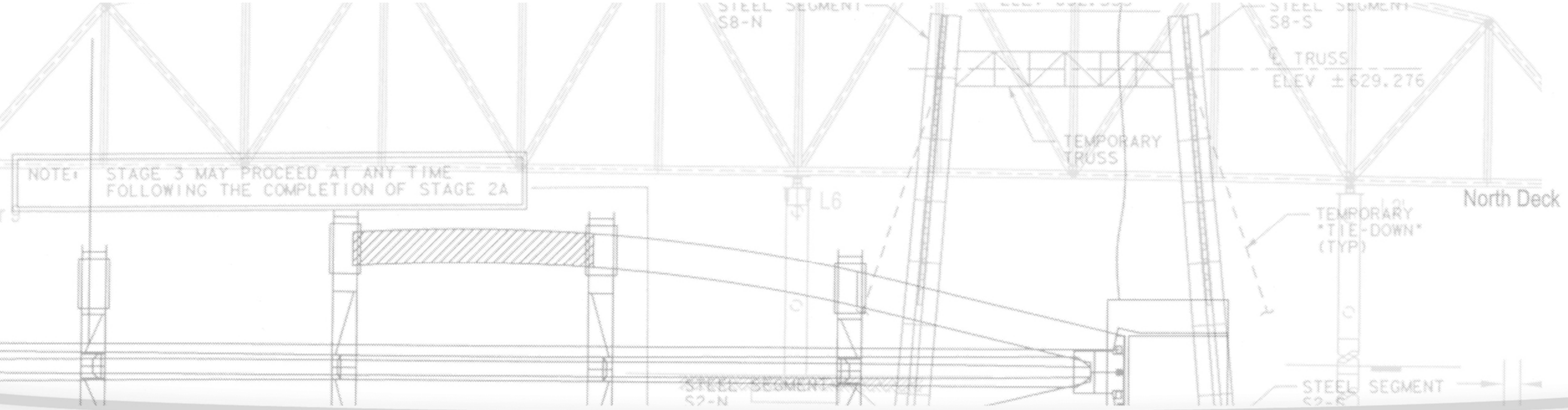


STEEL BRIDGE ERECTION & CONSTRUCTIBILITY

A CONSTRUCTION ENGINEER'S PERSPECTIVE

National Steel Bridge Alliance (NSBA)

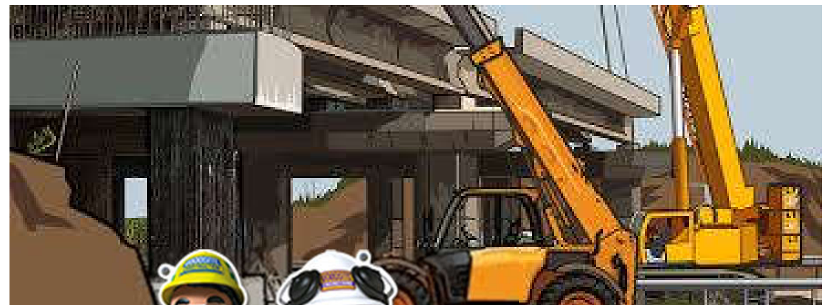
Minnesota DOT / 2021 NSBA Steel Bridge Forum

Presentation Overview

- Contractors and the 3-C's
- Constructability of Superstructures
- Design Loads for Temporary Structures
- Bridge Demolition and/or Re-decking
- Conclusions/Suggestions

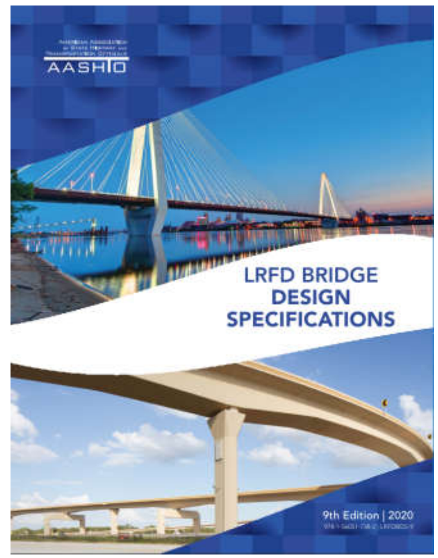
Presentation Overview

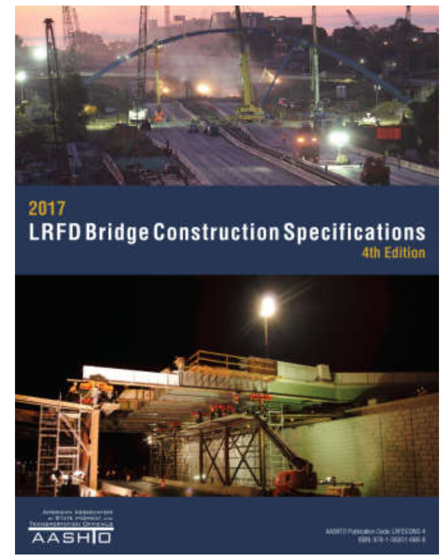
- Contractors and the 3-C's
    - Constructability
    - Costs
    - Competition
- Constructability of Superstructures
- Design Loads for Temporary Structures
- Bridge Demolition and/or Re-decking
- Conclusions/Suggestions



Presentation Overview

- Contractors and the 3-C's
- Constructability of Superstructures
  - Review of AASHTO Expectations
  - Review of Minimum Checks
- Design Loads for Temporary Structures
- Bridge Demolition and/or Re-decking
- Conclusions/Suggestions





Presentation Overview

- Contractors and the 3-C's
- Constructability of Superstructures
- Design Loads for Temporary Structures
  - Equipment
  - Environment
- Bridge Demolition and/or Re-decking
- Conclusions/Suggestions

Presentation Overview

- Contractors and the 3-C's
- Constructability of Superstructures
- Design Loads for Temporary Structures
- Bridge Demolition and/or Re-decking
  - Stability of girders with equipment removing concrete decks
  - Most Demos/Re-decking for Bridges Designed with ASD
  - How will LRFD designed bridges hold up?
- Conclusions/Suggestions

Sarah Long Demolition, Portsmouth, NH

I-75 Deck Replacement, Detroit, MI

Presentation Overview

- Contractors and the 3-C's
- Constructability of Superstructures
- Design Loads for Temporary Structures
- Bridge Demolition and/or Re-decking
- Conclusions/Suggestions

Owners
Designer Engineers

Construction Engineers
Contractors

Presentation Overview

- Contractors and the 3-C's
- Constructability of Superstructures
- Design Loads for Temporary Structures
- Bridge Demolition and/or Re-decking
- Conclusions/Suggestions

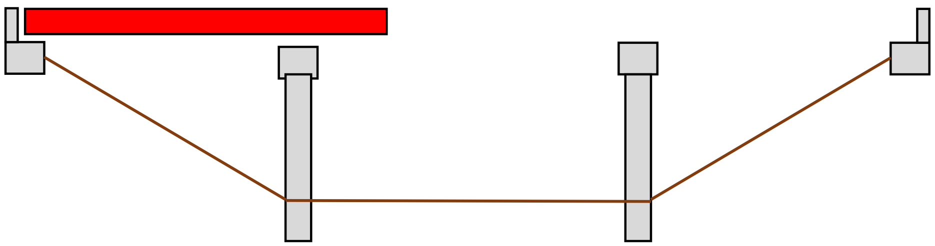
Owners
Designer Engineers

Construction Engineers
Contractors

Side Note

- Steel/Precast

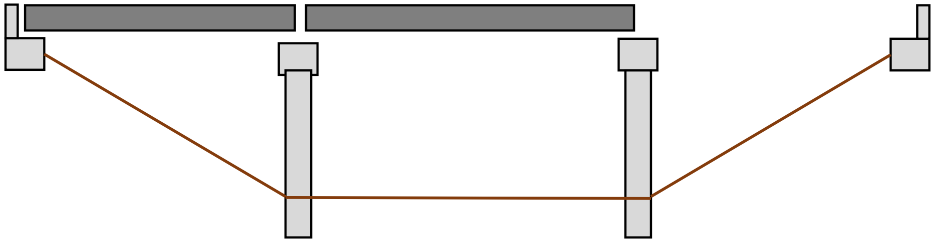
Simple 3-Span Precast Girder Bridge



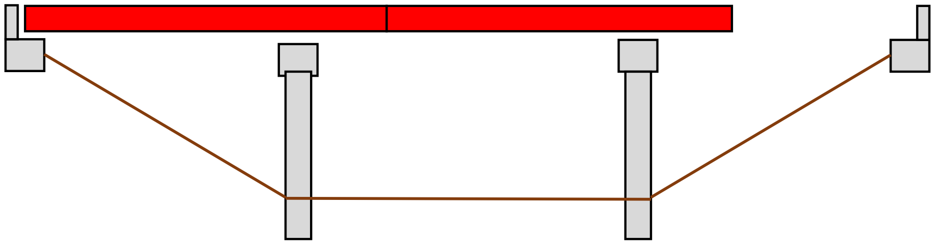
Simple 3-Span Continuous Steel Girder Bridge

Side Note

- Steel/Precast
- Similar
  - Short Spans (<200 ft) / Conventional



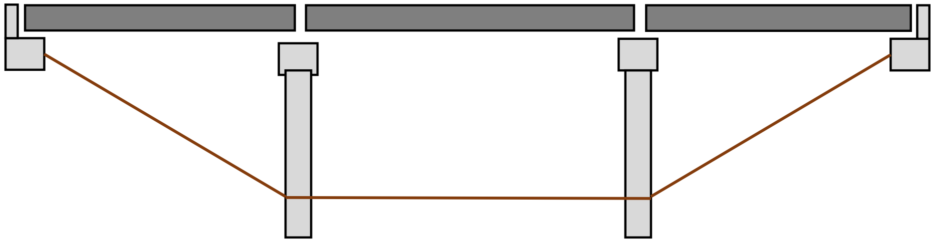
Simple 3-Span Precast Girder Bridge



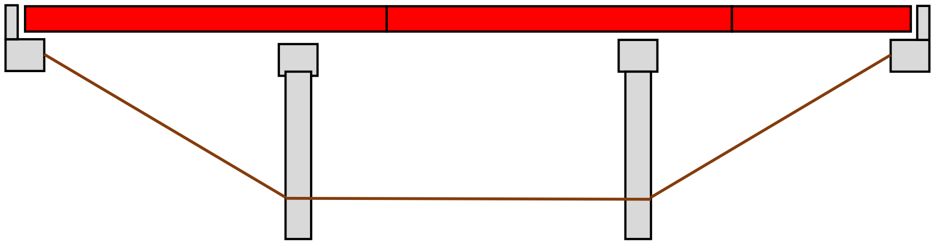
Simple 3-Span Continuous Steel Girder Bridge

Side Note

- Steel/Precast
- Similar
  - Short Spans (<200 ft) / Conventional



Simple 3-Span Precast Girder Bridge



Simple 3-Span Continuous Steel Girder Bridge

Side Note

- Steel/Precast
- Similar ….. But Different
  - Short Spans (<200 ft) / Conventional
  - Long Spans (>200 ft) / Complex

Spliced Precast

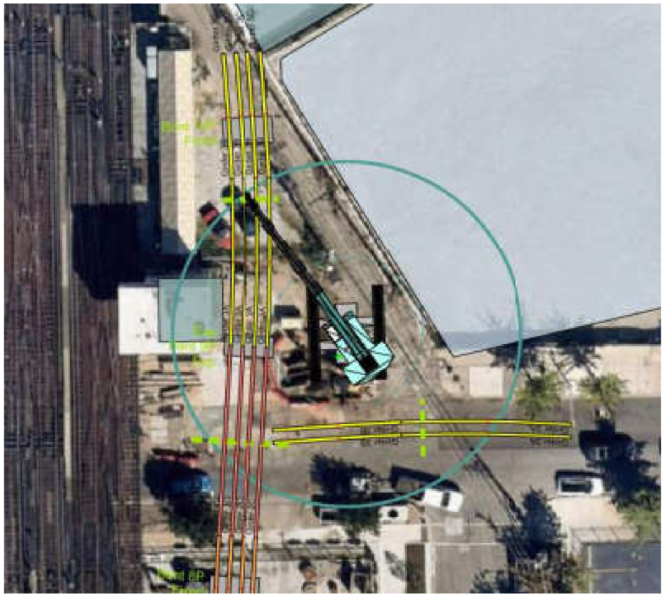
Spliced Steel

Contractors & the 3-C's

Constructability / Costs / Competition

Contractors & The 3-C's

- Constructability
  - Assessing site to determine direction and sequence of construction
    - Work from fixed pier preferred but not always possible
    - Working from one abutment to the other preferred but not always possible
    - Crane locations may be limited so girder erection must be planned ahead
    - Access may not be available so it has to be created
    - Access may not be available therefore dictating the construction method
    - Worker access must also be considered
  - Crane Sizing and Access
  - Girder Delivery



nearmap.com

Contractors & The 3-C's

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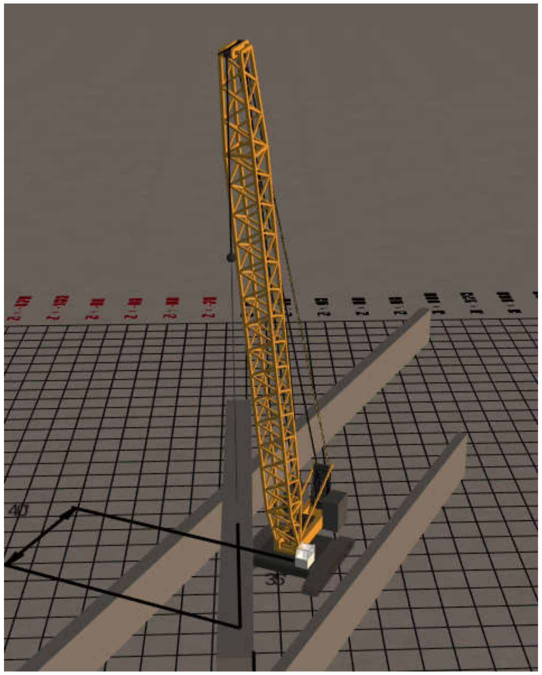

3D Lift Plan

Contractors & The 3-C's

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Whittier Memorial Bridge, Newburyport and Amesbury, MA

Contractors & The 3-C's

- Constructability
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Kate Shelly Replacement Bridge, Boone,IA

