Design of Long Span Steel Bridges

Hayden Porter

Texas Department of Transportation

April 25, 2025

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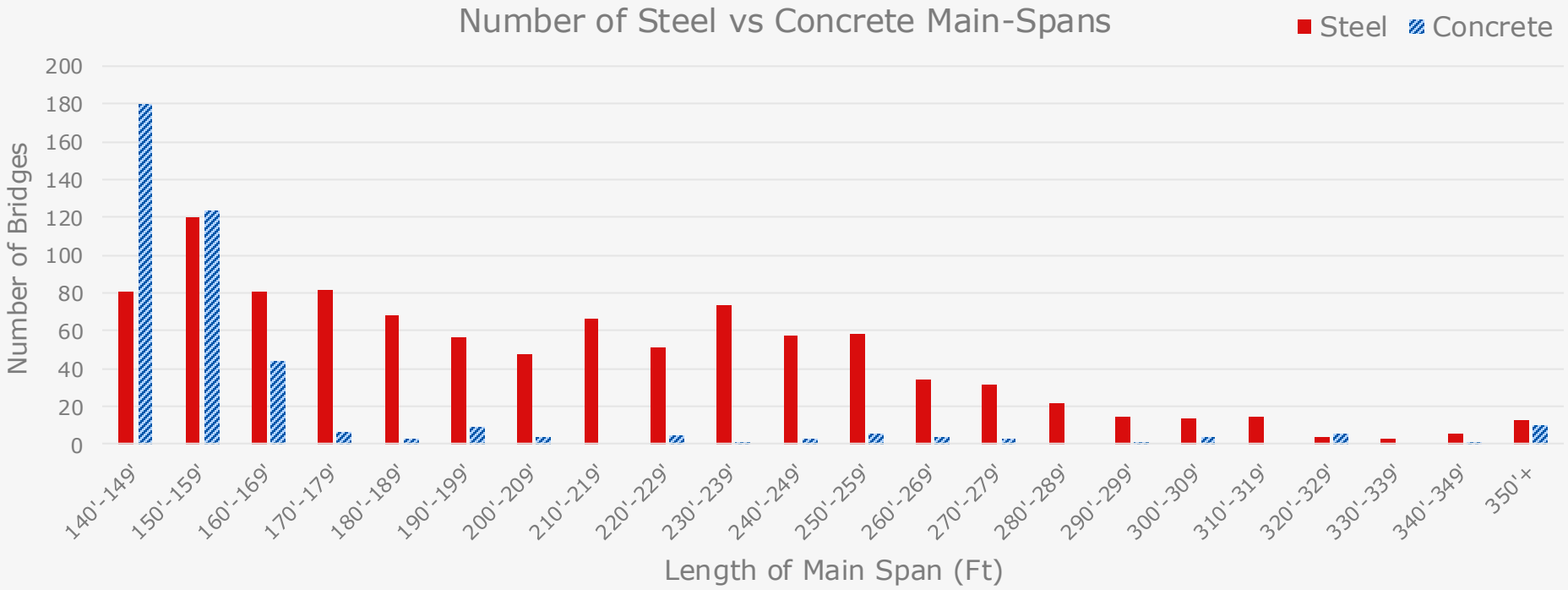
What is a Long Span Steel Bridge?

Depends on Many Variables

- Steel Bridges in Texas
- Plate Girder Superstructure (Suspension/Arched Truss)
- Structure Geometry (Skewed/Curved)

What is a Long Span Steel Bridge?



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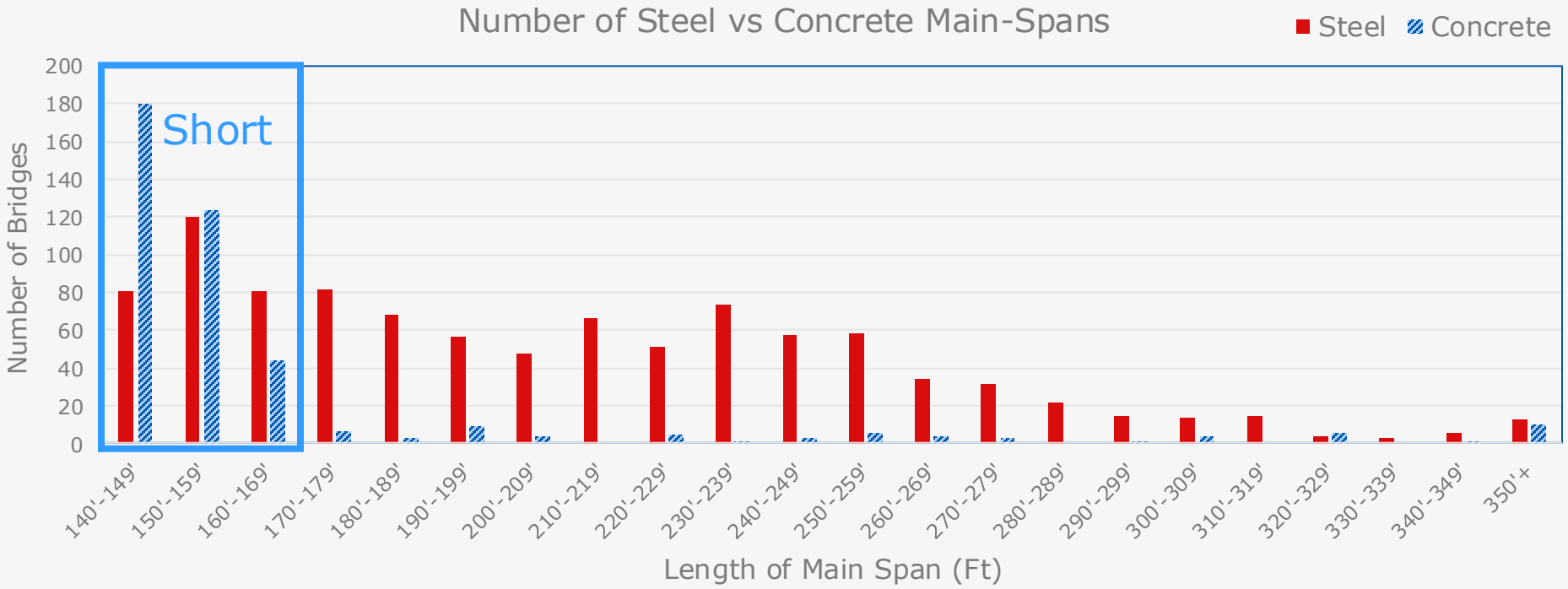

