Updates to Preferred Practices

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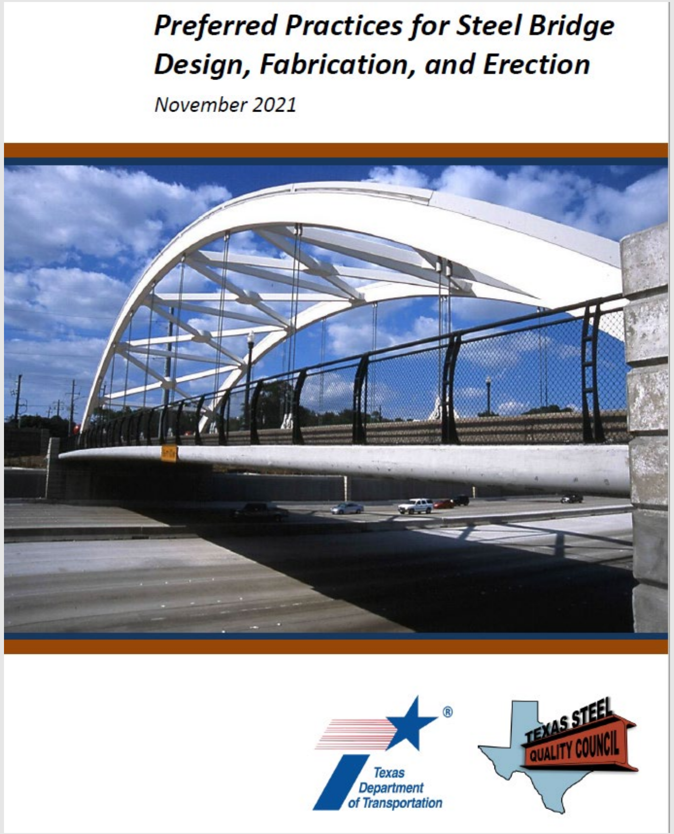
November 22, 2021

TxDOT Preferred Practices Document

- Previous version from June 2019
- November 2021 update is released
- Documents guidelines for steel bridges in Texas that Engineers should follow
- https://ftp.dot.state.tx.us/pub/txdot-info/library/pubs/bus/bridge/steel_bridge.pdf



Section 2.1.5: Expansion Joints

See TxDOT standard drawings SEJ-B and SEJ-M, "Sealed Expansion Joint Type B (Without Overlay) and Sealed Expansion Joint Type M (Without Overlay)," for strip seal expansion joint details. TxDOT prefers the joint on the SEJ standards for most bridges. Ensure slab depth is adequate for this joint. Reference the memo for the updated expansion joint details and associated "Bridge Expansion Joints Guidance" provided here: Revised Misc and Retaining Wall Standard Drawings Memo 2-13-20. The SEJ-M is likely preferred over the SEJ-B given the greater expansion capability of the 5" SEJ-M, the potential greater durability of a mechanical bladder attachment, and the typical greater thermal expansion of longer span steel steel bridges.

- TxDOT is researching and implementing
  - Semi-integral abutments
  - Seamless bridges

Section 2.1.7: Available Length of Material

Recent publications that have provided guidance on mill plate availability limits include:

- Plate Availability | American Institute of Steel Construction (aisc.org)
- Steel Plate Availability for Highway Bridges (Modern Steel Construction Sept 2011)

As noted, plate exceeding 85 feet length are not feasible, and shorter lengths may be need for thicker plate or fracture critical material. TxDOT has dropped requirements/notes prohibiting shop splices is specific span length zones. Consult a fabricator or steel mill on typical length limits. These limits vary from mill to mill and with material type and thickness.

Section 2.1.7: Available Length of Material

BRIDGES > DESIGN AND ESTIMATING > PLATE AVAILABILITY

Plate Availability

THE LENGTH AVAILABILITY for the various plate widths and thicknesses is a very common question engineers have when designing highway structures. Understanding availability of plate material while performing design iterations will ensure that the material used can be sourced from all steel mills and result in better economy for the overall bridge superstructure.

View the tables below and check out our *Modern Steel Construction* article **Steel Plate Availability for Highway Bridges**.