Contractors & The 3-C's

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US 20 – Iowa River Bridge

Contractors & The 3-C's

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Crum Creek Viaduct, Swarthmore, PA

Contractors & The 3-C's

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Crum Creek Viaduct, Swarthmore, PA

Contractors & The 3-C's

- Constructability
  - Assessing site to determine direction and sequence of construction
  - Crane Sizing and Access
    - What are the maximum picks?
    - What is the maximum pick radius?
    - Does the crane have clearance to make the pick?
    - Does a traditional crane even make sense?
    - How high are the girders from the base of the crane and what is the length of the required reach?
    - Land vs. water (same cranes have different capacities)?
    - Sometimes it takes an assist crane to set up the main crane
    - At the end of the day, safety is #1 priority
  - Girder Delivery

K7 over US24, Blue Springs, KS

Contractors & The 3-C's

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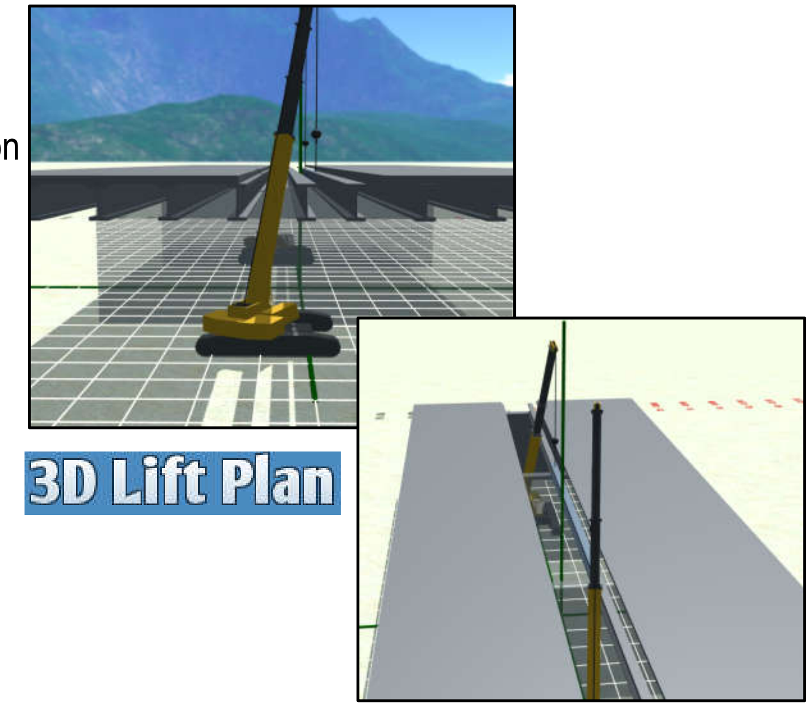

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Cleveland Innerbelt, Cleveland, OH

Contractors & The 3-C's

- Constructability
  - Assessing site to determine direction and sequence of construction
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South Omaha Bridge – 4100 Ringer Crane

Contractors & The 3-C's

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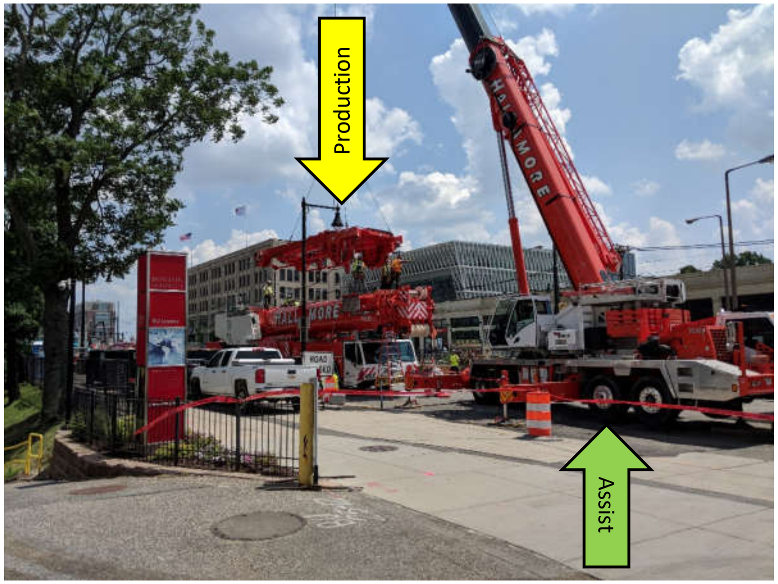

Contractors & The 3-C's

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Contractors & The 3-C's

- Constructability
  - Assessing site to determine direction and sequence of construction
  - Crane Sizing and Access
  - Girder Delivery
    - Trucks deliver directly within reach of the crane
    - Cranes may have to receive load and then walk with a load
      Crawler – Yes
      Hydraulic on Outriggers – No
    - How are girders delivered to the site?
    - Girder length, weight or delivery position may require two cranes
    - Sometimes the girders are too tall so they are delivered horizontally and require to be unloaded, set down and then tripped to vertical (two extra crane moves)

Boone County, IA

Contractors & The 3-C's

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Sandy Hook Sub Division, UPRR, MO

Contractors & The 3-C's

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Prairie Star Parkway, Lenexa, KS

Contractors & The 3-C's

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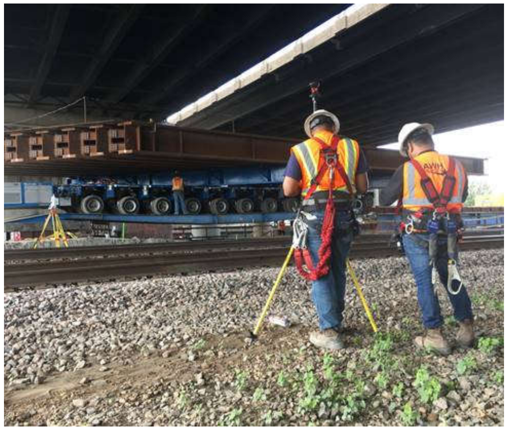

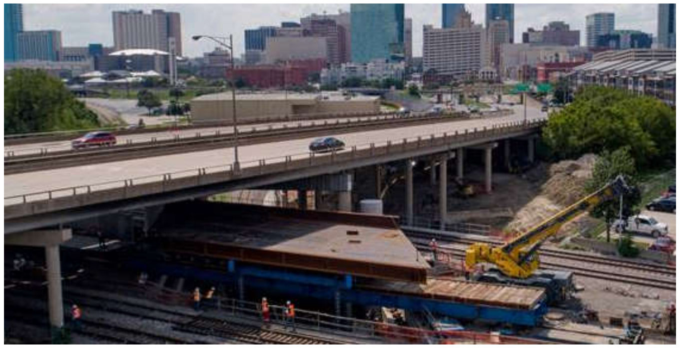

Hole In The Wall, Fort Worth, TX

Contractors & The 3-C's

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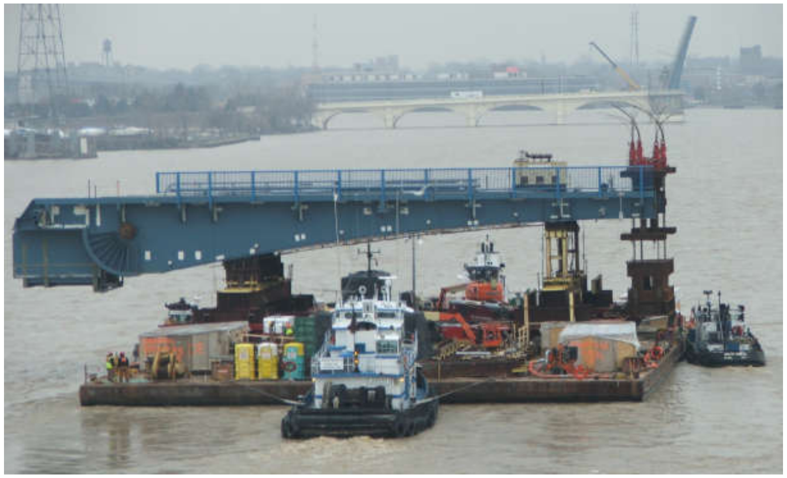

MLK Bridge Replacement, Toledo, OH

Contractors & The 3-C's

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Fore River, Quincy, MA

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KY 152 over Herrington Lake, Mercer and Garrard Counties, KY

Contractors & The 3-C's

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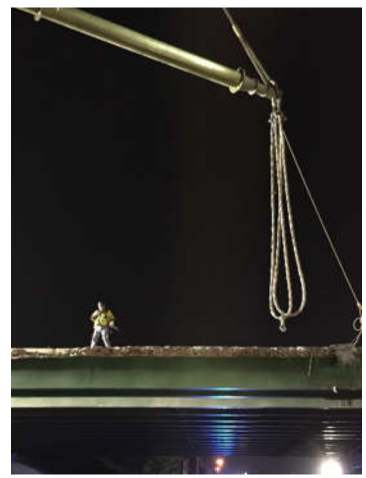
Cleveland Innerbelt, Cleveland, OH

Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
    - Picking girders (flange grabs, underslung slings, bolted/welded picking eyes)
    - Picking girders (spreader beams and picking trees)
    - Single Girder Picks vs. Paired Girder Picks
    - Temporary Top Flange Lateral Bracing (Stability Truss) to Erect
    - Temporary Lateral Bracing to Stabilize before Decking
  - Temporary Towers
  - Environmental Conditions
  - Overhangs
  - Demolition



Contractors & The 3-C's

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Cleveland Innerbelt, Cleveland, OH

Contractors & The 3-C's

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  - Environmental Conditions
  - Overhangs
  - Demolition

Comm. Ave Bridge, Boston, MA

Contractors & The 3-C's

- Constructability (Cont.)
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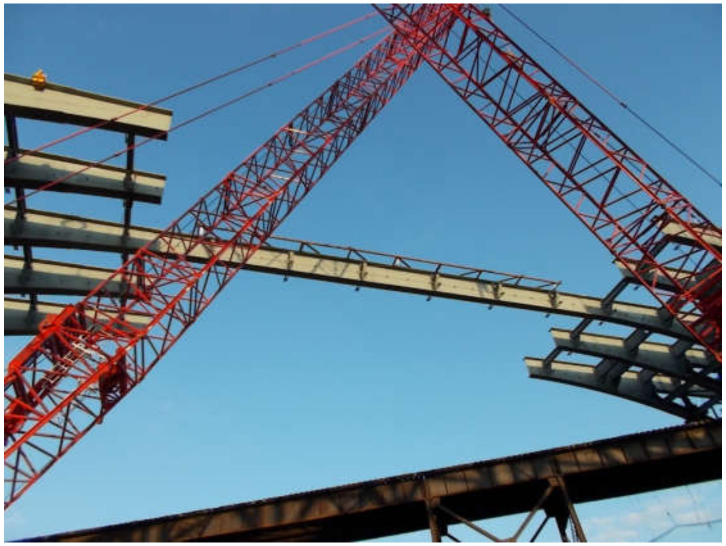

Cleveland Innerbelt, Cleveland, OH

Contractors & The 3-C's

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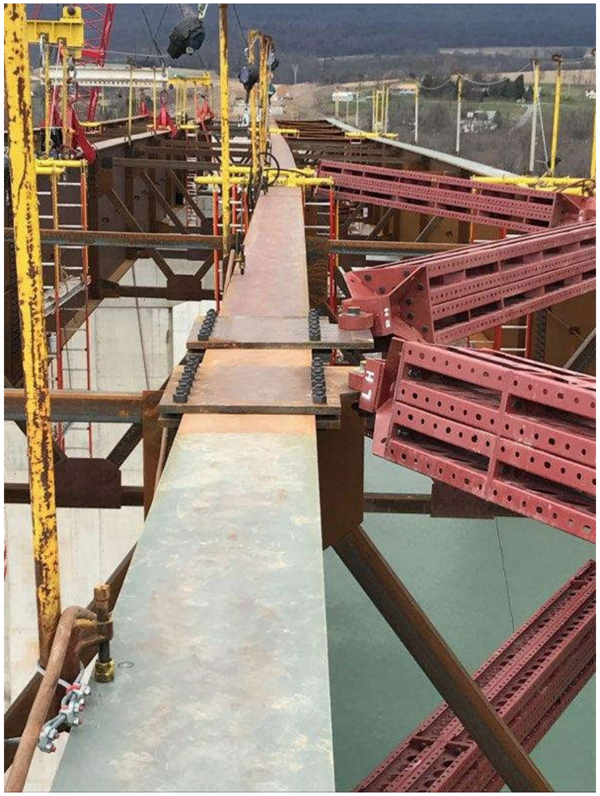

CSVT Project, Pennsylvania

Contractors & The 3-C's

- Constructability (Cont.)
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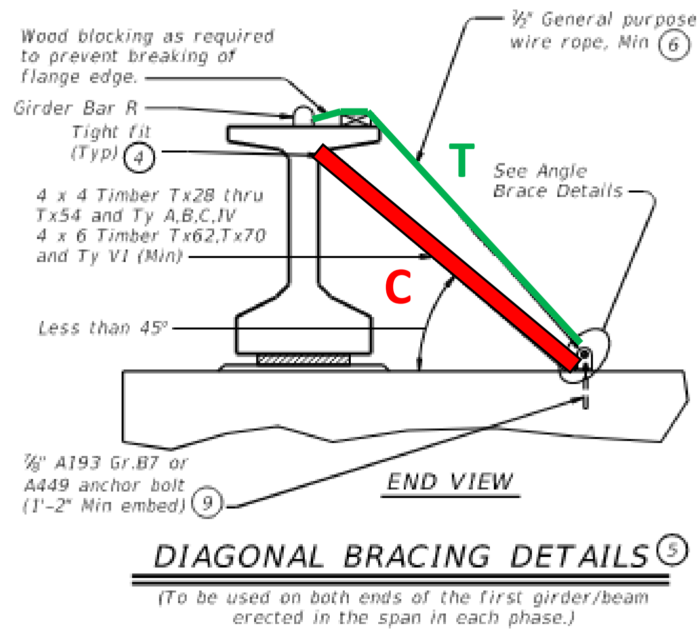

Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
  - Temporary Towers
    - Length of spans, number of girder segments in a span, the curvature of the girder, crane size, crane and delivery access all factor into the need
    - Pre-Manufactured
    - Pre-Owned
    - Built to fit the Need
    - Some are so unique there may not be a possible re-use
  - Environmental Conditions
  - Overhangs
  - Demolition

I-94 & I-69 Interchange, Port Huron, MI

Contractors & The 3-C's

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Margaret McDermott Bridge, Dallas, Tx.