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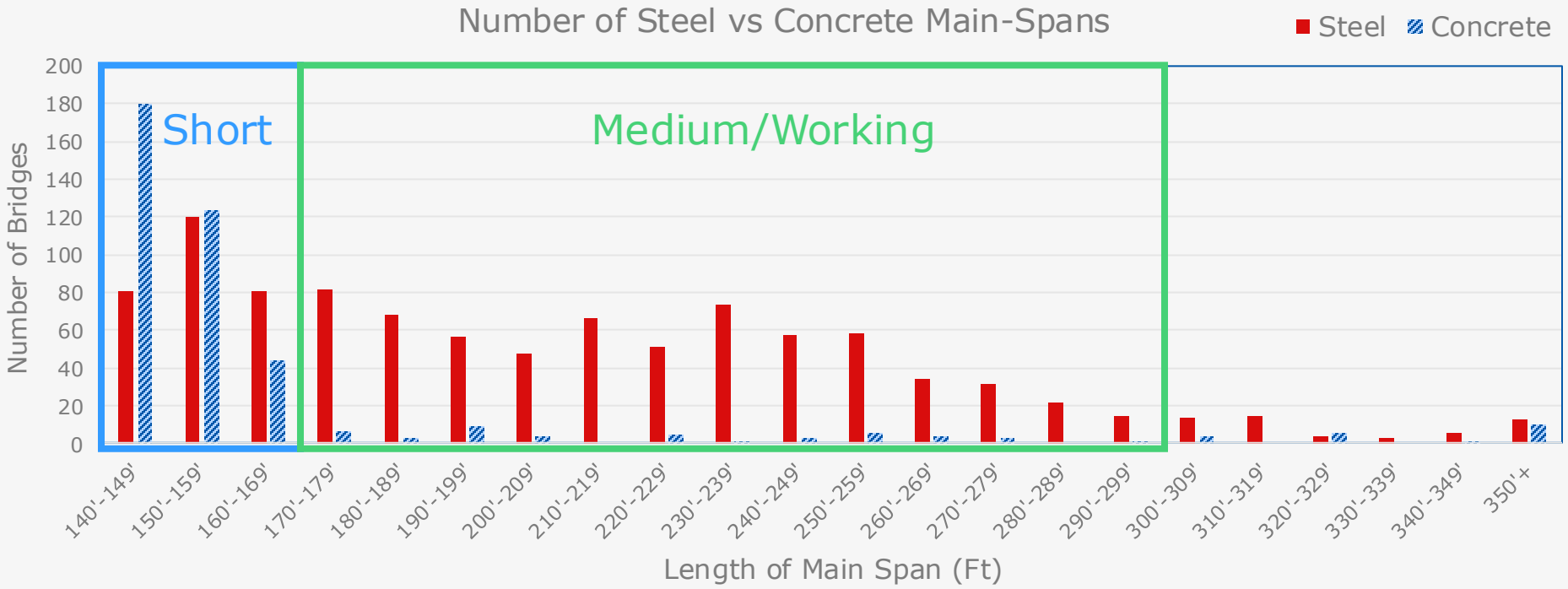

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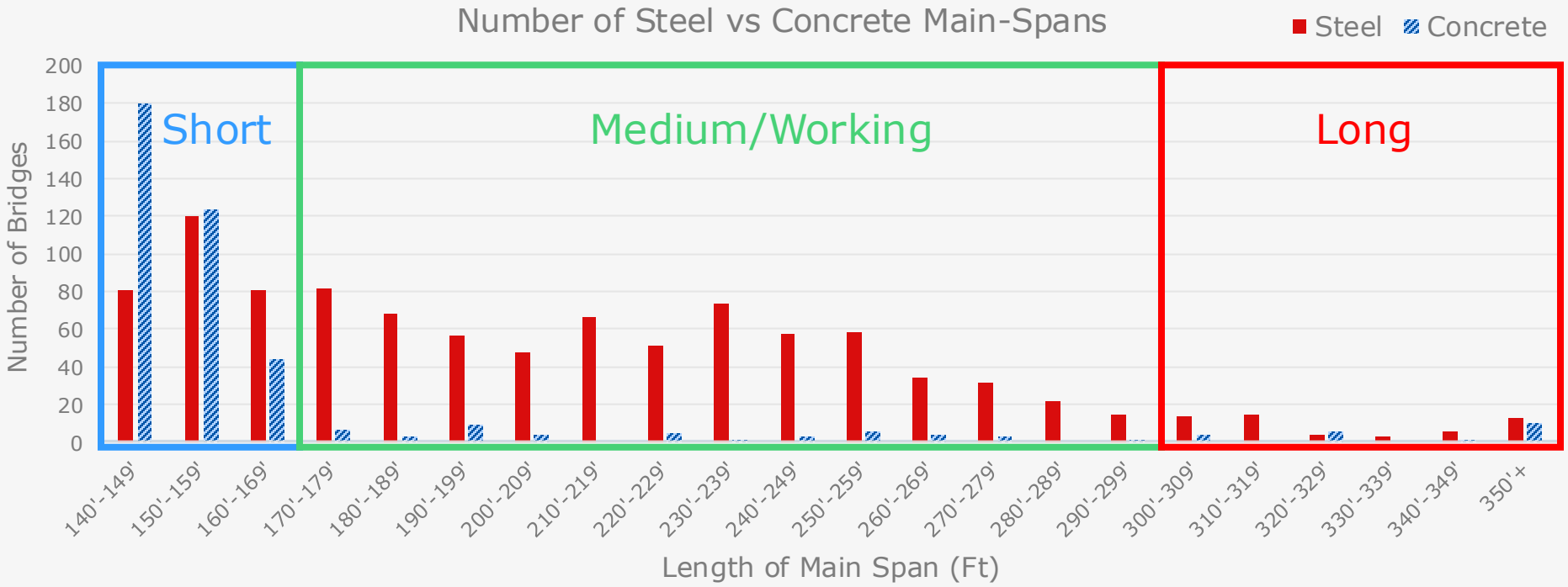