Table 1.4.1.A: Example Maximum Plate Length Availability ASTM A709 Grades 36, 50, 50W (all dimensions in inches)

Plate Thickness	Plate Width				
	72	84	96	108	120
½	972	972	972	972	972
¾	1035	1035	1035	1035	1035
1	1035	1035	1035	980	808
1½	1035	1035	1035	720	680
2	1035	1035	1035	720	680
2½	1035	1006	880	720	680
3	970	838	734	652	587
3½	830	920	800	635	600
4	720	800	685	600	600

Notes: Widths and thicknesses are grouped for convenience. Other widths and thicknesses are available in similar lengths. Interpolate between adjacent values for other size plates. Material in the shaded area is currently available from three domestic rolling mills.

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Steel Plate Availability for Highway Bridges

BY CHRISTOPHER GARRELL, P.E., LEED AP

An overview of plate sizes commonly produced by domestic mills.

THE LENGTH AVAILABILITY for the various plate widths and thicknesses is a very common question engineers have when designing highway structures. Understanding availability of plate material while performing design iterations will ensure that the material used can be sourced from all steel mills and result in better economy for the overall bridge superstructure.

The information listed below is not intended to be an all-encompassing summary of available plates that a mill may be able to produce. It is instead intended to provide a look at plate availability across the steel mills within the United States by width, thickness and length, as shown in Figure 1. Other widths, thicknesses and lengths may be available from one or more of these producers. In cases where a dimension is not shown, one should consult the steel mill or a local steel bridge fabricator. For specific contact information, please contact your local NSBA Regional Director (see sidebar). Alternatively, the AISC Steel Solutions Center can assist you by phone at 866.ASK.AISC and online at www.aisc.org/askaisc.

The tables that follow outline availability of A709-50 and A709-50W for non-fracture critical applications only. All units are in inches unless otherwise specified.

Fig. 1: The rationalization of plate availability.

Availability and Relative Cost

Steel plate producers in the United States are ArcelorMittal, Evraz, Nucor and SSAB. Geographically, most steel plate mills are located within the eastern third of the United States as shown in Figure 2. Despite their location, many plate providers will choose to equalize on freight or meet a competitive price depending on their target markets.

Fig. 2: Plate mill locations in the United States.

Usable Area

The source plate from which each component of a steel plate girder is cut and fabricated is referred to as the "mother" plate. Given the variability of plate squareness and the thickness of each cut, the net usable area of a mother plate is reduced. For example, consider the haunched girder section shown in Figure 3.

Section 2.2.2.5: Lateral Bracing

2.2.2.5. Lateral Bracing

Although some curved structures may require lateral bracing, only use where absolutely necessary. If possible, it is better to increase the flange thickness. Lateral bracing creates fatigue-sensitive details, is costly to fabricate, and difficult to install. Longer or tight radius spans may warrant some form of permanent or temporary form of lateral bracing to resist wind or torsional loads prior to the placement of the concrete deck.

- Added a last sentence indicating possible need (emphasis possible/sparingly)
- Will discuss additional in Addisu Tilahun's presentation on wind loads during construction

Section 2.2.11: Steel Span to Weight Ratios

2.2.11. Steel Span to Weight Ratios

NSBA has published Steel Span to Weight Curves as a quick method to determine the weight of structural steel per square foot of bridge deck for straight, low skew, plate girder bridges. These can be used as a reality check on the efficiency of a given design. These are published here: NSBA Steel Span to Weight Curves.

- Tool to be used as a reality check on designs

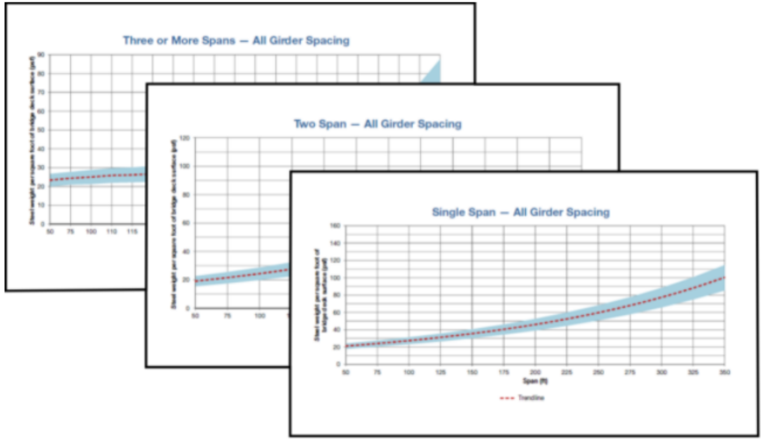
Section 2.2.11: Steel Span to Weight Ratios

