitting, of the members also changes. When the changes are small, the fit choice can be inconsequential, but when the changes are large, the proper fit choice is essential for achieving a successful project.

Article 6.7.2 of the AASHTO LRFD *Bridge Design Specifications* (8th Edition, 2017) specifies that the contract documents should state the fit condition for which the cross-frames or diaphragms are to be detailed for the following I-girder bridges:

- Straight bridges where one or more support lines are skewed more than 20 degrees from normal;
- Horizontally curved bridges where one or more support lines are skewed more than 20 degrees from normal and with an L/R in all spans less than or equal to 0.03; and
- Horizontally curved bridges with or without skewed supports and with a maximum L/R greater than 0.03.

where L is the span length bearing to bearing along the centerline of the bridge and R is the radius of the centerline of the bridge cross-section.

1

Dead Load Camber – Article 6.7.2

The “Fit” Decision

- Affects design decisions regarding rotation demands on the bearings.
- Affects internal force effects for which the cross-frames and girders must be designed.
- Allows Fabricator/Detailer complete shop drawings and successfully fabricate the bridge components.
- Allows Erector/Contractor assemble the steel and achieve the desired geometry in the field.

NSBA Steel Bridge Handbook

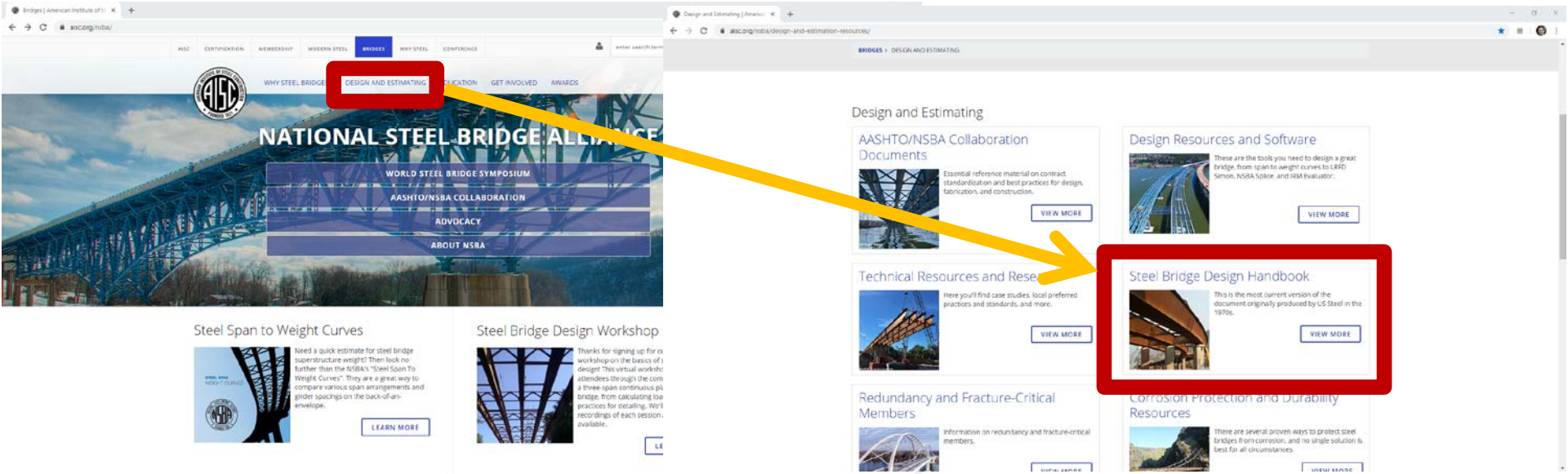
Smarter.
Stronger.
Steel.