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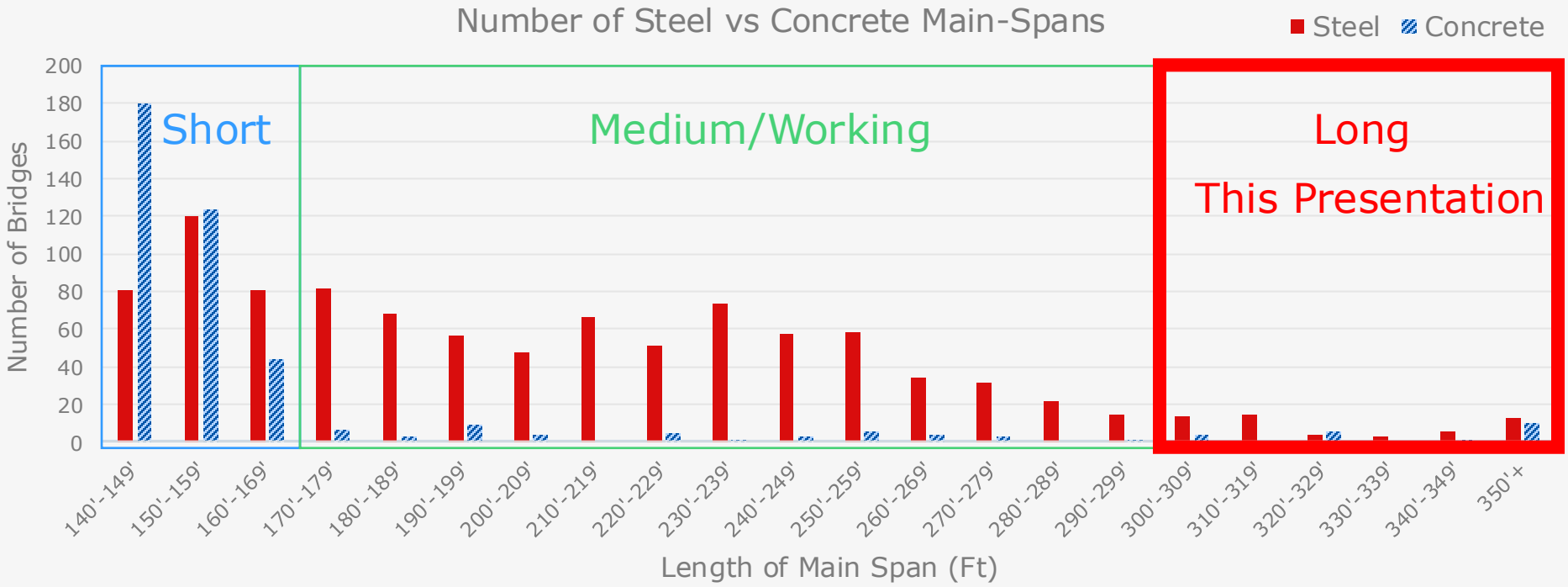


Bridge Division 30/60/90 Reviews

Bridge Division Requires that all steel bridges be submitted to BRG-PM for review at 30/60/90/100 completion intervals

- Essential to submit/perform these at the correct completion interval
- Too often we have gotten a 90% plan set at the 30% checkpoint

Bridge Division 30/60/90 Reviews

30% Checkpoint – *Bridge Layout & Typical Sections*

- Constructability
- Span/Unit Layout (Steel Efficiency)
- Skews
- Overall Scheme and Potential of Design
- Number/Location of Joints
- Span to Depth Ratio (If Possible)
- Girder Spacing (Number of Girders)
- AASHTO Span to Depth Ratios (2.5.2.6.3)
- Looking for any "Oddball" things

30%

Bridge Division 30/60/90 Reviews

60% Checkpoint – *Girder Elevations & Framing Plans* (enough info to get idea of girder design and if you're following preferred practices)

- Overall scope of girder design with relative refinement
- Following Preferred Practices???
- The more details there are → the better review we can provide → less "surprise" comments/changes at 90%

60%

Bridge Division 30/60/90 Reviews

90% Checkpoint – *All details completed*

- Following TxDOT Detailing Preferences???
- Enough in the plans for fabricators to be able to construct