Contractors & The 3-C's

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    - Pre-Owned
    - Built to fit the Need
    - Some are so unique there may not be a possible re-use
  - Environmental Conditions
  - Overhangs
  - Demolition

Whittier Memorial Bridge, Newburyport and Amesbury, MA

Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
  - Temporary Towers
    - Length of spans, number of girder segments in a span, the curvature of the girder, crane size, crane and delivery access all factor into the need
    - Pre-Manufactured
    - Pre-Owned
    - Built to fit the Need
    - Some are so unique there may not be a possible re-use
  - Environmental Conditions
  - Overhangs
  - Demolition

Cleveland Innerbelt, Cleveland, OH

Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
  - Temporary Towers
    - Length of spans, number of girder segments in a span, the curvature of the girder, crane size, crane and delivery access all factor into the need
    - Pre-Manufactured
    - Pre-Owned
    - Built to fit the Need
    - Some are so unique there may not be a possible re-use
  - Environmental Conditions
  - Overhangs
  - Demolition

Cleveland Innerbelt, Cleveland, OH

Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
  - Temporary Towers
  - Environmental Conditions
    - Temperature can affect the erected structure (especially orientation of the girders and time of day)
    - Wind impacts on erected girders (initial release, fully erected during deck forming)
  - Overhangs
  - Demolition

Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
  - Temporary Towers
  - Environmental Conditions
    - Temperature can affect the erected structure (especially orientation of the girders and time of day)
    - Wind impacts on erected girders (initial release, fully erected during deck forming)
  - Overhangs
  - Demolition

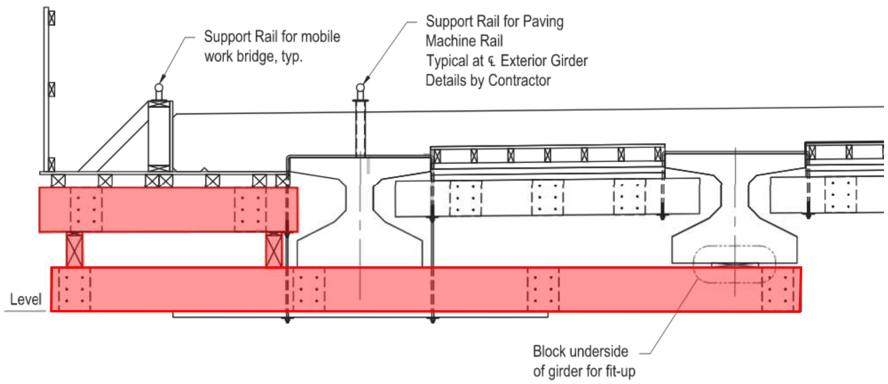
Blennerhasset Island Bridge, Parkersburg, WV

Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
  - Temporary Towers
  - Environmental Conditions
  - Overhangs
    - Bracket Type
    - Special Conditions
    - Finishing Machine
  - Demolition

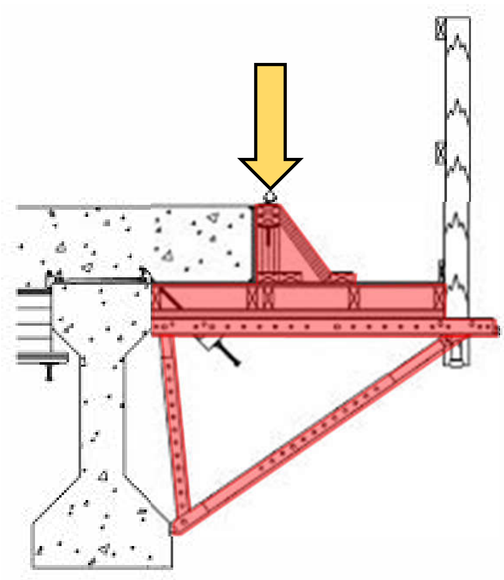
Contractors & The 3-C's

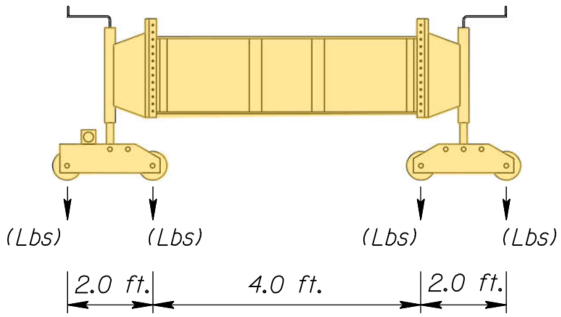
- Constructability (Cont.)
  - Rigging and Segment Stability
  - Temporary Towers
  - Environmental Conditions
  - Overhangs
    - Bracket Type
    - Special Conditions
    - Finishing Machine
  - Demolition



Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
  - Temporary Towers
  - Environmental Conditions
  - Overhangs
    - Bracket Type
    - Special Conditions
    - Finishing Machine
  - Demolition





Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
  - Temporary Towers
  - Environmental Conditions
  - Demolition
    - How do we need to remove the bridge?
    - How does this bridge want to come down? …. Safely!!!
    - How do we get rid of the debris?



Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
  - Temporary Towers
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    - How do we need to remove the bridge?
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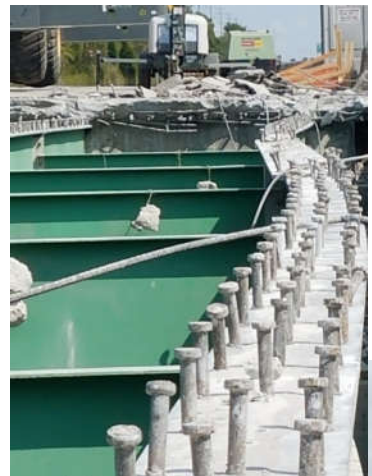

Contractors & The 3-C's

- Constructability (Cont.)
  - Rigging and Segment Stability
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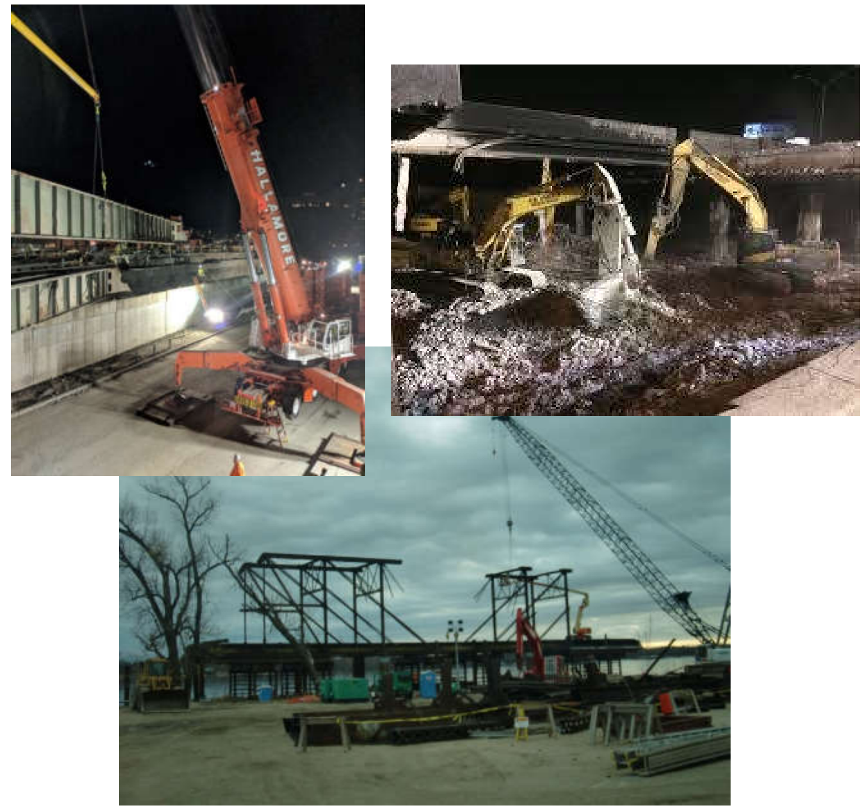


Contractors & The 3-C's

- Costs
  - Crane Rental/Mobilization
    - Size of crane
    - Duration of time on site
    - Shared needs vs. multiple crane sizes
  - Material
  - Labor Forces
  - Temporary Structures
  - Crane Work Platforms
  - Finishes/Coatings
  - Schedule

Contractors & The 3-C's

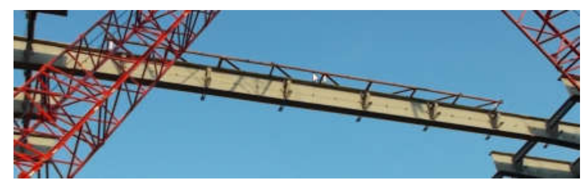
- Costs
  - Crane Rental/Mobilization
  - Material
    - Costs can fluctuate with demand
    - Expediting delivery schedules will generally increase costs
    - When contractors are asked to hold prices for extended periods cost can increase
    - Demand vs. Availability can be challenging
  - Labor Forces
  - Temporary Structures
  - Crane Work Platforms
  - Finishes/Coatings
  - Schedule

Contractors & The 3-C's

- Costs
  - Crane Rental/Mobilization
  - Material
  - Labor Forces
    - Union vs. Non-Union Locations
    - Laborers, Operators, Project Managers, Project Engineers
    - Demand vs. Availability can be challenging
  - Temporary Structures
  - Crane Work Platforms
  - Finishes/Coatings
  - Schedule

Contractors & The 3-C's

- Costs
  - Crane Rental/Mobilization
  - Material
  - Labor Forces
  - Temporary Structures
    - Foundations, Erect, Remove, Temporary Lane Closures
    - Top Flange Bracing (stability trusses)
    - Bottom Flange Lagging – DOT requirements
  - Crane Work Platforms
  - Finishes/Coatings
  - Schedule

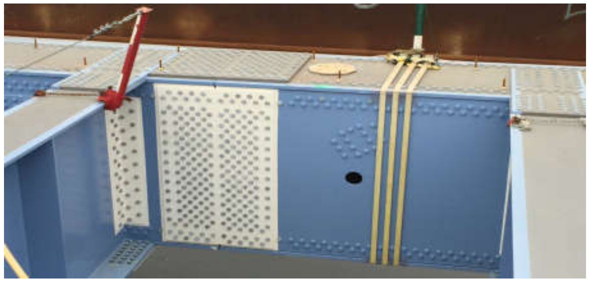


Contractors & The 3-C's

- Costs
  - Crane Rental/Mobilization
  - Material
  - Labor Forces
  - Temporary Structures
  - Crane Work Platforms
    - Crane Mats
    - Grading to Level Zones/Temporary Access Roads
    - Barges/Bulkheads/Trestles for water operations
  - Finishes/Coatings
  - Schedule

Contractors & The 3-C's

- Costs
  - Crane Rental/Mobilization
  - Material
  - Labor Forces
  - Temporary Structures
  - Crane Work Platforms
  - Finishes/Coatings
    - Steel – Weathering, Primed & Painted, Metalized, Primed, Painted over Metalized (extreme cases)
    - Precast - Some DOT's paint precast for aesthetics
  - Schedule

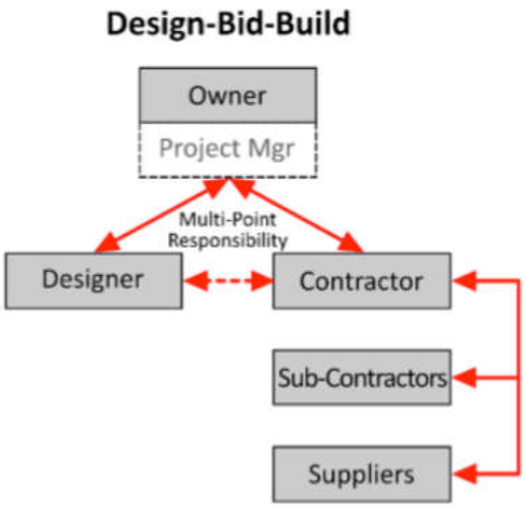


Contractors & The 3-C's

- Costs
  - Crane Rental/Mobilization
  - Material
  - Labor Forces
  - Temporary Structures
  - Crane Work Platforms
  - Finishes/Coatings
  - Schedule
    - Time is money >>> the more temporary works, the longer the erection schedule
    - Time is money >>> the more special care required in the field, the longer the erection schedule
    - Time is money >>> repairs to steel finishes or precast concrete corners can be expensive and extend the project schedule

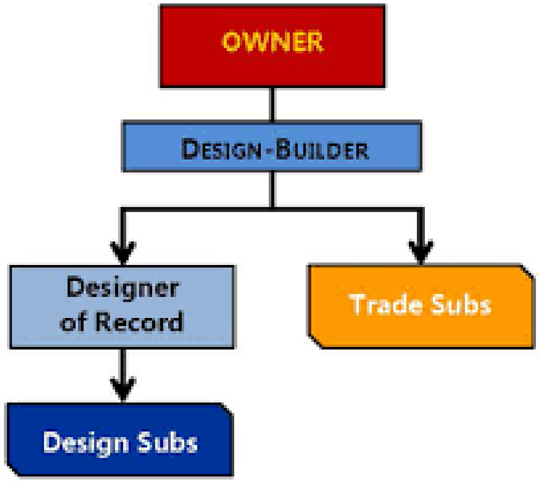
Contractors & The 3-C's

- Competition
  - Traditional Design-Bid-Build Project Delivery
    - What are my competitors doing?
    - What special equipment do my competitors own that I have to lease/purchase?
    - What location advantages do my competitors have?
  - Design Build Project Delivery
  - Construction Manager General Contractor (CMGC) Project Delivery



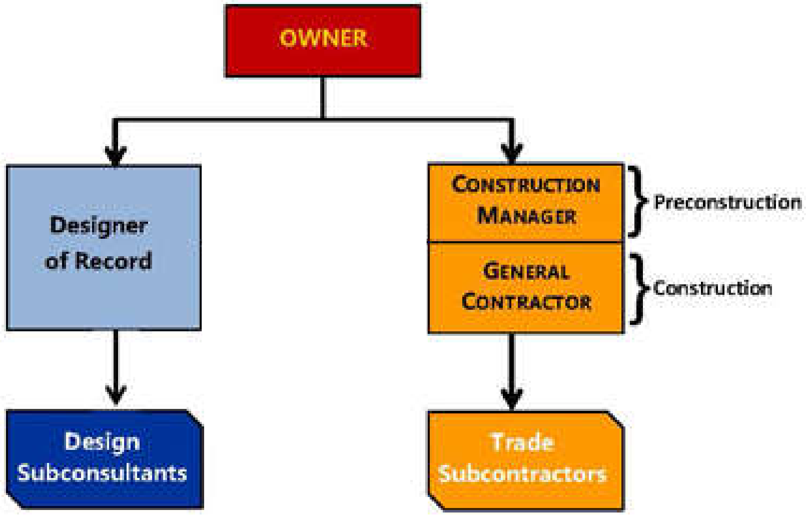
Contractors & The 3-C's

- Competition
  - Traditional Design-Bid-Build Project Delivery
  - Design Build Project Delivery
    - Best Idea and Price will win
    - The idea phase is pre-bid and may or may not be fully disclosed to the DOT's (ATC's)
    - Contractors/Designers
    - Sometimes missing is the Construction Engineer that is "bi-lingual"
      - Engineer who can speak the language of the Designer and the Contractor
  - Construction Manager General Contractor (CMGC) Project Delivery



Contractors & The 3-C's

- Competition
  - Traditional Design-Bid-Build Project Delivery
  - Design Build Project Delivery
  - Construction Manager General Contractor (CMGC) Project Delivery
    - Best Ideas are Discussed between Contractor/Designer/Owners after team selection
    - The idea phase is pre-final bid but costs and schedule and design are discussed with the owner's full knowledge



Constructability of Superstructures

Who is responsible for what and when?