Steel Span to Weight Curves

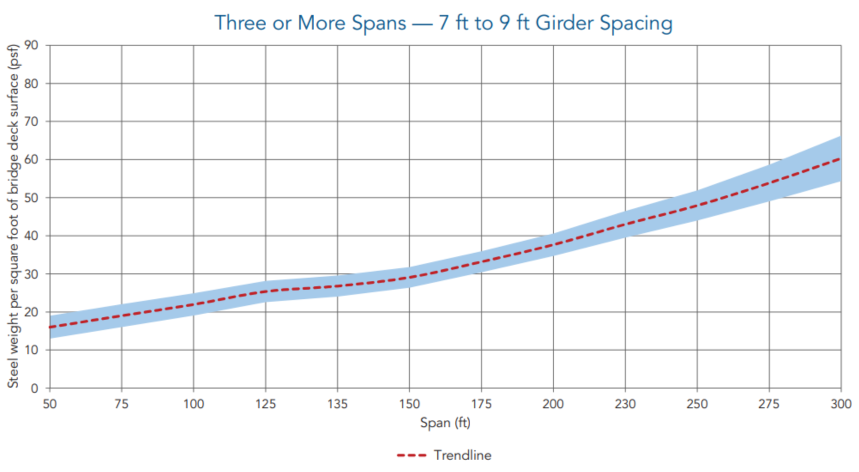
The Steel Span to Weight Curves are the quickest way to determine the weight of steel per square foot of bridge deck for straight, low skew, plate girder bridges. The Curves are organized by span arrangement (1, 2 or 3 or more span bridges) and girder spacings.

To use the graphs first determine the bridge span arrangement, then, utilizing the maximum span, find that value along the "x"-axis. Draw a line straight up until reaching the curve. Follow that line over to the "y"-axis to find the steel weight per square foot of bridge deck.

The curves are great for comparing various span arrangements and girder spacings. With some additional information the weight per square foot can easily be converted to a potential dollar value for the steel superstructure. The curves are based upon over 800 preliminary designs the NSBA has done through the years. In each instance the design was optimized for economics and is based upon standard AASHTO loading.



DOWNLOAD THE SPAN TO WEIGHT CURVES



Section 2.4.1: Flanges (of Tub Girder Sections)

Follow Chapter 3 Section 17 requirements in the *TxDOT Bridge Design Manual – LRFD* for all new two tub girder bridge designs. This is an FHWA-approved method to achieve system redundancy to avoid costly fracture critical bridge inspections.

- Now directly references the FHWA-approved criteria for new Texas twin-tub girder bridges to be considering not fracture critical
- Bridge Division is currently working on the existing inventory

Section 17 — System Redundancy Evaluation for Steel Twin Tub Girders

Structural Analysis

All two tub girder bridges must satisfy the requirements in this manual and must be evaluated for system redundancy of spans at the Extreme Event Limit State III as described in Chapter 2. Two types of analysis can be used to evaluate the Extreme Event III:

- **Approximate structural analysis**, as described in *Modeling the Response of Fracture Critical Steel Box-Girder Bridges*, Barnard et al., Research Report 5498-1, 2010 and the **Simplified Method** as described in the TxDOT Bridge Design Guide, for two tub girder bridges is permitted when:
  - Spans do not exceed 250 ft
  - Supports are skewed no more than 20 degrees
  - Horizontal curvature greater than 700 ft
  - Engineer ascertains that the use of an approximate analysis method is adequate.

  For the approximate analysis to be permitted for spans satisfying the conditions specified above, the entire self-weight of the span under consideration and the entire live load shall be assumed carried by the intact girder after the assumed fracture event. It shall also be assumed that prior to fracture, the fractured girder was carrying 50% of the total dead load and the entire live load on the bridge, and thus it shall be assumed that the bridge slab must transfer this load from the fractured girder to the intact girder.
- **Refined structural analysis**, as described in *Modeling the Response of Fracture Critical Steel Box-Girder Bridges*, Barnard et al., Research Report 5498-1, 2010, shall account for the capacity of the intact girder as well as portions of the fractured girder that can still provide structural resistance, such as interior support locations. The load distribution between the intact girder and the fractured girder shall be realistically modeled. A table of live load distribution coefficients for extreme force effects in each span is not required when evaluating system redundancy as specified in Chapter 3, Section 17 System Redundancy Evaluation for Steel Twin Tub Girders.