90%

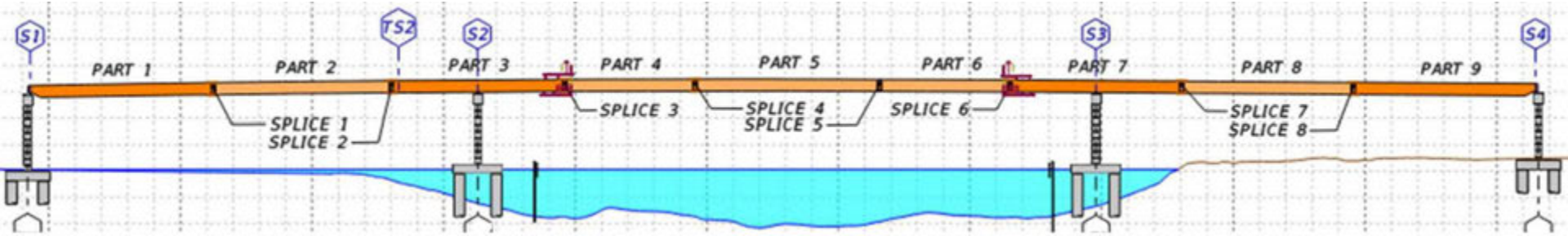
Stability During Construction

"Investigate and verify feasibility of a possible erection sequence during design and verify possible locations of shore towers and cranes." –TxDOT BDM

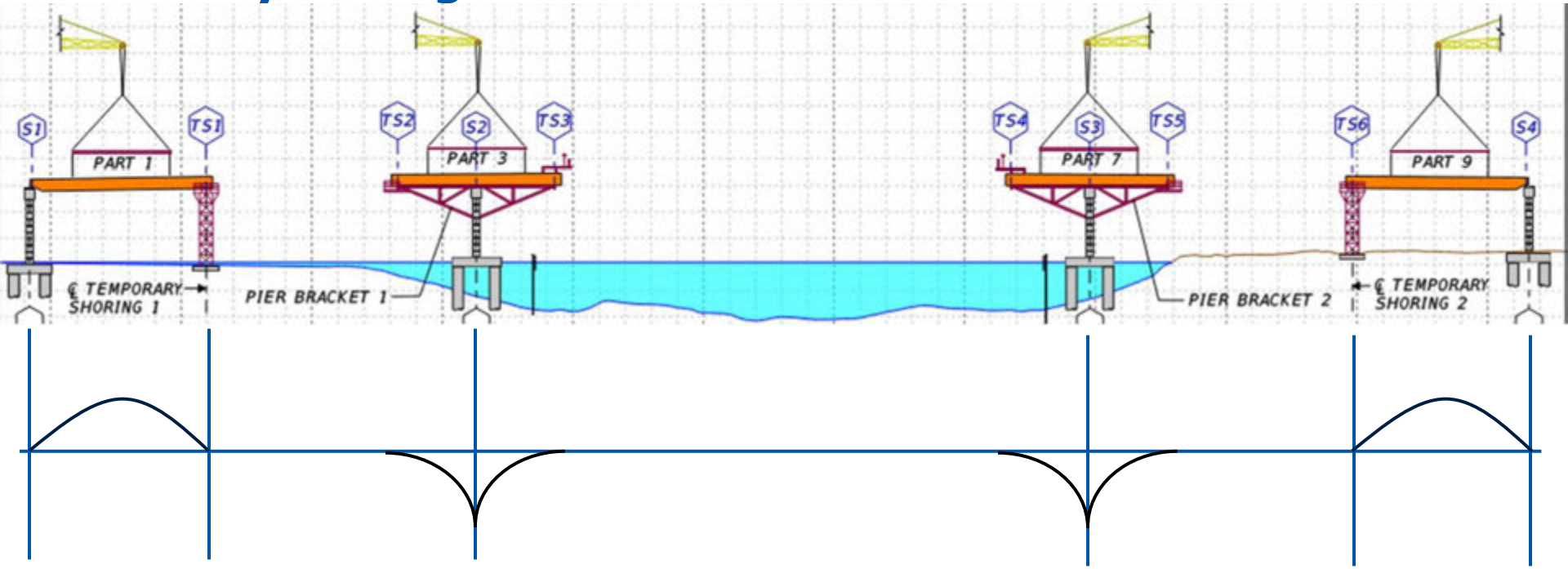
- Analyze a construction sequence during design. Some of these will control
- Place field splice at locations where shore towers will be possible
- Consult steel erector/erection engineer to ensure sequence is possible

Stability During Construction

For example…



Stability During Construction



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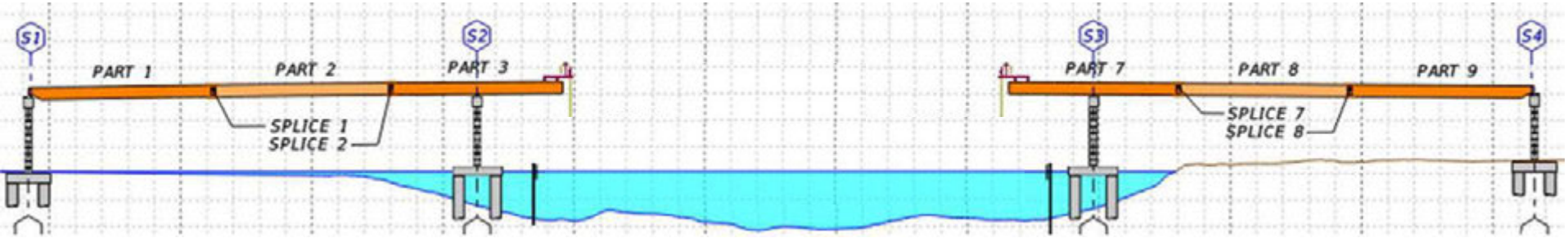