TYPICAL DESIGN BID BUILD

Who is responsible for what and when?

TYPICAL DESIGN BID BUILD

Owner / DOT → **Engineer of Record** → **Contractor**

We need a bridge

Has to be:

- **Affordable**
- **Safe**
- **Durable**

Don't want any unforeseen issues in construction

Who is responsible for what and when?

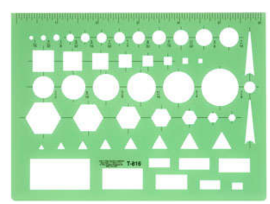
TYPICAL DESIGN BID BUILD

Owner / DOT → Engineer of Record → Contractor

We need a bridge

Best design option

(3) 250-ft steel girders spans.
Needs to have an 800-ft Radius



Who is responsible for what and when?

TYPICAL DESIGN BID BUILD

Owner / DOT → **Engineer of Record** → **Contractor**

We need a bridge

Best design option

This is how I would build it.
Going to cost you this much

Who is responsible for what and when?

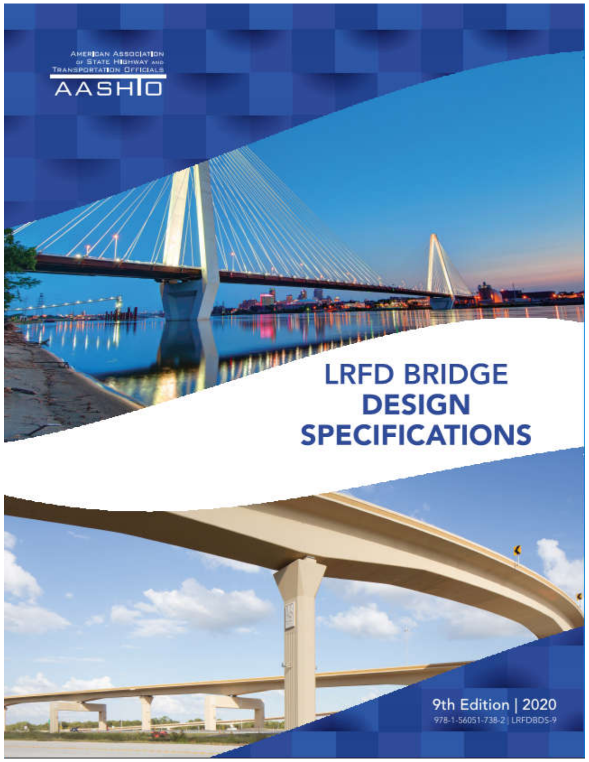
TYPICAL DESIGN BID BUILD

- **Contract Plans = Defines responsibilities of all parties (bidding / fabricating / erecting structure)**

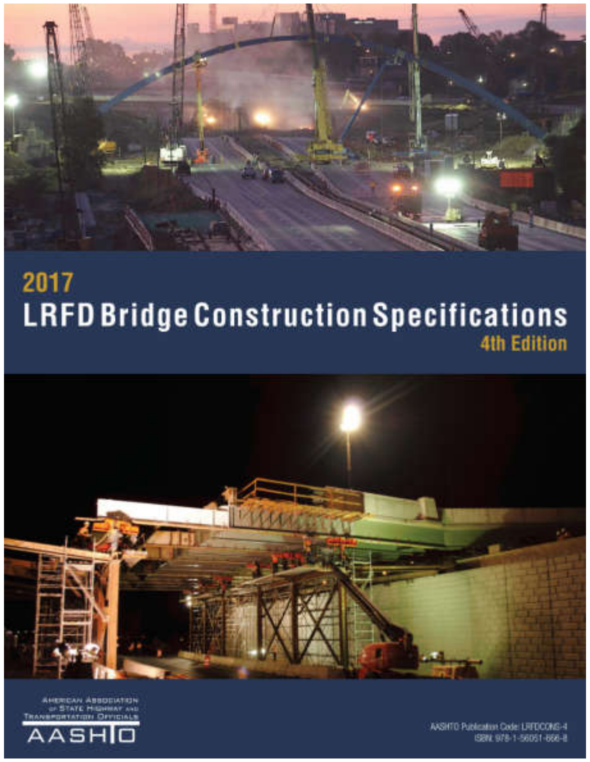
Who is responsible for what and when?

- When is a bridge complex enough so engineering is required to ensure constructability or stability during erection?
- When should a Department of Transportation (DOT) / Engineer of Record (EOR) make Contractors aware of limitations during construction?
- When does the DOT / EOR owe a Contractor a suggested erection sequence?
- What do the AASHTO Specifications say?

AASHTO Specifications

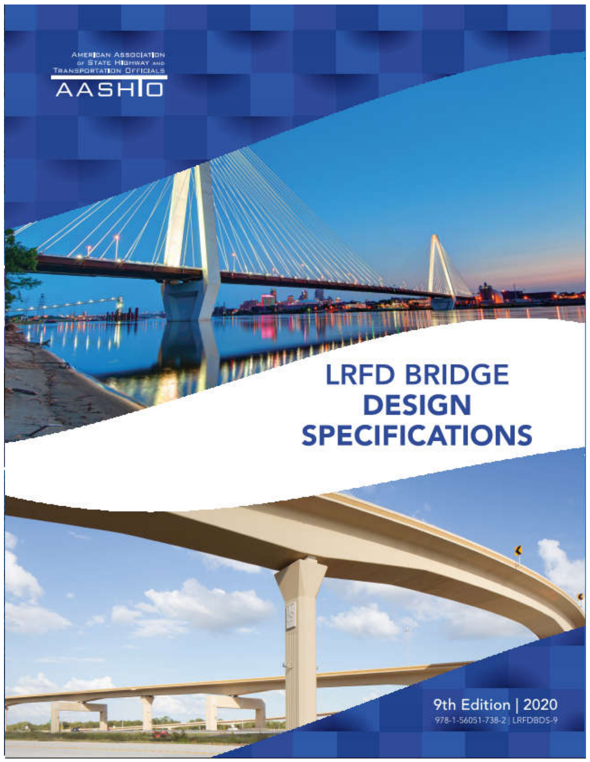


AASHTO Bridge Design Spec.

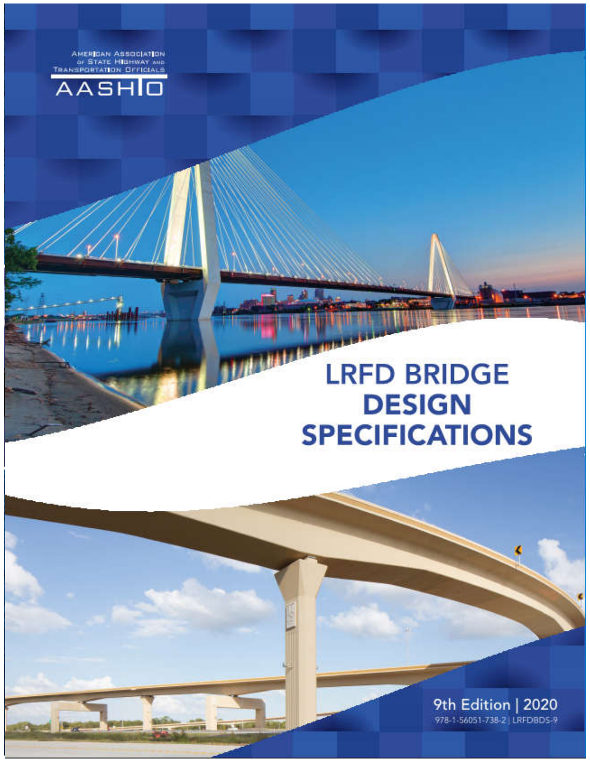


AASHTO Bridge Construction Specs.

AASHTO Bridge Design Specifications



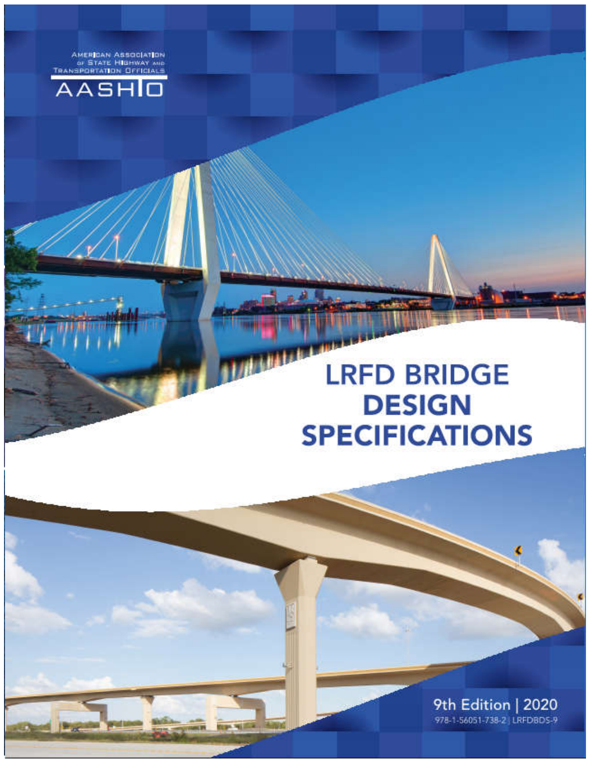
AASHTO Bridge Design Specifications



Key Sections:

Chapter 2 General Design and Location Features	• 2.5.3 – Constructibility
Chapter 5 Concrete Structures	• 5.12 – Provisions for Structure Components and Types
Chapter 6 Steel Structures	• 6.10.3 – Steel I-Section Constructibility • 6.11.3 – Box Section

AASHTO Bridge Design Specifications



Key Sections:

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Steel Structures
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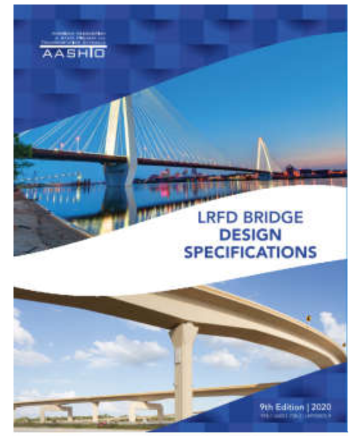
- 6.11.3 – Box Section

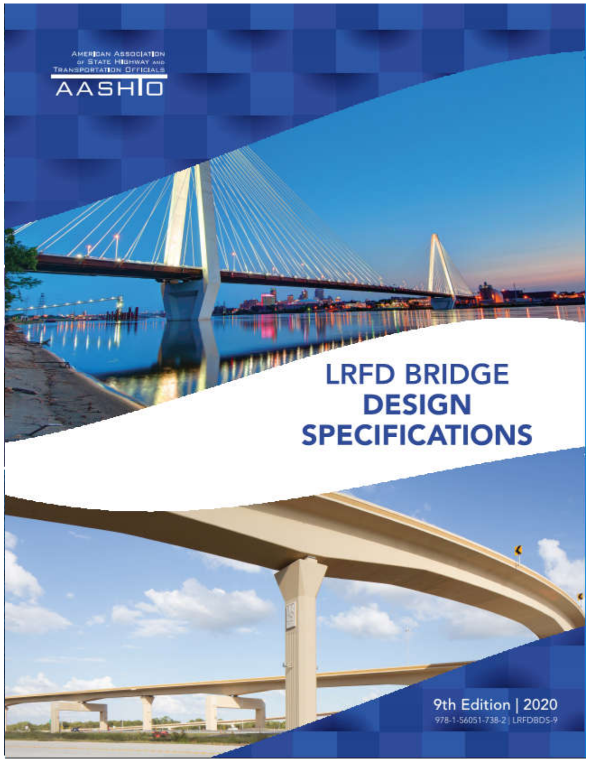
AASHTO – Constructibility

- *2.5.3: This section specifies, "Bridges should be designed in a manner such that fabrication and erection can be performed without undue difficulty or distress and that locked in construction force effects are within tolerable limits."*

- *2.5.3 (Cont.): Where the bridge is of unusual complexity, such as that would be unreasonable to expect an experienced contractor to predict and estimate a suitable method of construction while bidding the project, at least one feasible construction method shall be indicated in the contract documents. If the design requires some strengthening and/or temporary bracing or support during erection by the selected method, indication of the need thereof shall be indicated in the contract documents.*



AASHTO Bridge Design Specifications



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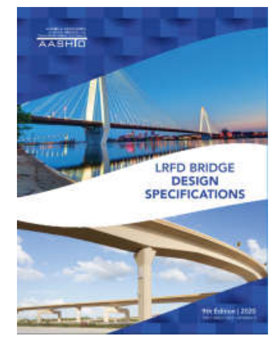
Precast Beams

5.12.3.2—Precast Beams

5.12.3.2.1—Preservice C... itions

The ... prestressed girders for shipping ... responsibility of the contractor.