Section 2.6: Diaphragm and Cross-Frames

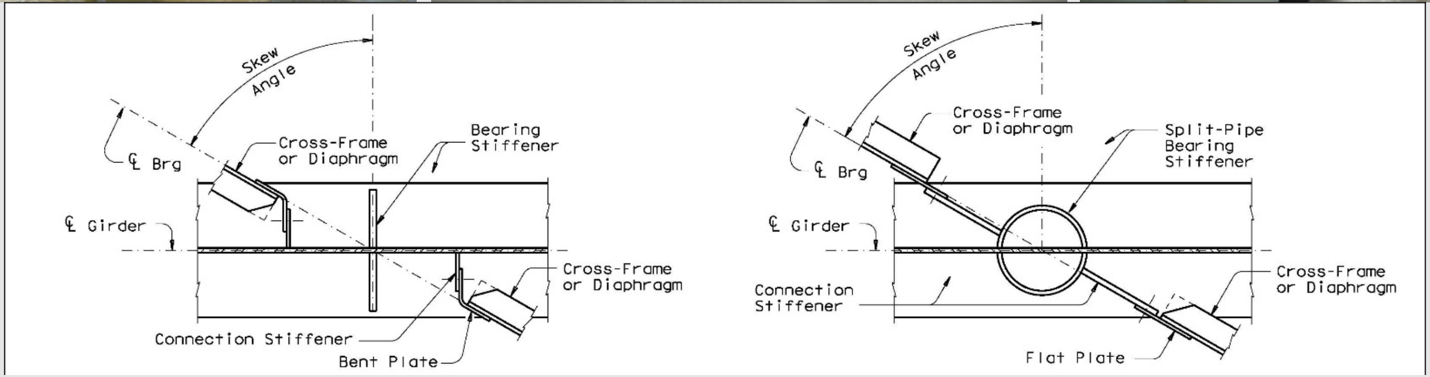
Provide diaphragms in all bays at interior bent and end bent support bearing locations of non-skewed bridges. Generally, these diaphragms will frame with the bearing stiffeners and provide essential stability and transfer of lateral loads to the substructure. Consider K-frame diaphragms in shallower cross-sections where effectiveness of X-frames may be impacted by beam spacing to depth ratio, especially at dapped girder ends. See Section 2.6.3 for diaphragm considerations at bearings in skewed bridges.

2.6.3. Diaphragm and Cross-Frame Plan Orientation

Standard drawing SGMD indicates that diaphragm/cross-frame lines at end bearings are parallel to the skew up to a 20-degree skew. Between 20- and 45-degree skews, diaphragm/cross-frame lines at end bearings are not quite parallel to the centerline of bearing, unless the split-pipe stiffener detail is used. Background on the split-pipe stiffener detail can be found on the SGMD standard and the following research reports and article:

- Cross-Frame and Diaphragm Layout Connection Details (0-5701-PSR)
- Cross-Frame Connection Details for Skewed Steel Bridges (0-5701-1)
- Two Halves are Better Than None (MSC July 2016)

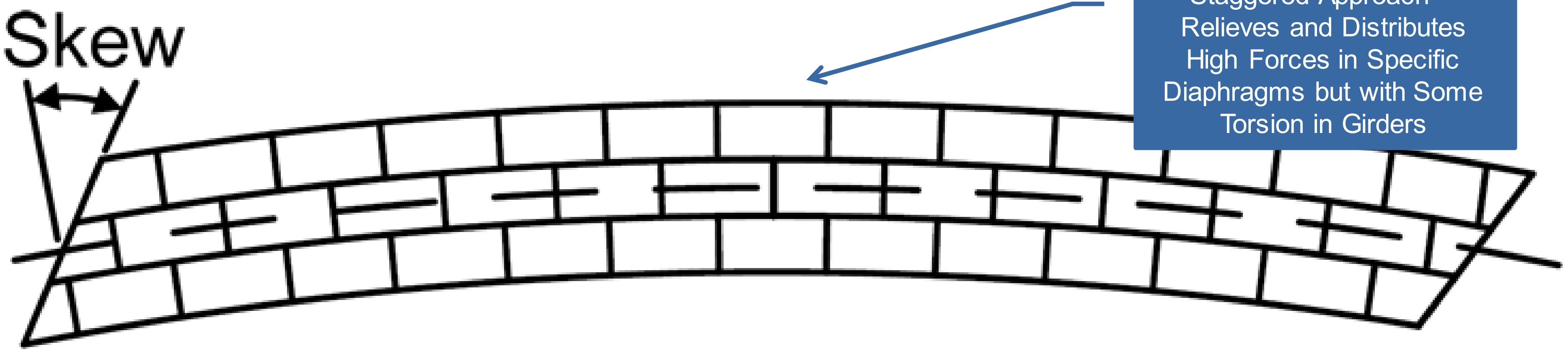
Split Pipe Stiffener (Now in SGMD Standard)