NSBA Steel Bridge Design Handbook

- 25 Volumes
  - 19 Written Chapters
  - 6 Design Examples
- Updated for AASHTO LRFD 9th Edition
- Download for free at aisc.org/sbdh

NSBA Steel Bridge Design Handbook

https://www.steelbridges.org/



NSBA Steel Bridge Design Handbook

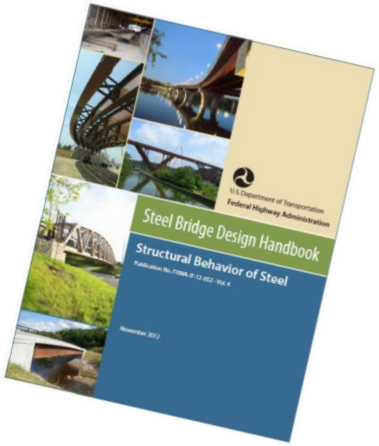
History of the Handbook

- Highway Structures Handbook
  - US Steel, 1970's
- AISC
  - Several updated chapters over several years
  - LFD and LRFD design examples
- NSBA
  - Update for LRFD and a few new chapters
- FHWA
  - Provided funding to update and complete in 2012
  - Updated again in 2016
- NSBA
  - NSBA took back over in 2021 and performed the most recent update

NSBA Steel Bridge Design Handbook

Chapters

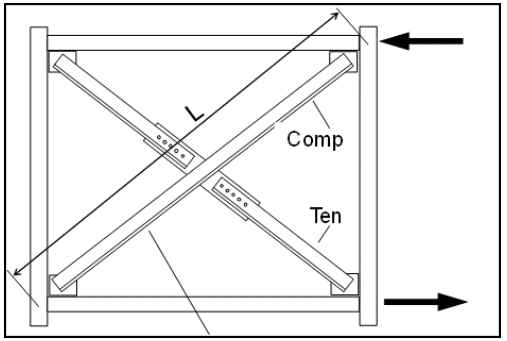
1. Bridge Steels and Their Mechanical Properties
2. Steel Bridge Fabrication
3. Steel Bridge Shop Drawings
4. Structural Behavior of Steel
5. Selecting the Right Bridge Type
6. Stringer Bridges: Making the Right Choices
7. Loads and Load Combinations
8. Structural Analysis
9. Redundancy



NSBA Steel Bridge Design Handbook

Chapters (cont'd)

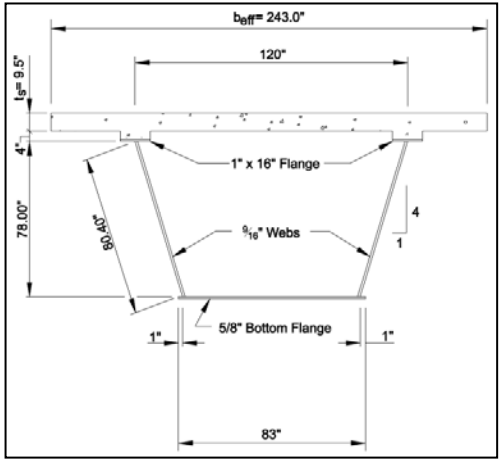
10. Limit States
11. Design for Constructability
12. Design for Fatigue
13. Bracing System Design
14. Field Splice Design
15. Bearing Design
16. Substructure Design
17. Bridge Deck Design
18. Load Rating of Steel Bridges
19. Corrosion Protection of Steel Bridges