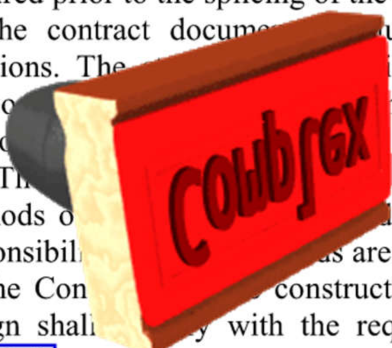


Spliced Precast Girders

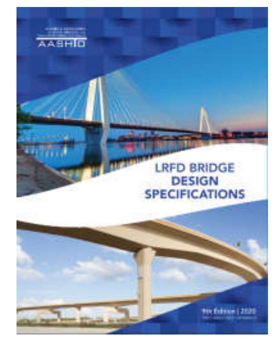
5.12.3.4—Spliced Precast Girders

The method of construction assumed for the design shall be shown in the contract documents. All supports required prior to the splicing of the girder shall be shown
on the contract docum[illegible]uding elevations and
reactions. The [illegible]ion during which the
tempo[illegible]hall also be shown on
the c[illegible]

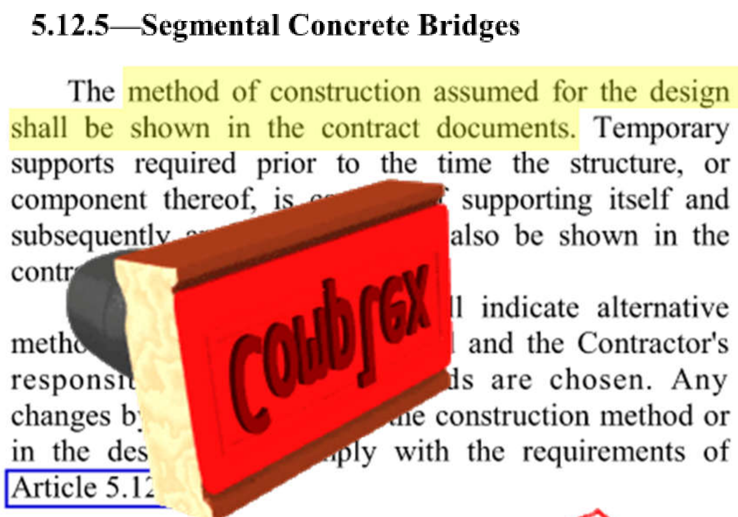
Th[illegible]l indicate alternative
methods o[illegible] and the Contractor's
responsibil[illegible]s are chosen. Any changes
by the Con[illegible] construction method or to the
design shal[illegible]y with the requirements of Article
5.12.5.5.



Images Courtesy of: www.post-tensioning.org



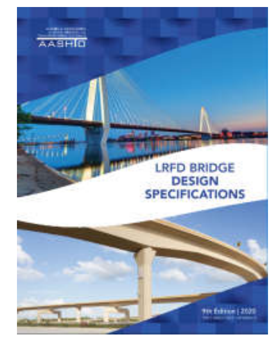
Segmental Concrete Bridges


5.12.5—Segmental Concrete Bridges

The method of construction assumed for the design shall be shown in the contract documents. Temporary supports required prior to the time the structure, or component thereof, is c… supporting itself and subsequently … also be shown in the contr…

…ll indicate alternative meth… and the Contractor's responsi… ds are chosen. Any changes b… the construction method or in the des… ply with the requirements of Article 5.12…

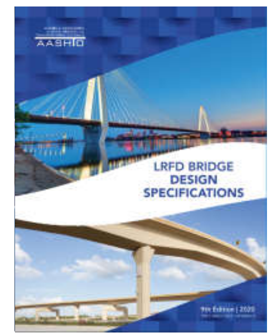
Images Courtesy of: http://www.asbi-assoc.org/



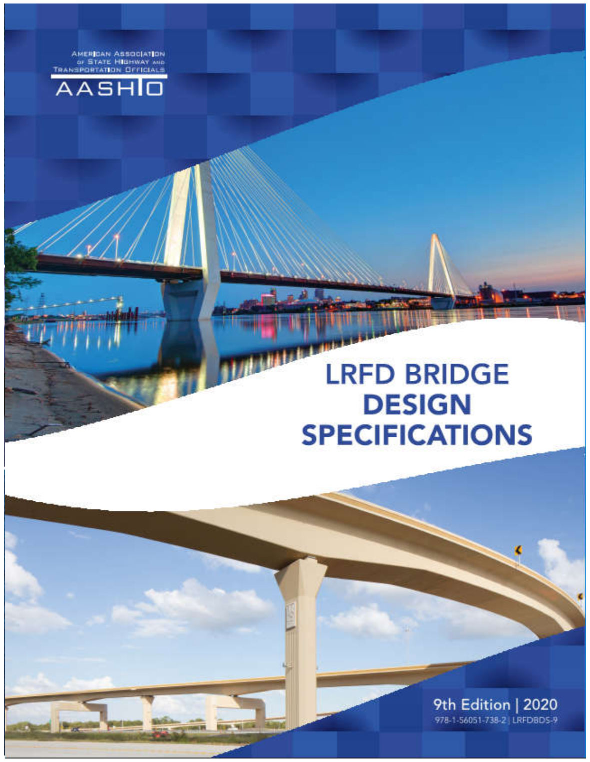
Segmental Concrete Bridges

Table 5.12.5.3.3-1—Load Factors and Tensile Stress Limits for Construction Load Combinations

Load Combination	LOAD FACTORS															STRESS LIMITS				See Note
	Dead Load			Live Load			Wind Load			Other Loads					Earth Loads	Flexural Tension		Principal Tension		
	DC *DW*	*DIFF*	*U*	*CEQ* *CLL*	*IE*	*CLE*	*WS*	*WUP*	*WE*	*CR*	*SH*	*TU*	*TG*	A AI *WA*	*EH* *EV* *ES*	Excluding "Other Loads"	Including "Other Loads"	Excluding "Other Loads"	Including "Other Loads"	
a	1.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	γ_{TG}	1.0	1.0	$0.190\sqrt{f'_c}$	$0.220\sqrt{f'_c}$	$0.110\sqrt{f'_c}$	$0.126\sqrt{f'_c}$	—
b	1.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	γ_{TG}	1.0	1.0	$0.190\sqrt{f'_c}$	$0.220\sqrt{f'_c}$	$0.110\sqrt{f'_c}$	$0.126\sqrt{f'_c}$	—
c	1.0	1.0	0.0	0.0	0.0	0.0	0.7	0.7	0.0	1.0	1.0	1.0	γ_{TG}	1.0	1.0	$0.190\sqrt{f'_c}$	$0.220\sqrt{f'_c}$	$0.110\sqrt{f'_c}$	$0.126\sqrt{f'_c}$	—
d	1.0	1.0	0.0	1.0	0.0	0.0	0.7	1.0	0.7	1.0	1.0	1.0	γ_{TG}	1.0	1.0	$0.190\sqrt{f'_c}$	$0.220\sqrt{f'_c}$	$0.110\sqrt{f'_c}$	$0.126\sqrt{f'_c}$	1
e	1.0	0.0	1.0	1.0	1.0	0.0	0.3	0.0	0.3	1.0	1.0	1.0	γ_{TG}	1.0	1.0	$0.190\sqrt{f'_c}$	$0.220\sqrt{f'_c}$	$0.110\sqrt{f'_c}$	$0.126\sqrt{f'_c}$	2
f	1.0	0.0	0.0	1.0	1.0	1.0	0.3	0.0	0.3	1.0	1.0	1.0	γ_{TG}	1.0	1.0	$0.190\sqrt{f'_c}$	$0.220\sqrt{f'_c}$	$0.110\sqrt{f'_c}$	$0.126\sqrt{f'_c}$	3



AASHTO Bridge Design Specifications



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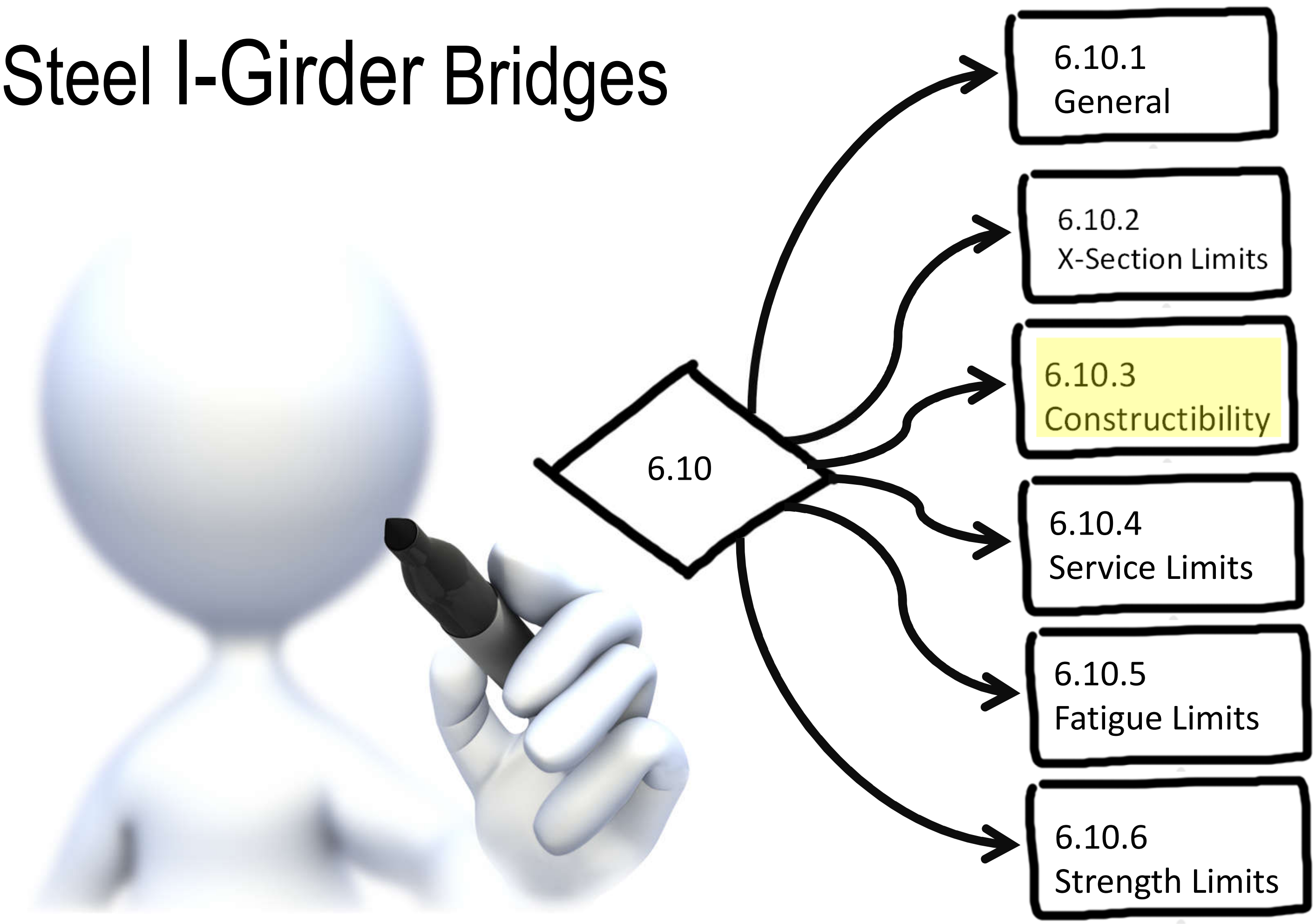
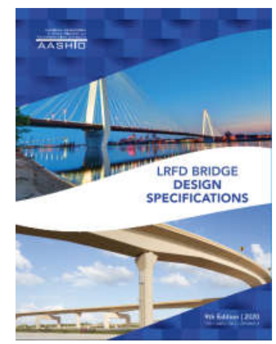
Steel I-Girder Bridges





Steel I-Girder Bridges - Constructibility

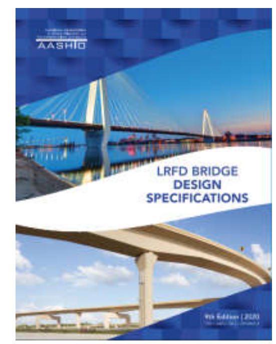
6.10.3—Constructibility

6.10.3.1—General

The provisions of Article 2.5.3 shall apply. In addition to providing adequate strength, nominal yielding or reliance on post-buckling resistance shall not be permitted for main load-carrying members during critical stages of construction, except for yielding of the web in hybrid sections. This shall be accomplished by satisfying the requirements of Articles 6.10.3.2 and 6.10.3.3 at each critical construction stage. For sections in positive flexure that are composite in the final condition, but are noncomposite during construction, the provisions of Article 6.10.3.4 shall apply. For investigating the constructibility of flexural members, all loads shall be factored as specified in Article 3.4.2. For the calculation of deflections, the load factors shall be taken as 1.0.

Potential uplift at bearings shall be investigated at each critical construction stage.

Webs without bearing stiffeners at locations subjected to concentrated loads not transmitted through a deck or deck system shall satisfy the provisions of Article D6.5.



Steel I-Girder Bridges - Constructibility

6.10.3.2.1—Discretely Braced Flanges in Compression

For critical stages of construction, each of the following requirements shall be satisfied. For sections with slender webs, Eq. 6.10.3.2.1-1 shall not be checked when f_ℓ is equal to zero. For sections with compact or noncompact webs, Eq. 6.10.3.2.1-3 shall not be checked.

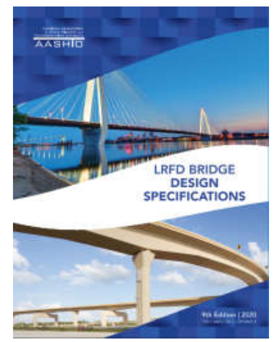
$$f_{bu} + f_\ell \leq \phi_f R_h F_{yc}, \qquad (6.10.3.2.1\text{-}1)$$

$$f_{bu} + \frac{1}{3} f_\ell \leq \phi_f F_{nc}, \qquad (6.10.3.2.1\text{-}2)$$

and

$$f_{bu} \leq \phi_f F_{crw} \qquad (6.10.3.2.1\text{-}3)$$

What are critical stages of construction?