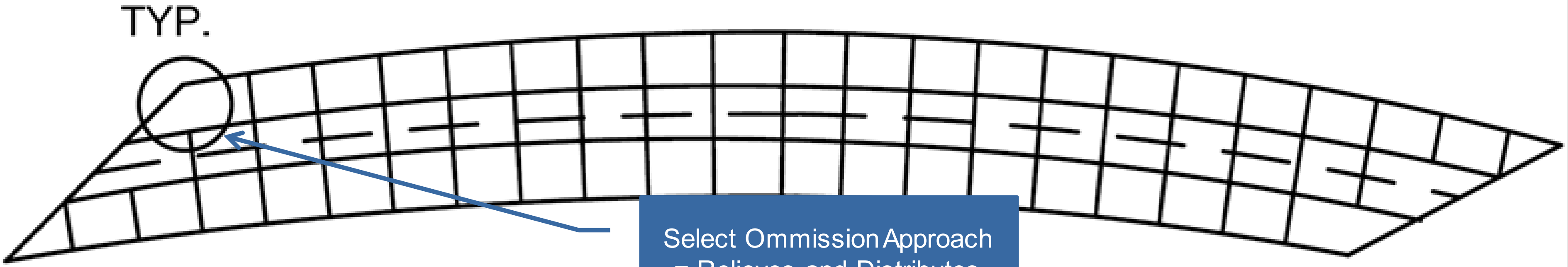


Section 2.6.3: Diaphragm and Cross-Frame Plan Orientation

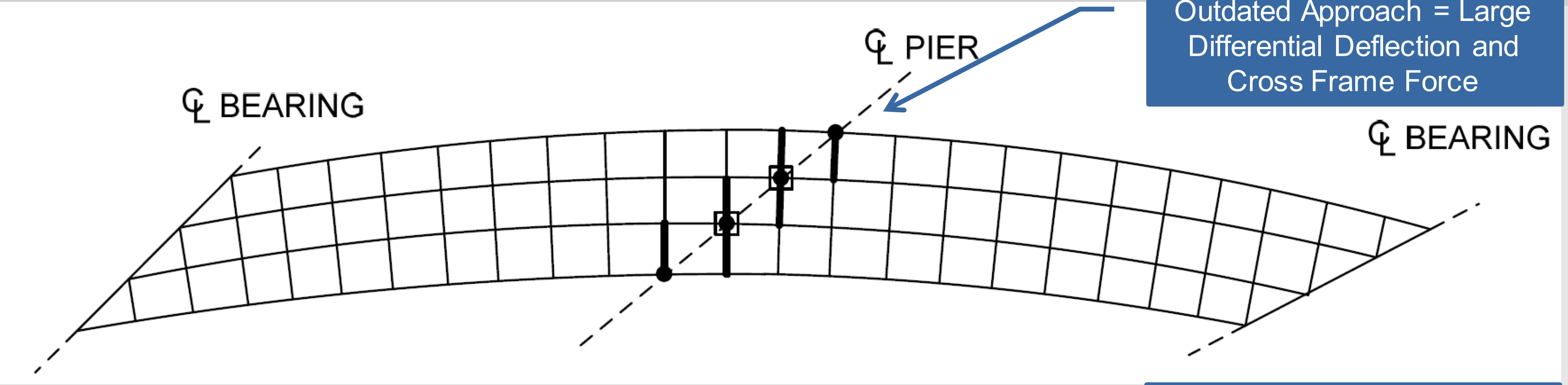
Skewed bridges with support skews over 20 degrees present additional challenges in diaphragm layout including whether to stagger or keep diaphragms lined up across the bridge. Lean-on bracing and split pipe stiffeners and skewed diaphragms at supports can help in these situations to avoid large forces in the diaphragm assemblies. Section 2.4 and 2.5 of this document, Steel Bridge Design Handbook Vol. 13 (dot.gov), as well as *NHI Course No. 130095 Analysis and Design of Skewed and Curved Steel Bridges with LRFD*, provide good information.