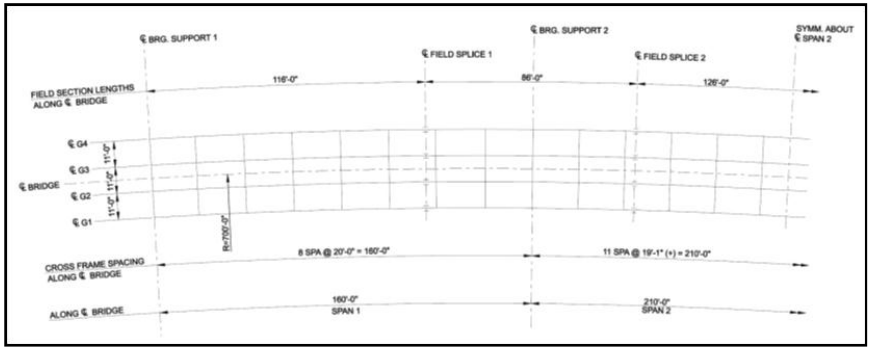


NSBA Steel Bridge Design Handbook

Design Examples

20. 3-span Straight Steel I-Girder Bridge
21. 2-span Straight Steel I-Girder Bridge
22. 2-span Straight Steel Wide-Flange Beam Bridge
23. 3-span Straight Steel Tub-Girder Bridge
24. 3-span Curved Steel I-Girder Bridge
25. 3-span Curved Steel Tub-Girder Bridge

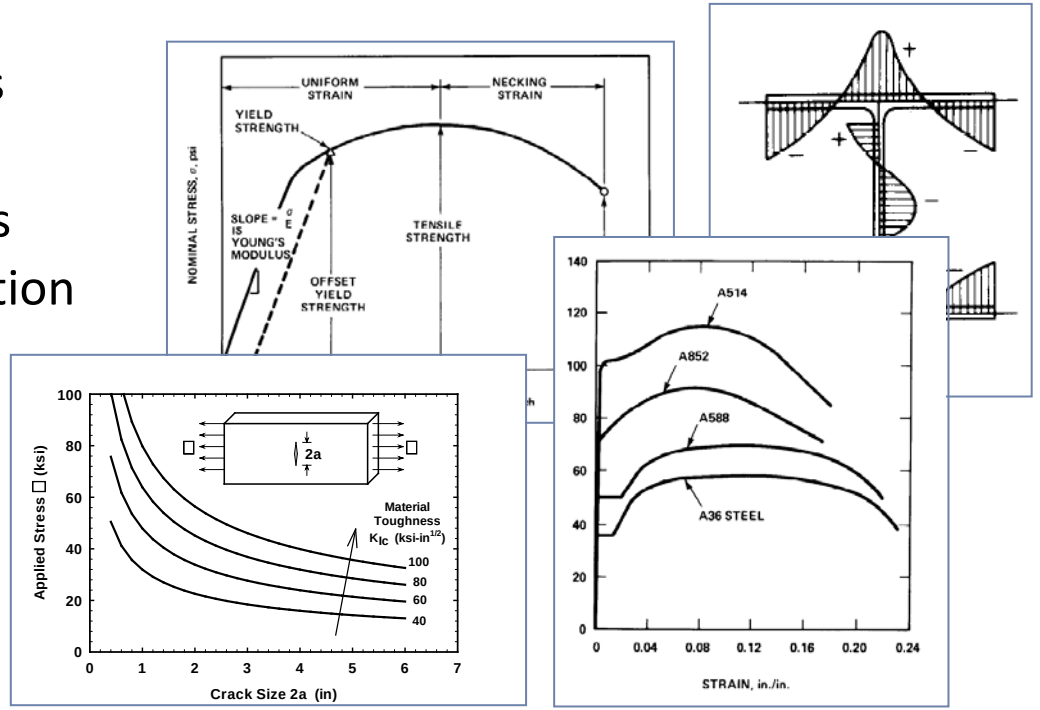




NSBA Steel Bridge Design Handbook

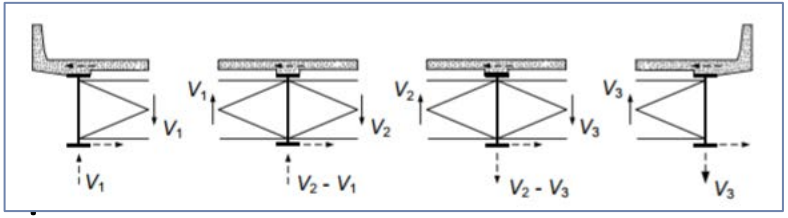
Vol. 1 - Bridge Steels and Their Mechanical Properties