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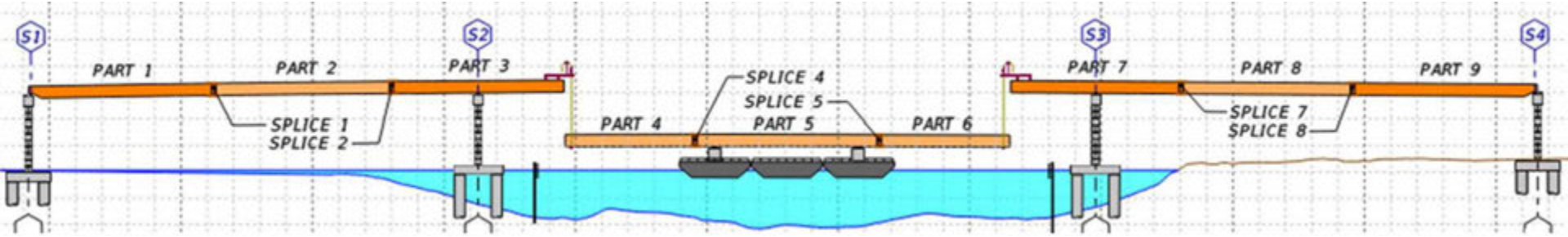

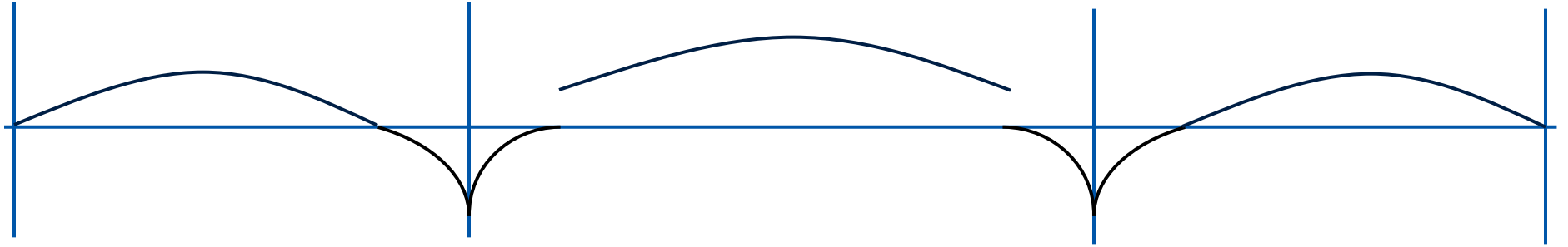

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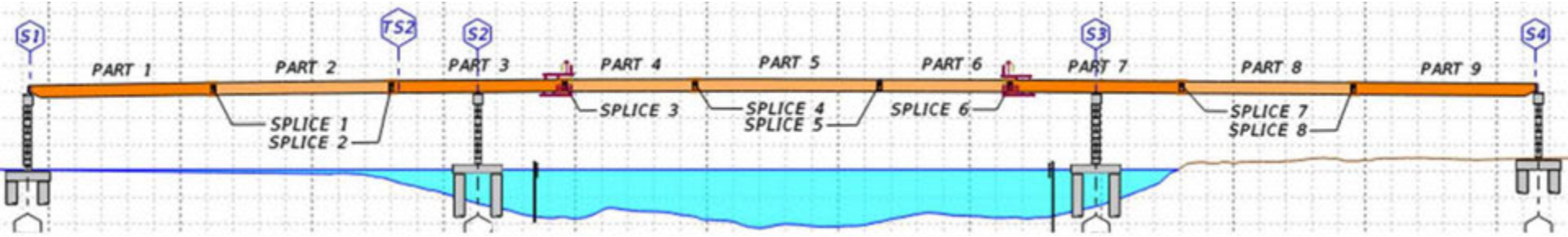
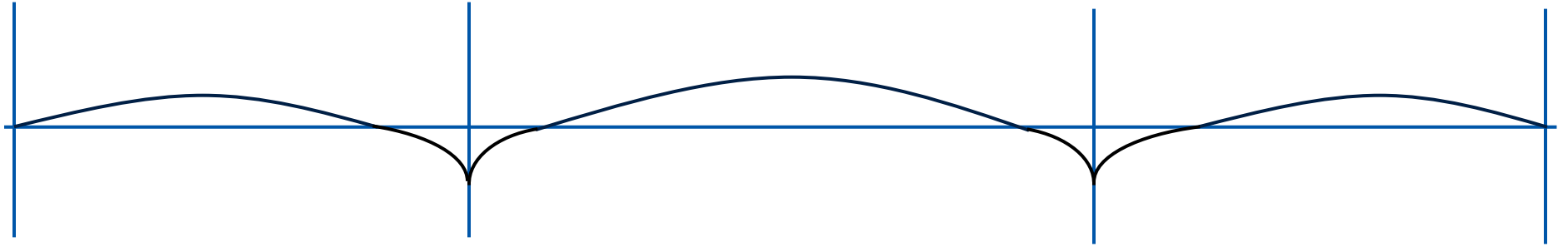




Field Splice

Strategic placement of field splices to avoid conflicts

- Field segments are limited to 140’ lengths, for transportation and lifting limitations
- Locate splices near inflection point of girder
- Consider total length of the splice plate required. Plate will interfere with your cross frame/stiffener connections if you're not careful