Section 2.6.3: Diaphragm and Cross-Frame Plan Orientation

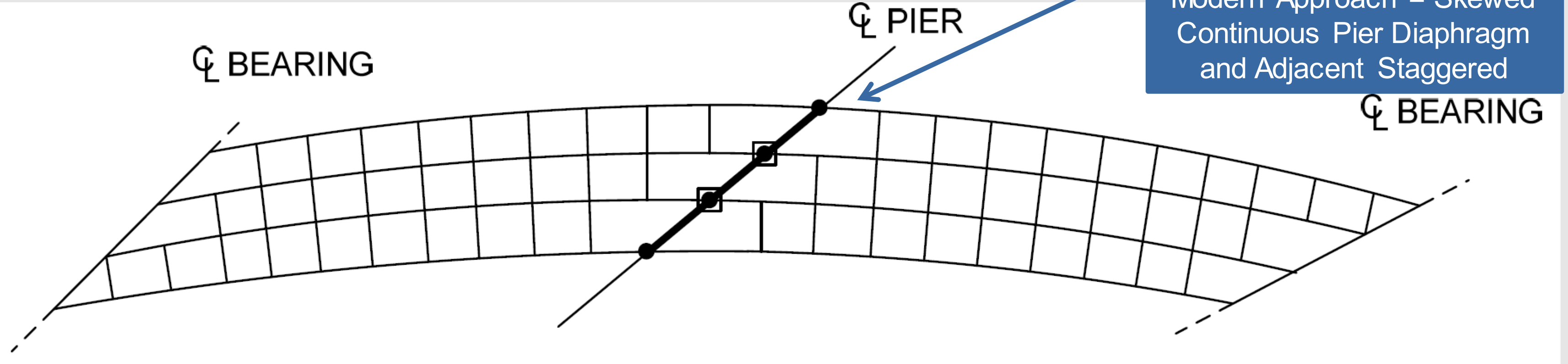




Section 2.6.3: Diaphragm and Cross-Frame Plan Orientation



Outdated Approach = Large Differential Deflection and Cross Frame Force



Modern Approach = Skewed Continuous Pier Diaphragm and Adjacent Staggered

2.6.4 Diaphragm Fit Condition for Skewed and Curved Bridges

Provide an indication of the geometric fit condition required for the diaphragms for skewed and curved bridges as required in AASHTO LRFD 6.7.2. Generally, there are three loading fit conditions:

- No-Load Fit (NLF)
- Steel Dead Load Fit (SDLF)
- Total Dead Load Fit (TDLF)

The following two documents provide recommended guidance:

- Skewed and Curved Steel I-Girder Bridge Fit (NSBA Technical Subcommittee)
- Skewed and Curve Steel I-Girder Bridge Fit (Summary)

Section 2.6.4: Diaphragm Fit Condition for Skewed and Curved Bridges

Table 1 **Common Fit Conditions**

Loading Condition Fit	Construction Stage Fit	Description	Practice
No-Load Fit (NLF)	Fully-Cambered Fit	The cross-frames are detailed to fit to the girders in their fabricated, plumb, fully-cambered position under zero dead load.	The fabricator (detailer) sets the drops using the no-load elevations of the girders (i.e., the fully cambered girder profiles).
Steel Dead Load Fit (SDLF)	Erected Fit	The cross-frames are detailed to fit to the girders in their ideally plumb as-deflected positions under the bridge steel dead load at the completion of the erection.	The fabricator (detailer) sets the drops using the girder vertical elevations at steel dead load, calculated as the fully cambered girder profiles minus the steel dead load deflections.
Total Dead Load Fit (TDLF)	Final Fit	The cross-frames are detailed to fit to the girders in their ideally plumb as-deflected positions under the bridge total dead load.	The fabricator (detailer) sets the drops using the girder vertical elevations at total dead load, which are equal to the fully cambered girder profiles minus the total dead load deflections.