- **Includes:**
  - Product Specifications
  - Steel Manufacturing
  - Mechanical Properties
  - Weldability & Fabrication
  - Corrosion Resistance

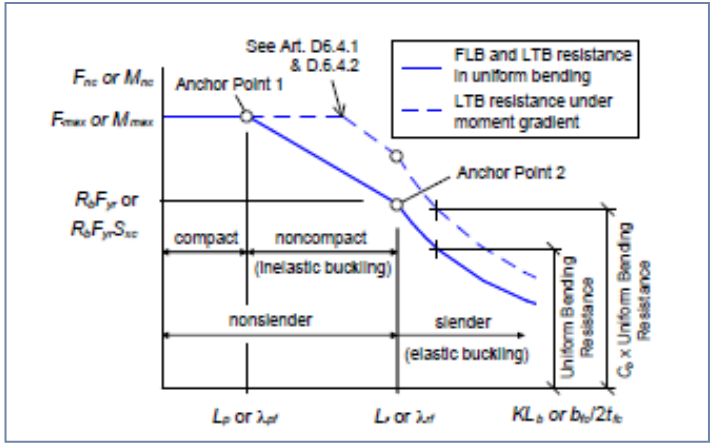


NSBA Steel Bridge Design Handbook

Vol. 4 – Structural Behavior of Steel



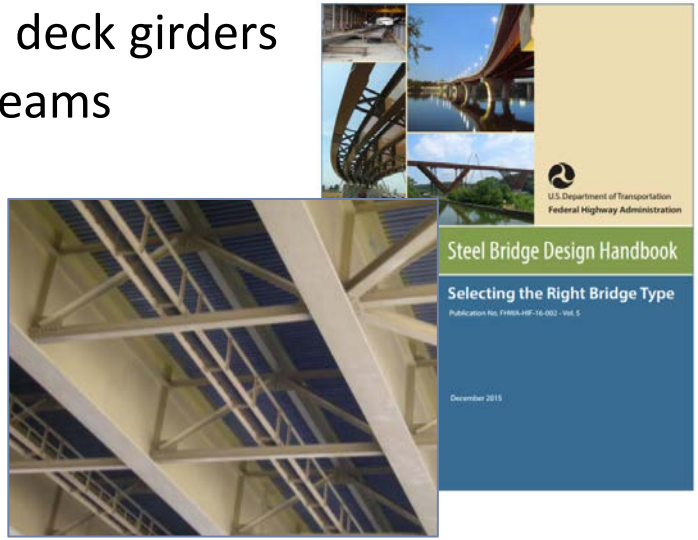
- **Includes:**
  - Member Behavior and Strength Design
  - Tension Members
  - Compression Members
  - I-section Flexural Members
  - Combined Flexural and Torsion
  - Box-Section Flexural Members
  - Miscellaneous Flexural Members
  - Combined Flexure and Axial Load



NSBA Steel Bridge Design Handbook

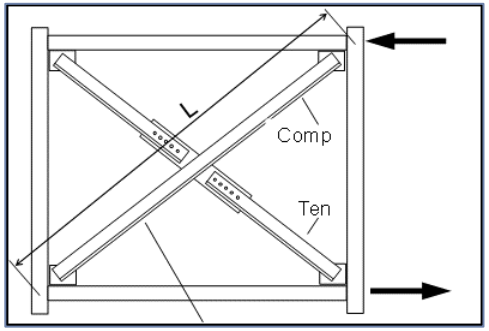
Vol. 5 – Selecting the Right Bridge Types
Vol. 6 – Stringer Bridges: Making the Right Choices

- **Includes:**
  - Discussion on Various Bridge Types and when appropriate
  - Details encountered in composite deck girders
  - Welded plate girders and rolled beams
  - Specific design details