Steel I-Girder Bridges - Constructibility

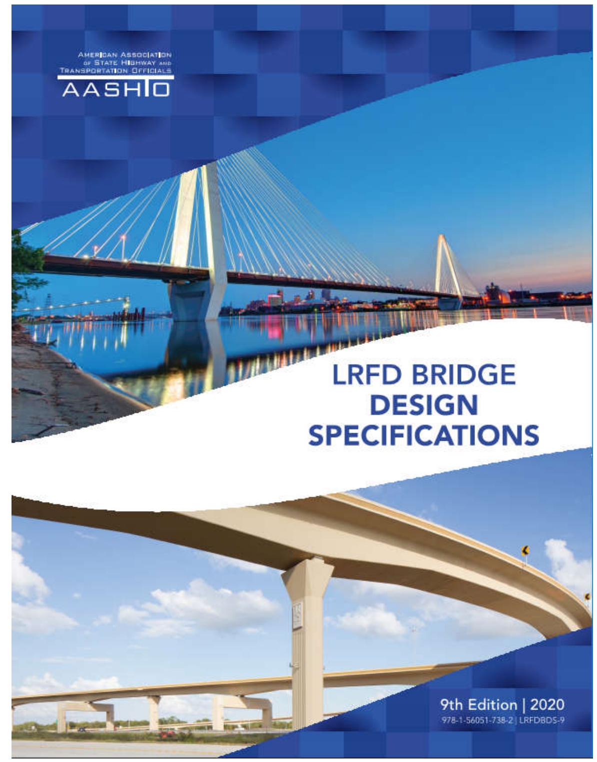
6.10.3.4—Deck Placement

6.10.3.4.1—General

Sections in positive flexure that are composite in the final condition, but are noncomposite during construction, shall be investigated for flexure according to the provisions of Article 6.10.3.2 during the various stages of the deck placement.

Geometric properties, bracing lengths and stresses used in calculating the nominal flexural resistance shall be for the steel section only. Changes in load, stiffness and bracing during the various stages of the deck placement shall be considered.

The effects of forces from deck overhang brackets acting on the fascia girders shall be considered.



Steel I-Girder Bridges - Constructibility

6.10.3.4—Deck Placement

6.10.3.4.1—General

Sections in positive flexure that are composite in the final condition, but are noncomposite during construction, shall be investigated for flexure according to the provisions of Article 6.10.3.2 during the various stages of the deck placement.

Geometric properties, bracing lengths and stresses used in calculating the nominal flexural resistance shall be for the steel section only. Changes in load, stiffness and bracing during the various stages of the deck placement shall be considered.

The effects of forces from deck overhang brackets acting on the fascia girders shall be considered.

Following pour sequence is important!

Images Courtesy of: www.sellwoodbridge.org

Steel I-Girder Bridges - Constructibility

6.10.3.4—Deck Placement

6.10.3.4.1—General

Sections in positive flexure that are composite in the final condition, but are noncomposite during construction, shall be investigated for flexure according to the provisions of Article 6.10.3.2 during the various stages of the deck placement.

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The effects of forces from deck overhang brackets acting on the fascia girders shall be considered.

Images Courtesy of: https://www.gamcoform.com/overhang-bracket

Steel I-Girder Bridges - Constructibility

6.10.3.4—Deck Placement

6.10.3.4.1—General

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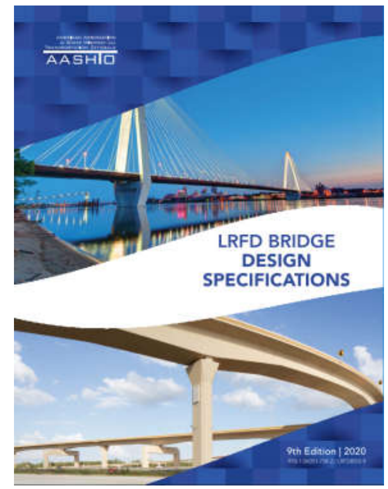
The effects of forces from deck overhang brackets acting on the fascia girders shall be considered.

Overhang Torsional Analysis Guidance added to Commentary 9th Edition.

C6.10.3.4.1

During construction of steel girder bridges, concrete deck overhang loads are typically supported by cantilever forming brackets typically placed at 3.0 to 4.0 ft spacings along the exterior members. The eccentricity of the deck weight and other loads acting on the overhang brackets creates applied torsional moments on the exterior members. As a result, the following issues must be considered in the design of the exterior members:

- The applied torsional moments bend the exterior girder top flanges outward. The resulting flange lateral bending stresses tend to be largest at the brace points at one or both ends of the unbraced length. The lateral bending stress in the top flange is tensile at the brace points on the side of the flange opposite from the brackets. These lateral bending stresses should be considered in the design of the flanges.
- The horizontal components of the reactions on the cantilever-forming brackets are often transmitted directly onto the exterior girder web. The girder web may exhibit significant plate bending deformations due to these loads. The effect of these deformations on the vertical deflections at the outside edge of the deck should be considered. The effect of the reactions from the brackets on the cross-frame forces should also be considered.
- Excessive deformation of the web or top flange may lead to excessive deflection of the bracket supports causing the deck finish to be problematic.

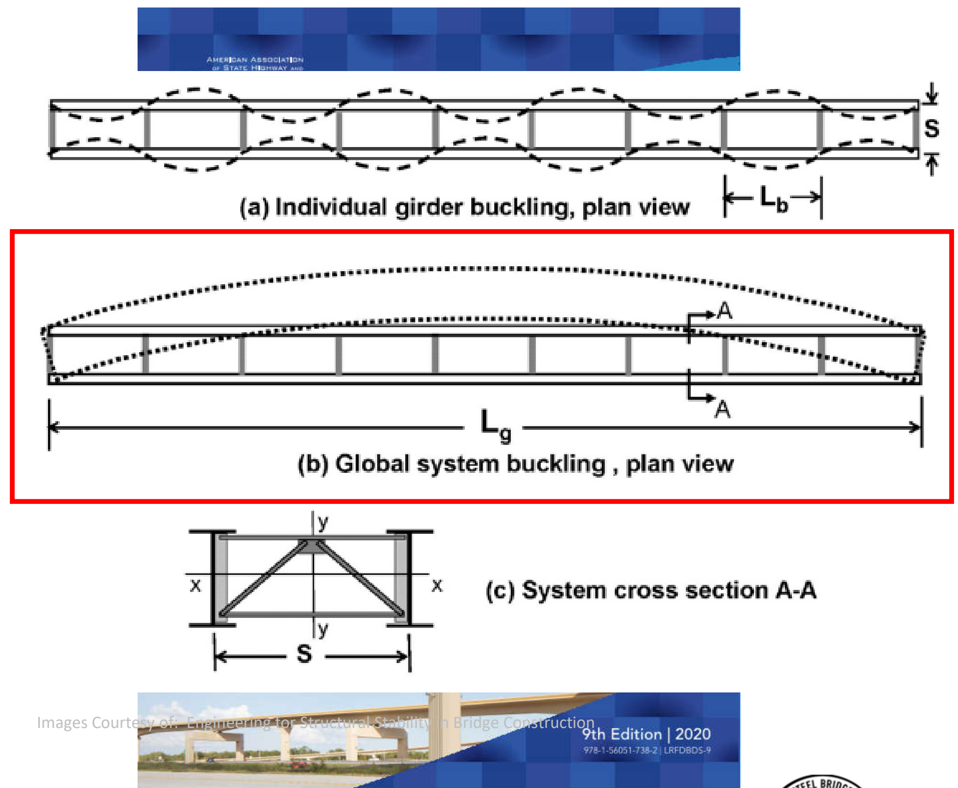


Steel I-Girder Bridges– System Stability

6.10.3.4.2—Global Displacement Amplification in Narrow I-Girder Bridge Units

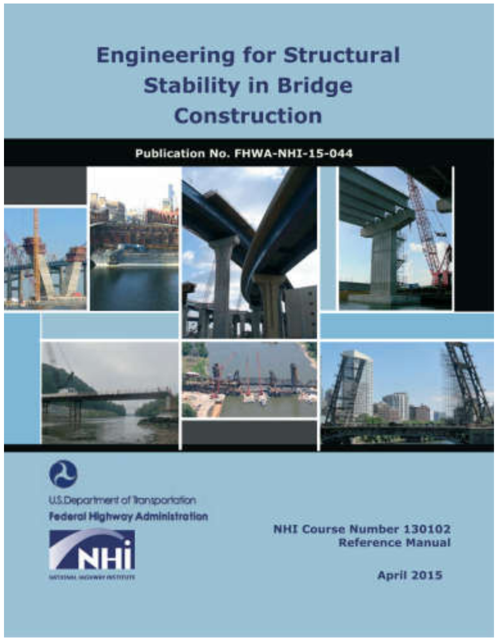
$$M_{gs} = C_{bs} \frac{\pi^2 w_g E}{L^2} \sqrt{I_{eff} I_x} \qquad (6.10.3.4.2\text{-}1)$$

- AASHTO check of narrow 2 or 3 girder system stability during deck pouring
- If Mult > 0.7 Mgs design has following options:
  - Add flange lateral bracing
  - Increase system stiffness
  - Verify with owner that second order displacements are within acceptable tolerances