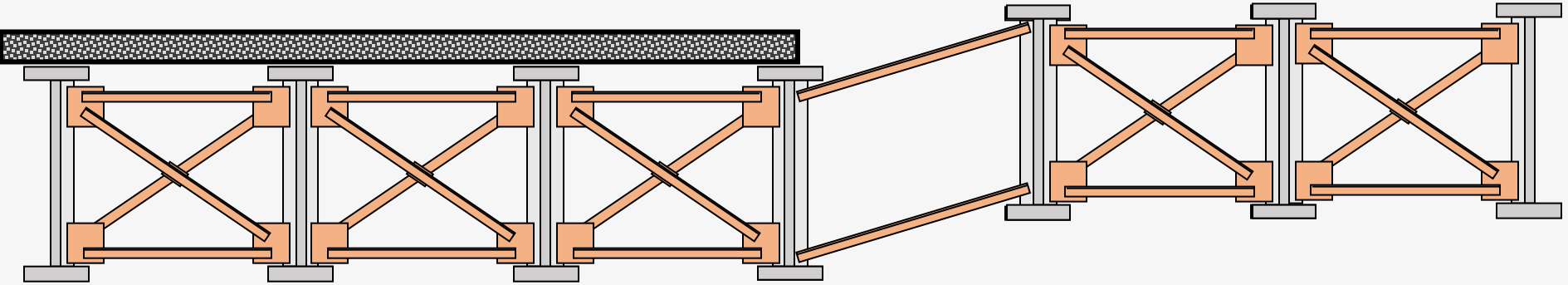
Phased Construction

Pay attention to how the different phased sections' stiffness (composite vs non-composite) play into the expected deflections

- Phase 1 alone might be very slim span, pay attention to global stability!
- A good opportunity to investigate the use of lean-on bracing in the phased bay

"While designing, think about how everything fits together – for example, how rotation, deflection…, twist, stiffness…, and skew affect interaction between different elements."
-TxDOT Preferred Practices for Steel Bridge Design

Phased Construction



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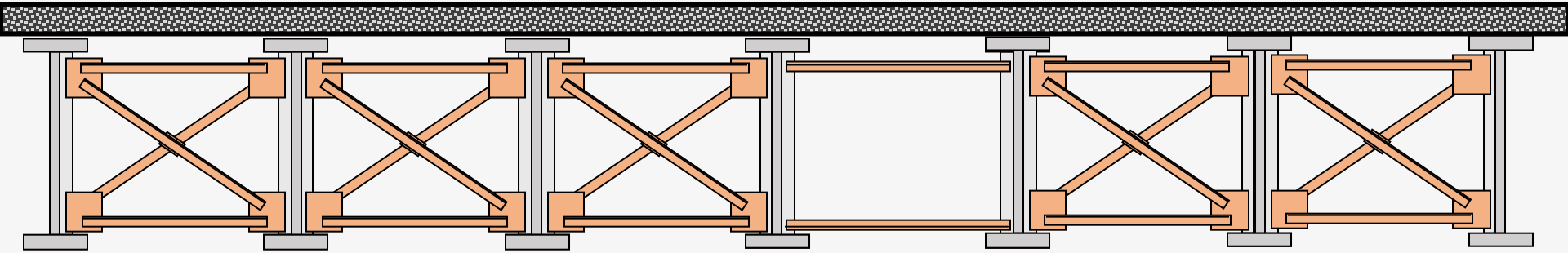

Variable vs Uniform Depth Girders

Variable Depth girders are shorter at mid span and taller at the supports. Only using beam depth where it is needed

- Helps to save material
- Useful for tight vertical clearances

Appropriate Use of Lateral Bracing

"In lieu of permanent **Bottom Flange** lateral bracing, increase bottom flange size (width) if practical…" –TxDOT BDM

-Can be needed on long or tight radius spans (only use when necessary)

- Fatigue-sensitive details
- Costly to fabricate
- Difficult to install
- Difficult to inspect
- Contact TxDOT Bridge Division – Design Section for approval

Appropriate Use of Lateral Bracing

Top Flange lateral bracing may be required to resist wind loads during construction

- Try to avoid by increasing flange size (width)
- NOT required to contact TxDOT Bridge Division – Design Section for approval

Photo credit: AISC

10’ Maximum Girder Spacing

- TxDOT standard drawings do not support girder spacings of more than 10 feet (PCP, SGTS, Empirical deck design)
- Slabs (or floor systems) cannot adequately support certain overloads
- Re-decking while maintaining traffic is more challenging

10’ Maximum Girder Spacing

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However…

10’ Maximum Girder Spacing

- Studies show that structural steel Lbs/SqFt goes DOWN as girder spacing does UP
- AISC/NSBA Standard Plans for Steel Bridges
  - Supports girder spacings of 8, 10, 12, and 14 Ft
- Use of C-C Girder spacing > 10’ is OK…
  …but……BE CAREFUL!
  - Traditional deck design REQUIRED (Signed & Sealed)
  - Use of TxDOT standards NOT permitted
  - ALL assumptions around the deck need to be verified

Independent Design Checks

May be required for complex or exotic structures

- Account for additional time/cost needed to perform review
- Contact Bridge Division – Design Section for questions if you will need on a case-by-case scenario

Photo source: https://www.freepik.com/premium-vector/superhero-comics-hero-speech-bubble-vector-illustration_31974542 8.htm