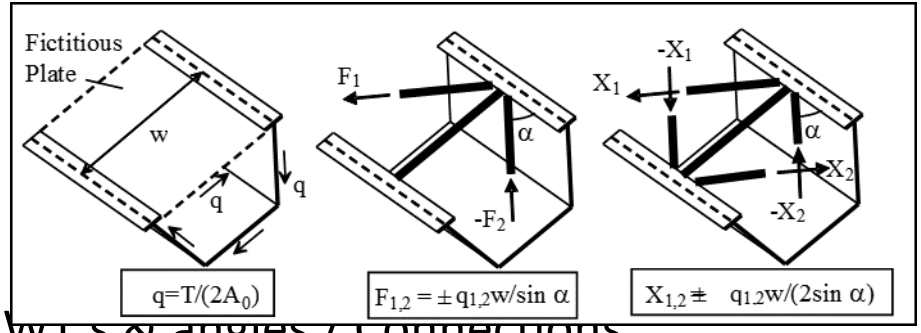


NSBA Steel Bridge Design Handbook

Vol. 13 – Bracing System Design



- **Includes:**
  - Bracing of I-Girders
    - Stability & Strength / Skew Effects
    - System Buckling
  - Bracing of Tub Girders
    - Top Lateral Bracing
    - Intermediate Bracing
  - Bracing Member Design
    - Compression & Tension / WT's & angles / Connections