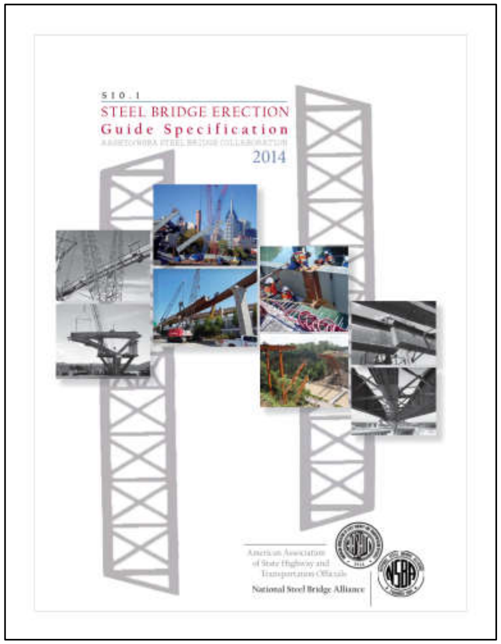


Images Courtesy of: Engineering for Structural Stability in Bridge Construction

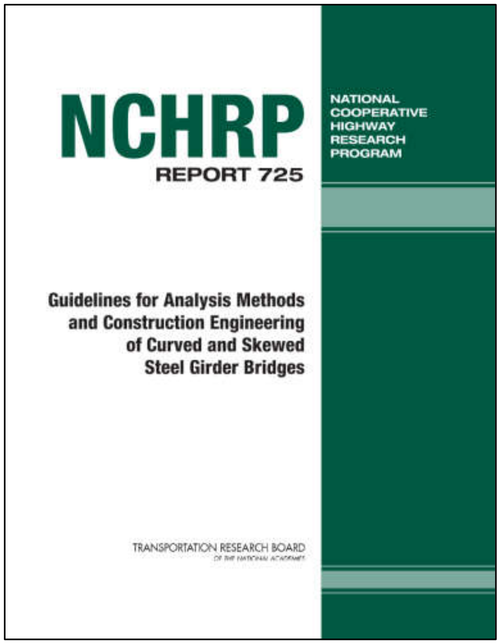
Useful Resources - Erection Analysis



FHWA-NHI-15-044
ALL MATERIAL TYPES



NSBA / AASHTO S10.1

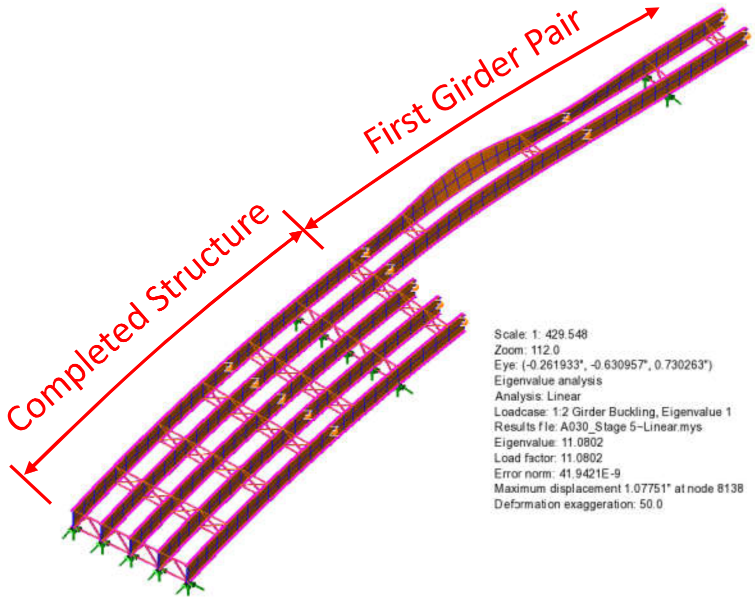


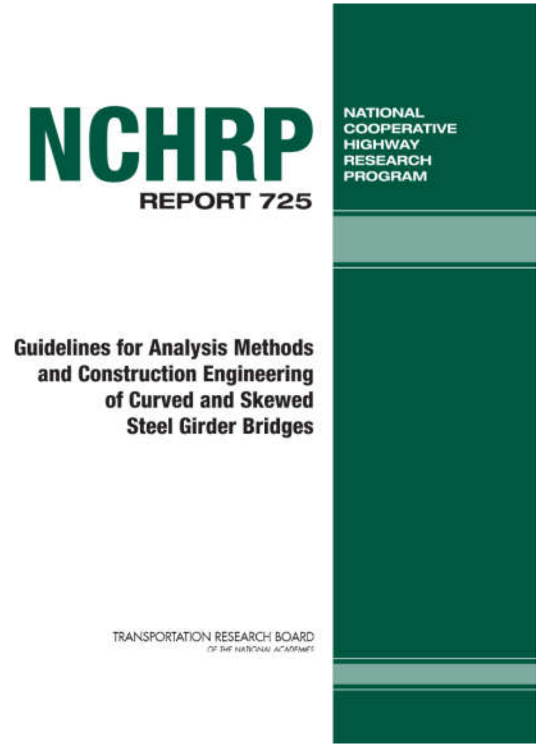
NCHRP Report 725

STEEL BRIDGE SPECIFIC GUIDES

Steel I-Girder Bridges - System Stability

$$M_{crG} = C_b \frac{\pi^2 sE}{L_s^2} \sqrt{I_{ye} I_x} \qquad \text{Eq. 3}$$

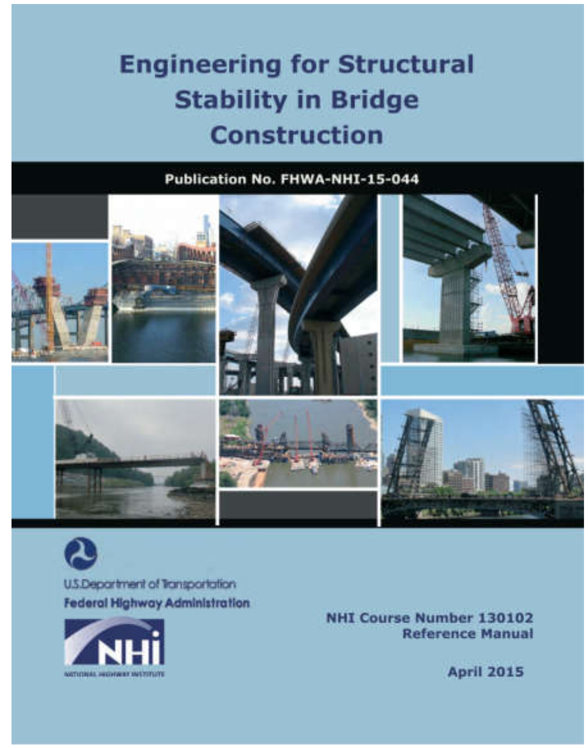




Steel I-Girder Bridges - System Stability

$$M_{gs} = \frac{\pi^2 SE}{L_g^2}\sqrt{I_y I_x}$$

Equation 5-12



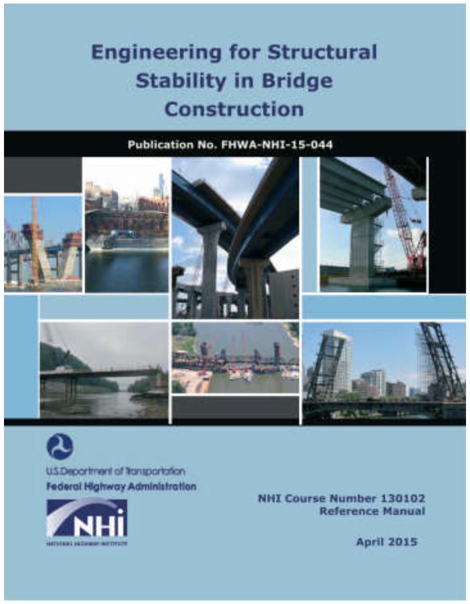
Critical Stages of Construction

7.2.2 Critical Erection Stages

The erection plan and supporting engineering calculations must address both strength and stability at each stage of erection. Deformations associated with each stage should also be evaluated. Critical erection stages for the girder bridge structure during construction normally consist of at least the following:

- Lifting of girders/members
- Placement of the initial girder and any associated temporary bracing used to hold the girder in place
- First pair of girders set with permanent bracing installed
- All girders and bracing installed prior to the deck placement *[total structure stable in wind]*
- All girders and bracing installed during the deck placement
- Application of the deck overhang bracket loads to the fascia girders during the deck placement

Contractor / Construction Engineer



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Fulbright Expressway, Fayetteville, AR

Critical Stages of Construction

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KY 152 over Herrington Lake, Mercer and Garrard Counties, KY

Critical Stages of Construction

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Gateway Interchange Flyovers, Johnson County, KS

Critical Stages of Construction

DETOUR

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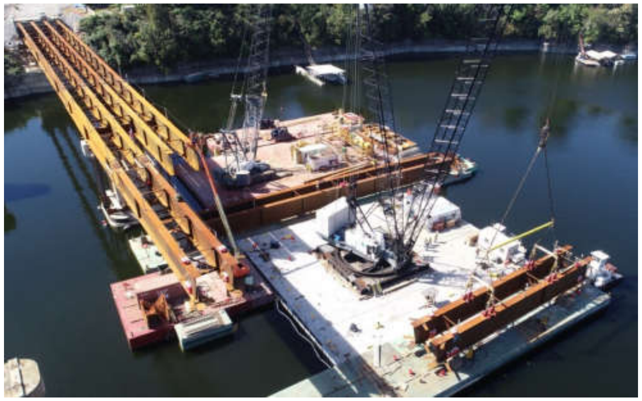

KY 152 over Herrington Lake, Mercer and Garrard Counties, KY

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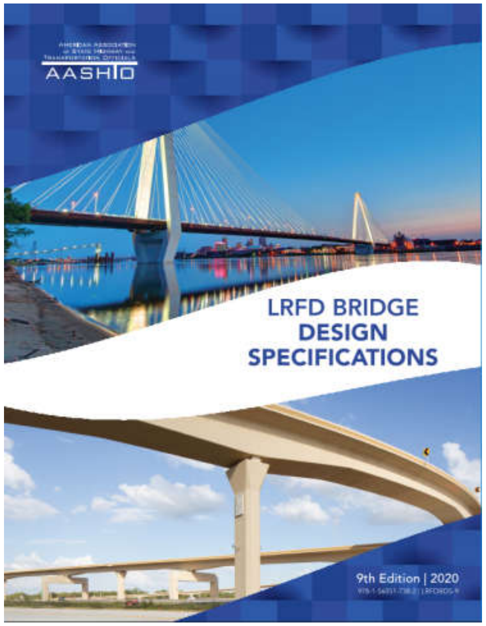


AASHTO dictates these stages shall be considered by Design Engineer

Should be considered by Design Engineer
What design reference should a designer use to evaluate?

Wind on Completed Bridge Prior to Deck Pour

- AASHTO design specifications currently do not include section on winds on a completed structure prior to pouring deck
- Designer could use “AASHTO Guide Specifications for Wind Loads on Bridges During Construction”
- Other state specific references are available

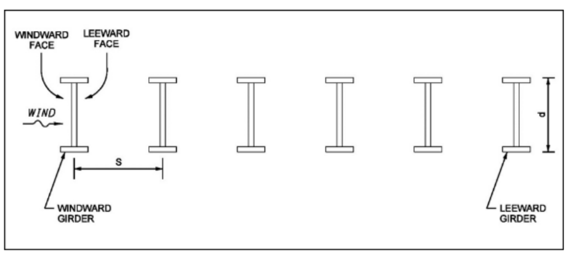
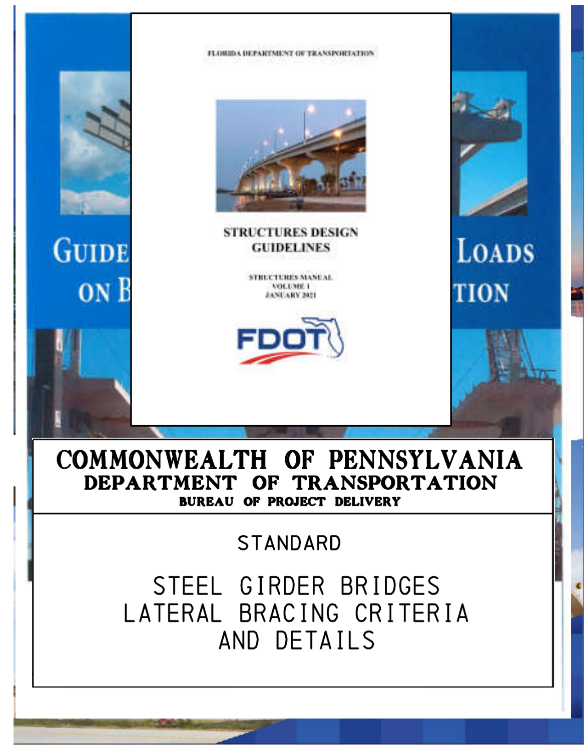
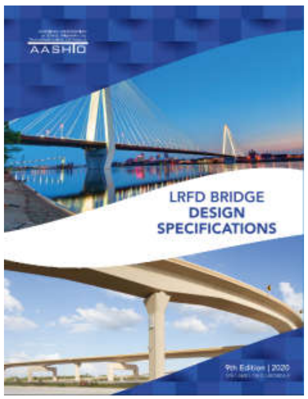


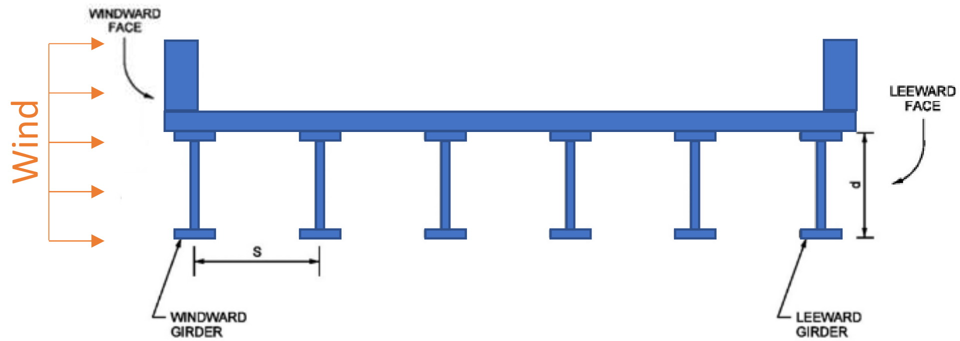
Figure 7-12 Girder Wind Load Terminology

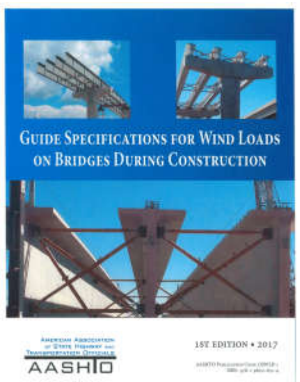
COMPONENT TYPE	CONSTRUCTION CONDITION	FORCE COEFFICIENT (C_f)
I-Shaped Girder Superstructure	Deck forms not in place	2.2 (1)
	Deck forms in place	1.1
U-Shaped and Box-Girder Superstructure	Deck forms not in place	1.5
	Deck forms in place	1.1
Flat Slab or Segmental Box-Girder Superstructure	Any	1.1

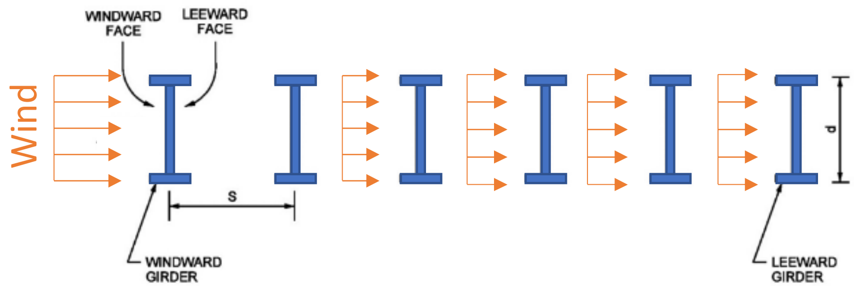


AASHTO - Wind During Erection

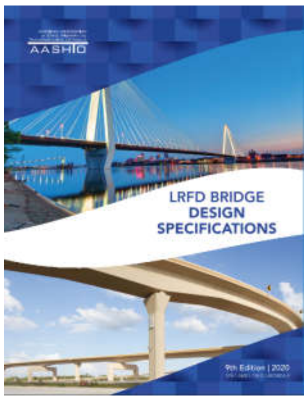






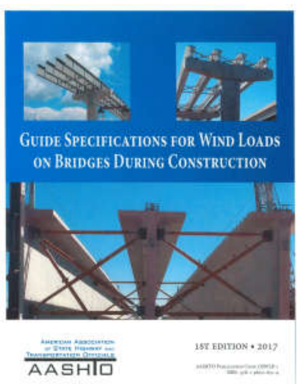


AASHTO - Wind During Erection



$$P_Z = 2.56 \times 10^{-6} V^2 K_z G C_D$$

Component		Drag Coefficient, C_D Windward	Drag Coefficient, C_D Leeward
I-Girder and Box-Girder Bridge Superstructures		1.3	N/A
Trusses, Columns, and Arches	Sharp-Edged Member	2.0	1.0
	Round Member	1.0	0.5
Bridge Substructure		1.6	N/A
Sound Barriers		1.2	N/A

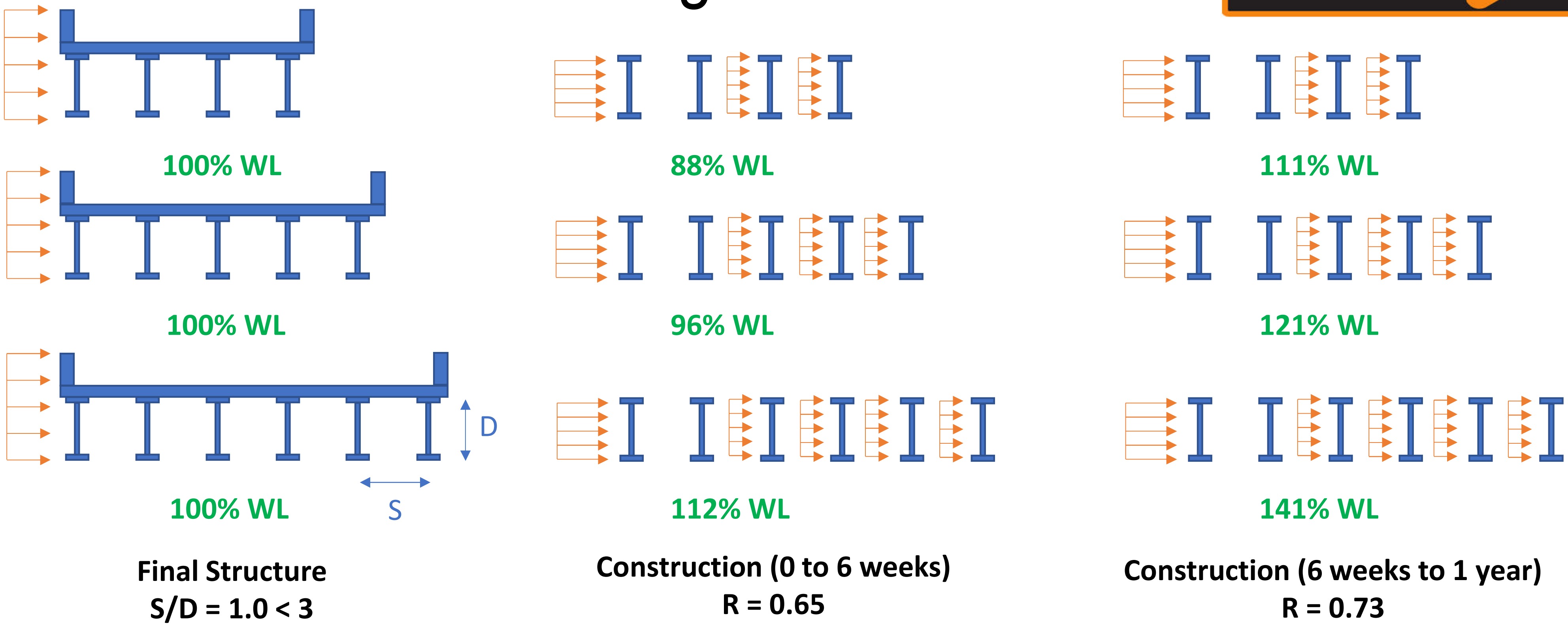


$$P_z = 2.56 \times 10^{-6} V^2 R^2 K_z G C_D$$

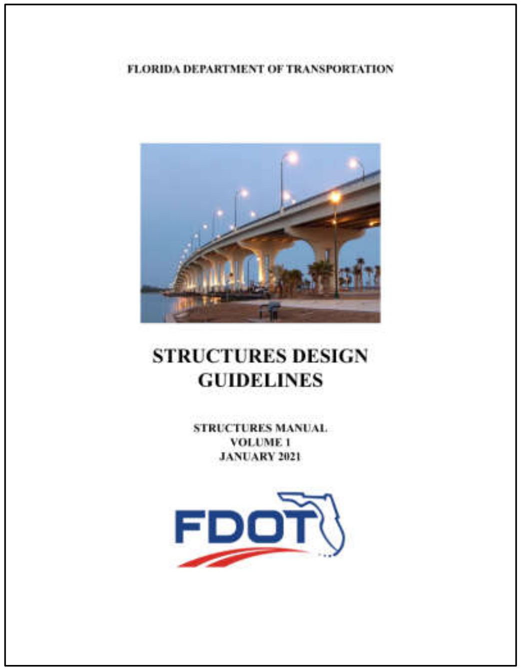
	R
0-6 weeks	0.65
6 weeks to 1 year	0.73
>1-2 years	0.75
>2-3 years	0.77
>3-7years	0.84