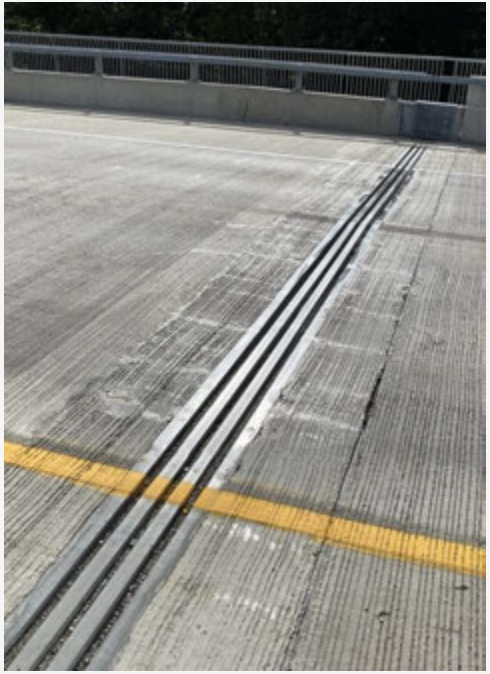
Expansion Joints

Try to limit expansion lengths to use standard strip seal expansion joints (SEJ)

- 5” SEJ-M handles many situations (accommodated movement up to 5”)

Expansion Joints

- Modular joints and finger joints are expensive, difficult to construct and maintain, and have shown poor long-term performance; use them only as a last resort
- Finger joints are slightly more familiar to us, but seem to struggle with keeping them clean and then suffer from breaking and becoming ineffective
- Modular joints are slightly more expensive, and a little more foreign to us, but seem to be performing slightly better maintenance-wise
- Contact Bridge Division – Field Operations for assistance on a case-by-case scenario

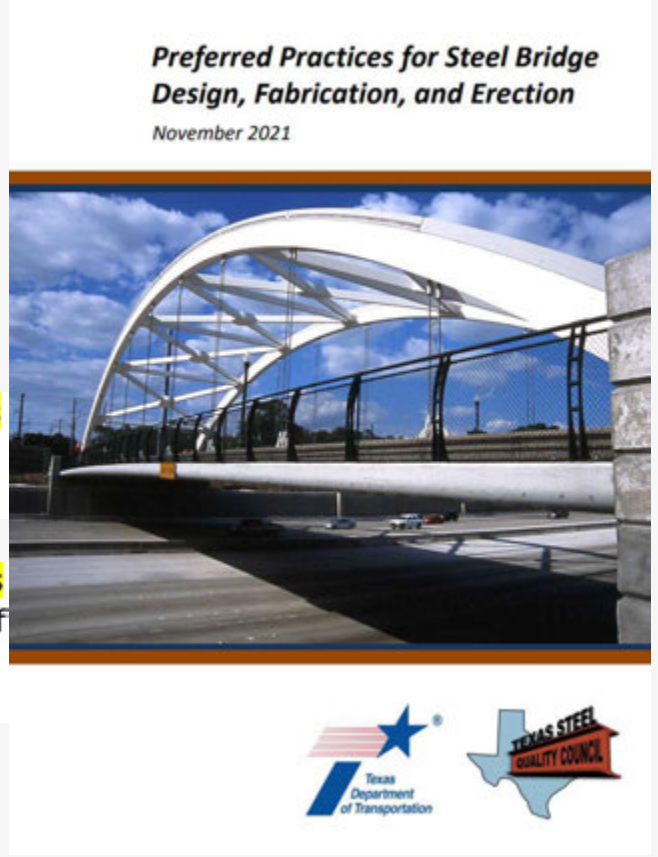


TxDOT Preferred Practice

- Valuable resource for ANY steel bridge in Texas
- Provides Guidance

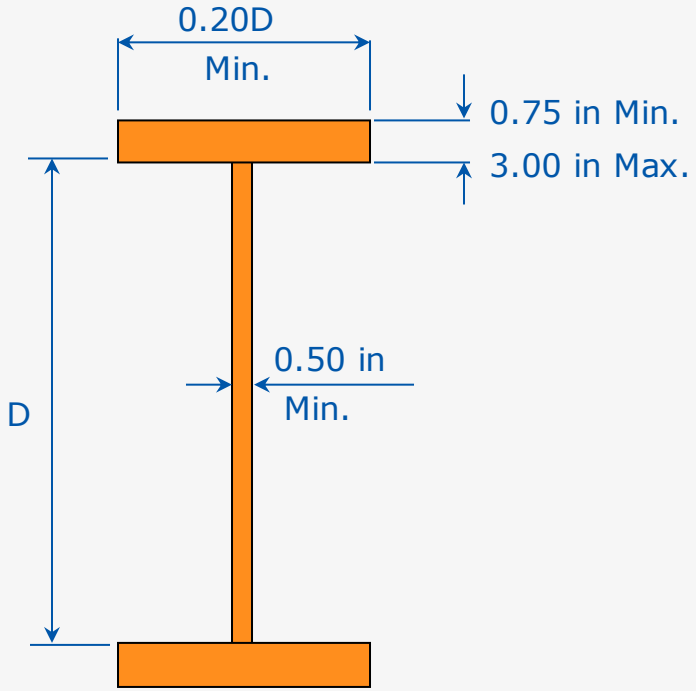
"Designs that merely satisfy design specifications are rarely good. Good designs reflect consideration of the requirements of fabrication, construction, and maintenance."

"Always provide enough access for bolting, welding, and painting. Keep designs simple by maximizing the use of common details and minimizing the number of plate sizes and rolled shapes fabricators are required to purchase. Complicated details are always hard to fabricate and build."