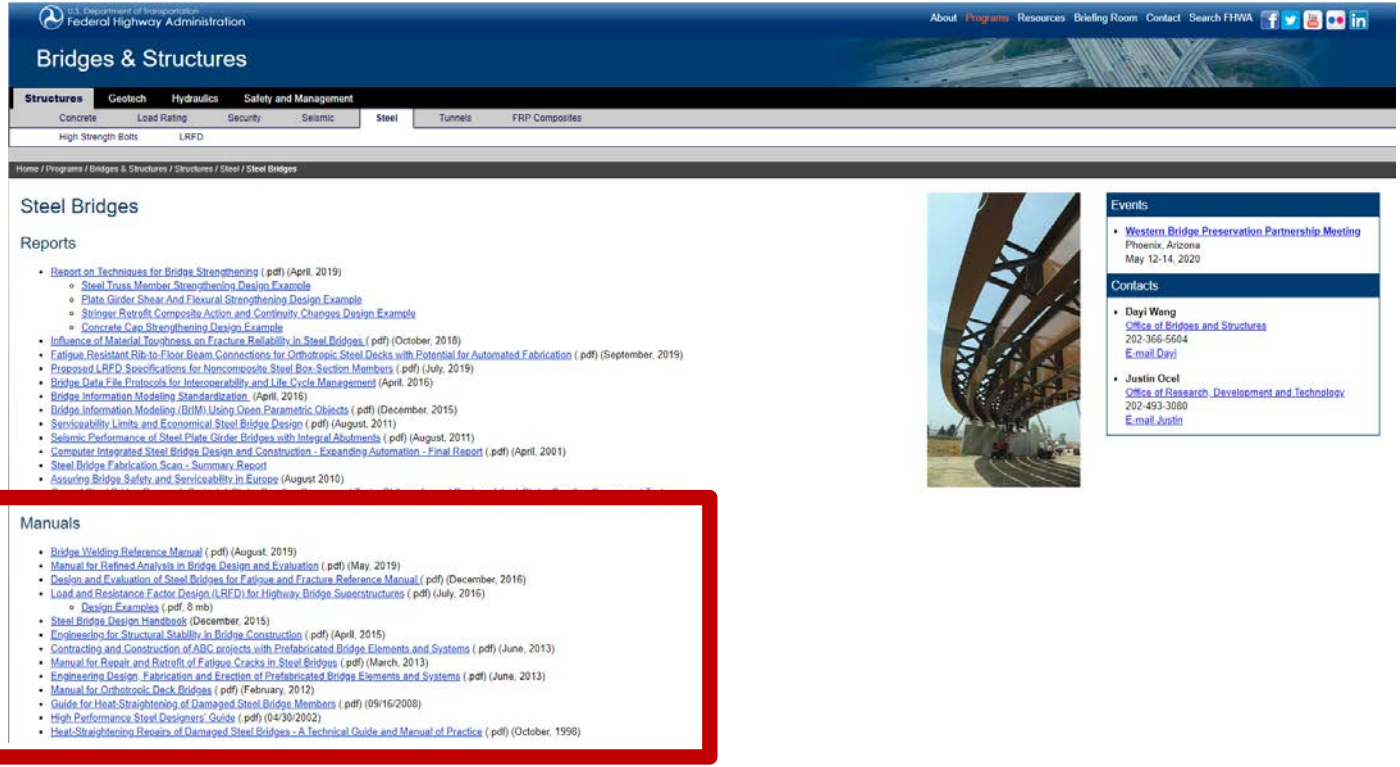


- Other FHWA Technical References

Smarter.
Stronger.
Steel.

Other FHWA Technical Resources

FHWA Office of Bridges and Structures - http://www.fhwa.dot.gov/bridge/



Other FHWA Technical Resources

FHWA Office of Bridges and Structures - http://www.fhwa.dot.gov/bridge/

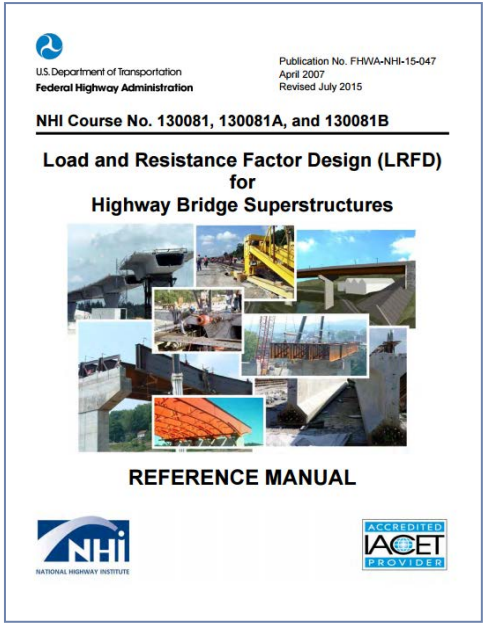
Manuals

- Bridge Welding Reference Manual (.pdf) (August, 2019)
- Manual for Refined Analysis in Bridge Design and Evaluation (.pdf) (May, 2019)
- Design and Evaluation of Steel Bridges for Fatigue and Fracture Reference Manual (.pdf) (December, 2016)
- Load and Resistance Factor Design (LRFD) for Highway Bridge Superstructures (.pdf) (July, 2016)
    - Design Examples (.pdf, 8 mb)
- Steel Bridge Design Handbook (December, 2015)
- Engineering for Structural Stability in Bridge Construction (.pdf) (April, 2015)
- Contracting and Construction of ABC projects with Prefabricated Bridge Elements and Systems (.pdf) (June, 2013)
- Manual for Repair and Retrofit of Fatigue Cracks in Steel Bridges (.pdf) (March, 2013)
- Engineering Design, Fabrication and Erection of Prefabricated Bridge Elements and Systems (.pdf) (June, 2013)
- Manual for Orthotropic Deck Bridges (.pdf) (February, 2012)
- Guide for Heat-Straightening of Damaged Steel Bridge Members (.pdf) (09/16/2008)
- High Performance Steel Designers' Guide (.pdf) (04/30/2002)
- Heat-Straightening Repairs of Damaged Steel Bridges - A Technical Guide and Manual of Practice (.pdf) (October, 1998)

Other FHWA Technical Resources

FHWA Office of Bridges and Structures - http://www.fhwa.dot.gov/bridge/

- **LRFD for Highway Superstructures Reference Manual**
- http://www.fhwa.dot.gov/bridge/pubs/nhi15047.pdf
- AASHTO LRFD 7th Edition, 2015 Interims
- Chapters include:
  - General Design and Location Features
  - Loads and Load Factors
  - Structural Analysis
  - Steel Girder Superstructures
  - Decks and Deck Systems
  - Bearings and Joints
- Design Example – 2 Span Steel Plate Girder