Table 2 **Recommended Fit Conditions for Straight I-Girder Bridges (including Curved I-Girder Bridges with L/R in all spans ≤ 0.03)**

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 $I_s \leq 0.30$ +/-			
	Recommended	Acceptable	Avoid
Any span length	TDLF or SDLF		NLF
Skewed Bridges with Skew > 20 deg and $I_s > 0.30$ +/-			
	Recommended	Acceptable	Avoid
Span lengths up to 200 ft +/-	SDLF	TDLF	NLF
Span lengths greater than 200 ft +/-	SDLF		TDLF & NLF

Table 3 **Recommended Fit Conditions for Horizontally Curved I-Girder Bridges ($(L/R)_{MAX} > 0.03$)**

Radial or Skewed Supports			
	Recommended	Acceptable	Avoid
$(L/R)_{MAX} \geq 0.2$	NLF[1]	SDLF[2]	TDLF
All other cases	SDLF	NLF	TDLF

Note 1: The recommendation transitions to NLF at or above a maximum L/R of 0.2 because research on these types of bridges (NCHRP 2015) shows that the increase in the cross-frame forces from SDLF detailing can become more significant as the degree of curvature increases.

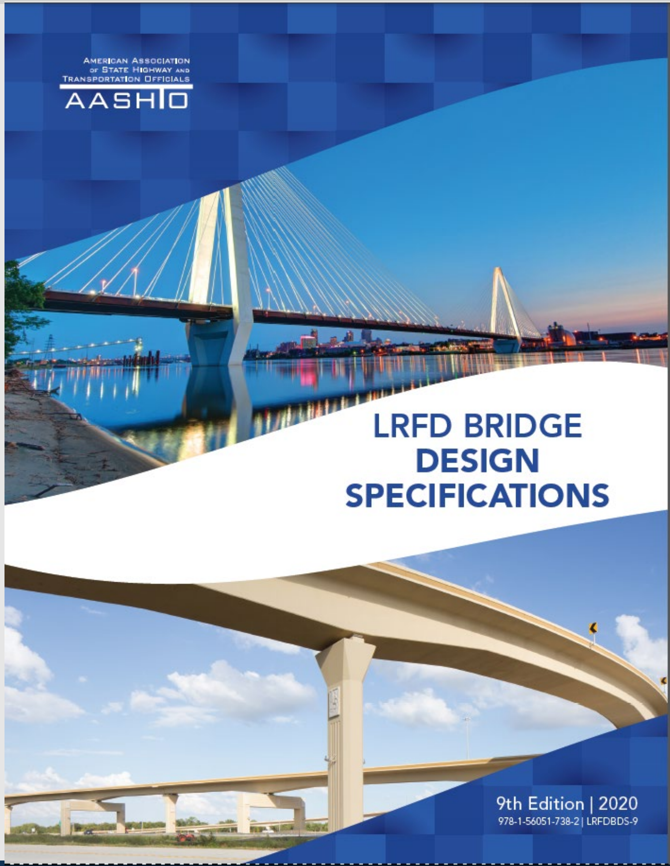
Note 2: SLDF detailing is considered acceptable in these cases if the additive locked-in force effects are considered (see Design and Analysis section below).

Other General Changes

- Changed Division reference for painting items
  - TxDOT separated the Materials and Tests function from the Construction Division
  - TxDOT Materials and Test Division (MTD)
    - Service and expertise in materials in quality and technology
    - Develops and maintains TxDOT specs and test procedures, testing materials for compliance, and administering quality monitoring and quality assurance
    - Assist in field resolution of materials related problems and implementing new or improved materials
  - Prefabricated Structural Materials Section (Jason Tucker)
  - Coatings & Traffic Materials Section (Johnnie Miller)

Other Manual and Guidance News from Bridge Division

- TxDOT Bridge Design Manual (Nov 2021)
- TxDOT Bridge Design Guide (Nov 2021)
- TxDOT Bridge Detailing Guide
- TxDOT Pier Protection Guide (a new guide)
  - Bent (Pier) Protection Guide (txdot.gov)
- Expect Webinar in Mid December



Questions?

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