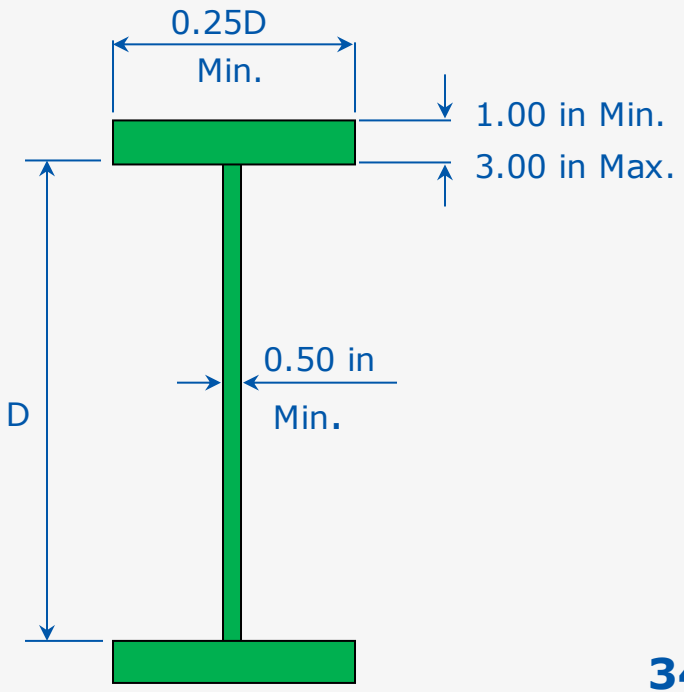


TxDOT Preferred Practice - Geometric Constraints

Straight girders



Curved girders



Limit number of different plate thicknesses, and do not use a small quantity of one flange thickness.

TxDOT Preferred Practice - Geometric Constraints

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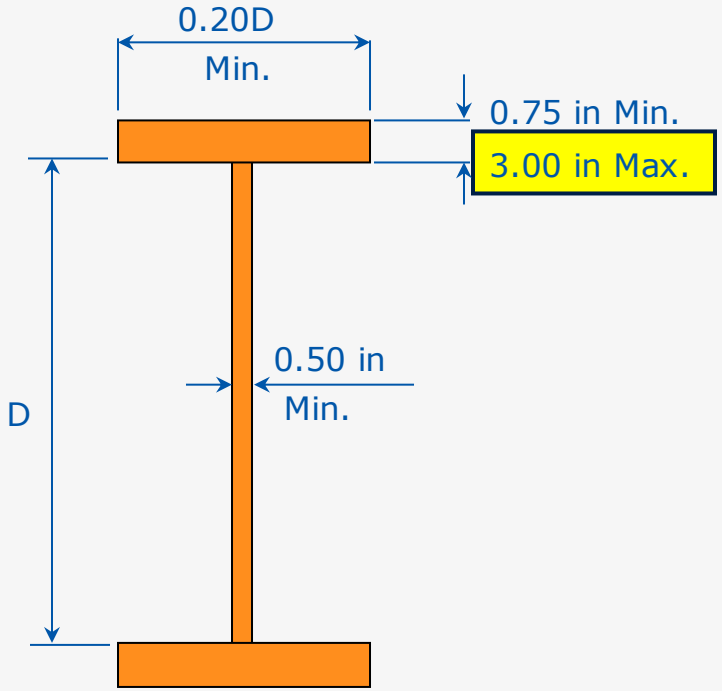

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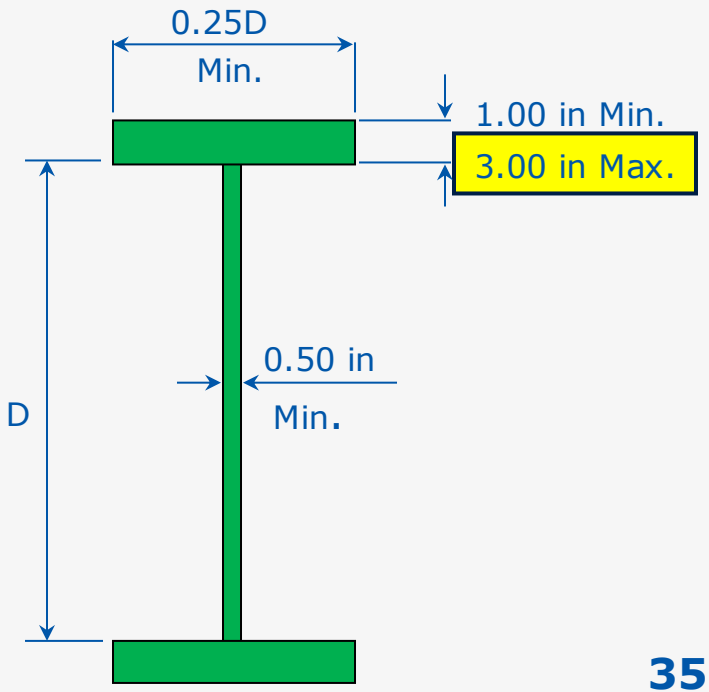

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TxDOT Preferred Practice - Geometric Constraints

- "Overall girder depth should not exceed 10' for ease of shipping." -2.2.1.0.4 Preferred Practices…
- Not always possible…
  - Vary girder depth to limit sections that exceed 10'
  - Consider use of OPTIONAL bolted longitudinal splice
- Longitudinal stiffeners only allowed in girders with web > 10'

Photo credit: Tony Ream

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Conclusions

- Stability During Construction (Investigate Constructable Construction Sequence)
- Field Splice (Plan Ahead for Locations)
- Phases/Widenings (Stability/Fit-up Details)
- Variable Depth Girders (Saves Material/Vertical Clearance)
- Lateral Bracing (Bottom Flange vs. Top Flange)
- 10’ Girder Spacing (TxDOT Standards/Assumptions)
- Independent Design Checks (Likely Needed)
- Expansion Joints (Modular/Finger as Last Resort)
- TxDOT Preferred Practices (Geometric Limitations/Useful Resource)

Questions?

Hayden Porter, P.E.

BRG-DES@txdot.gov

TxDOT Bridge Division - Design