Other FHWA Technical Resources

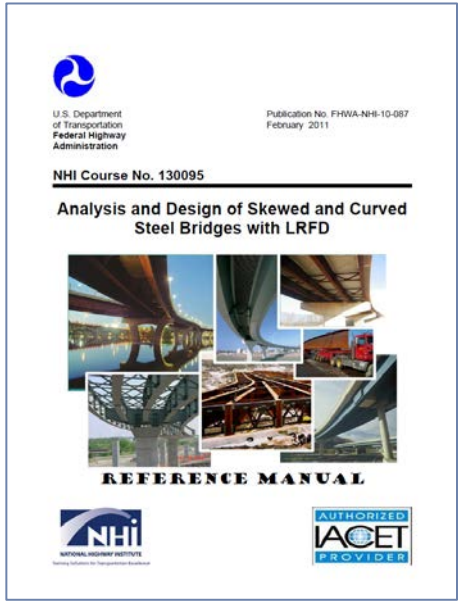
FHWA Office of Bridges and Structures - http://www.fhwa.dot.gov/bridge/

- Manual for Repair and Retrofit of Fatigue Cracks in Steel Bridges
- NHI Engineering for Structural Stability in Bridge Construction
- Manual of Refined Analysis
- Guide for Heat-Straightening of Damaged Steel Bridge Members
- Various Technical Advisories, Memos, and Ongoing Research
  - Clarification of Requirements for Fracture Critical Members (Memo)
  - Field Data Collection of Truck Spray (Research)

Other FHWA Technical Resources

FHWA Office of Bridges and Structures - http://www.fhwa.dot.gov/bridge/

- **NHI Analysis and Design of Skewed and Curved Bridges with LRFD**
  - Reference Manual you get when you take the NHI class 130095
- AASHTO LRFD 5th Edition
- Chapters include
  - Evolution of Curved Girder Design Specifications
  - Structural Analysis Topics
  - Design Considerations
  - Fabrication and Construction Considerations
  - Two Design Examples
    - Skewed and Curved I-girder bridge
    - Tub girder bridge



- Summary

Smarter.
Stronger.
Steel.

Summary

Introduced/Reviewed Several Steel Bridge Design Resources

- AASHTO/NSBA Collaboration Guidelines and Specifications
  - Guidelines for Design Details (G1.4-2006)
  - Guidelines for Design for Constructability (G12.1-2016)

- NSBA Design Resources
  - Continuous Span Standards
  - Steel Span Weight Curves

Summary

Introduced/Reviewed Several Steel Bridge Design Resources

- NSBA Technical Resources
  - NSBA Bolted Field Splices for Steel Bridge Flexural Members
  - NSBA Skewed and Curved Steel I-Girder Bridge Fit
- NSBA Design Resources
  - NSBA SIMON
  - NSBA Splice Spreadsheet
- NSBA Steel Bridge Handbook
- Other FHWA Resources

Learning Assessment

Question: Which of these documents provides guidance regarding the detailing of cross frames and girders in a steel bridge superstructure?

A – FHWA Steel Bridge Design Handbook Chapter on Bracing System Design

B – NSBA White Paper on Skewed and Curved Steel I-Girder Bridge Fit Paper

C – NSBA Continuous Span Standards

D – NSBA Bolted Field Spice Design Examples

Learning Assessment

Question: Which of these documents provides guidance regarding the detailing of cross frames and girders in a steel bridge superstructure?

B – NSBA White Paper on Skewed and Curved Steel I-Girder Bridge Fit Paper

Thank You

Vin Bartucca

Bartucca@aisc.org

857-337-7108

www.aisc.org/nsba/

Smarter. Stronger. Steel.