Rolled I-Beams	2.2
Concrete I-Beams	2.0
Closed and Open Box-Girders	2.1
Round Members	1.0

AASHTO - Wind During Erection



FDOT – Wind During Erection


FLORIDA DEPARTMENT OF TRANSPORTATION

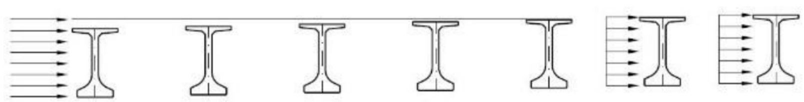
STRUCTURES DESIGN GUIDELINES

STRUCTURES MANUAL
VOLUME 1
JANUARY 2021

FDOT

Table 2.4.3-2 Drag Coefficient During Construction

Component Type		Drag Coefficient (C_D)				
		S/D ≤ 3		S/D > 3		
		Beams/ Girders 1-5	Beam/ Girder 6+	Beam/ Girder 1	Beam/ Girder 2	Beam/ Girder 3+
Superstructure	I-Shaped Steel Girder	2.2	1.1	2.5	0	1.1
Superstructure	I-Shaped Concrete Beam/Girder	2.0	1.0	2.0	0	1.0
Superstructure	U-Shaped Beam/ Girder or Steel Box Girder	2.2				
Superstructure	Flat Slab or Segmental Box Girder	1.5				
Substructure		1.6				



- Based on research at University of Florida, Funded by FDOT
- Drag Coefficients and Gust Factors vary from AASHTO w/ AASHTO being more conservative

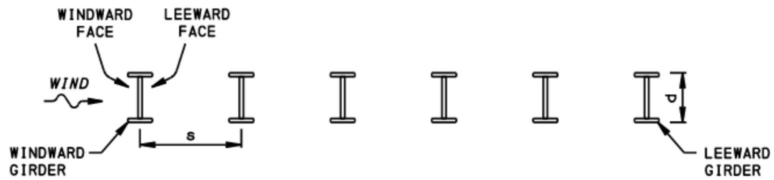
PennDOT – Wind Prior to Deck Pour

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF PROJECT DELIVERY

STANDARD

STEEL GIRDER BRIDGES
LATERAL BRACING CRITERIA
AND DETAILS

MINIMUM DESIGN WIND PRESSURE(PSF)
FOR LATERAL BRACING DURING CONSTRUCTION



CONSTRUCTION DURATION	0-6 WEEKS		6 WEEKS-1 YEAR		1-2 YEARS	
SUPERSTRUCTURE HEIGHT ABOVE GROUND LEVEL (FT.)	$s/d \le 2$	$2 < s/d \le 4$	$s/d \le 2$	$2 < s/d \le 4$	$s/d \le 2$	$2 < s/d \le 4$
0-15	19	21	26	28	29	32
20	20	22	27	30	31	34
25	21	23	28	31	32	35
30	22	24	30	32	34	37
40	24	26	31	34	36	39
50	25	27	33	36	38	41
60	26	28	34	37	39	42
70	27	29	35	39	40	44
80	28	30	37	40	42	45
90	28	31	38	41	43	47
100	29	31	38	42	43	47

- Guidance for wind on completed structure prior deck placement
- Not meant for staged construction analysis
- Provides general rules for designer

PennDOT – Wind Prior to Deck Pour

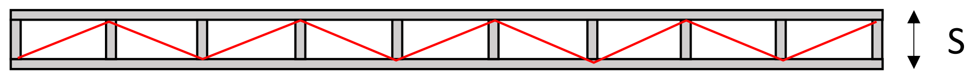
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF PROJECT DELIVERY

STANDARD

STEEL GIRDER BRIDGES
LATERAL BRACING CRITERIA
AND DETAILS

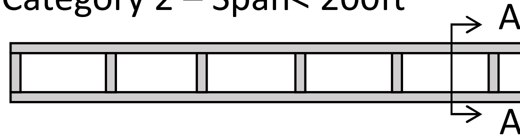
Lateral Bracing Requirements Based on Span Length

Category 1 - Span > 300ft

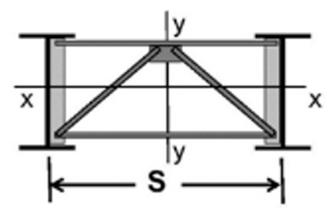


Lateral Bracing Required

Category 2 – Span< 200ft

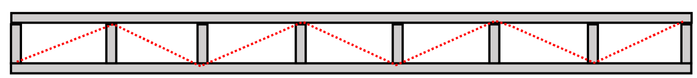


No Lateral Bracing Required



Section A-A

Category 3 – 200 ft < Span < 300ft



Evaluate Need Based on Lateral Deflection

PennDOT – Wind Prior to Deck Pour

DETOUR

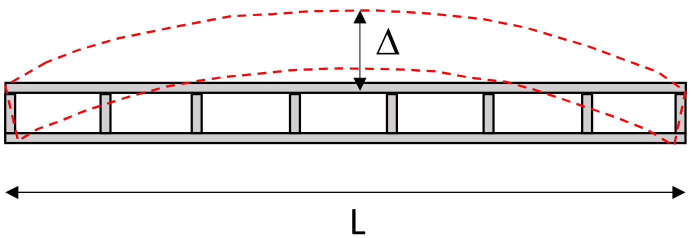
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF PROJECT DELIVERY

STANDARD

STEEL GIRDER BRIDGES
LATERAL BRACING CRITERIA
AND DETAILS

Lateral Bracing Requirements Based on Span Length (Cont.)

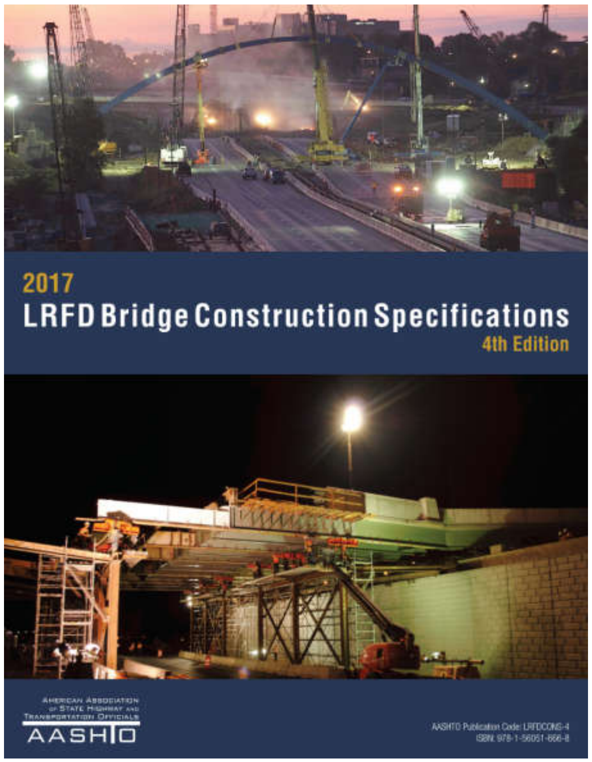
Category 3 – 200 ft < Span < 300ft



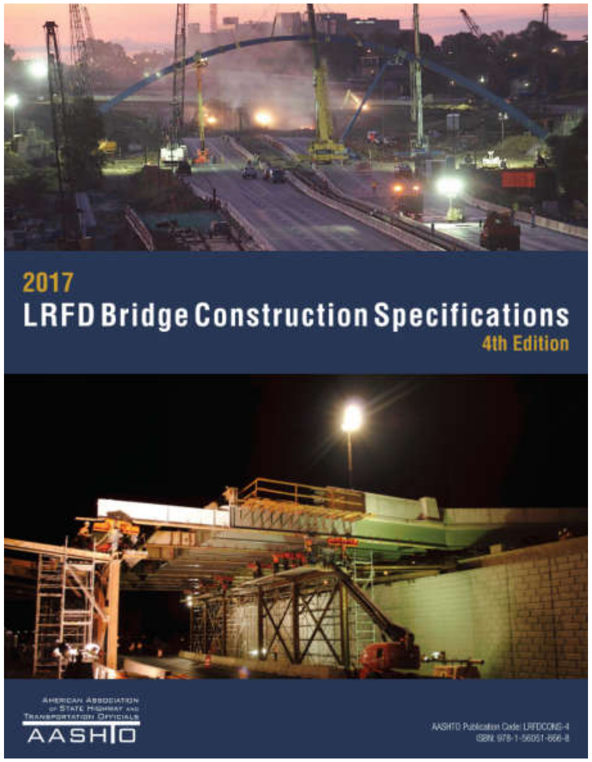
Δ - Displacement Wind no Deck < Must be less than L/150

Otherwise lateral bracing required

AASHTO Bridge Construction Specifications



AASHTO Bridge Construction Specifications



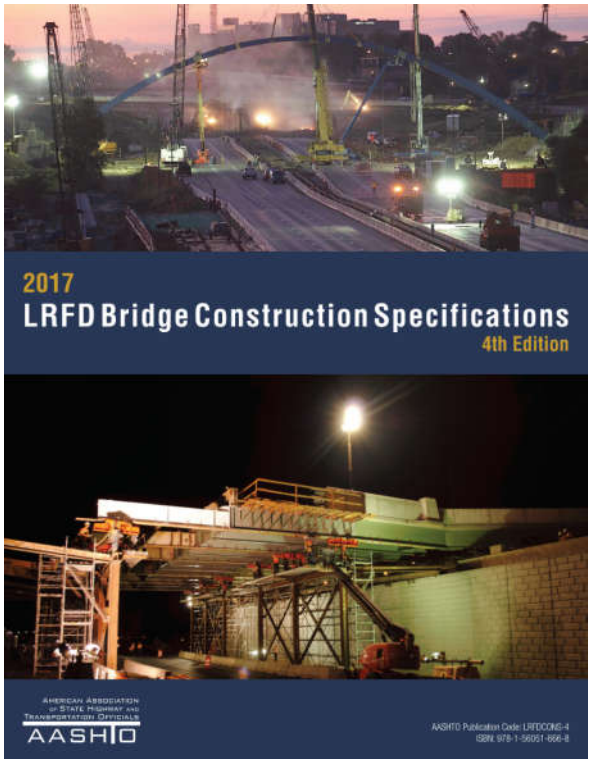
Key Sections:

Chapter 8

Concrete Structures

- 8.13 – Precast Concrete Members
- 8.16 – Special Provisions for Segmental Bridges

AASHTO Bridge Construction Specifications



Key Sections:

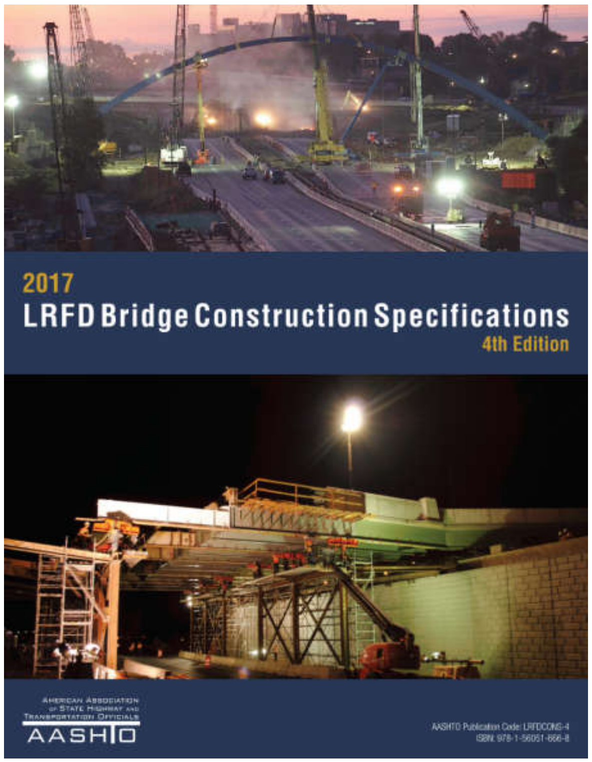
Chapter 8
Concrete Structures

- 8.13 – Precast Concrete Members
- 8.16 – Special Provisions for Segmental Bridges

Chapter 11
Steel Structures

- 11.2 – Erection Drawings
- 11.8 – Additional Provisions for Curved Girders

AASHTO Bridge Construction Specifications



Key Sections:

Chapter 8
Concrete Structures

- 8.13 – Precast Concrete Members
- 8.16 – Special Provisions for Segmental Bridges

Chapter 11
Steel Structures

- 11.2 – Erection Drawings
- 11.8 – Additional Provisions for Curved Girders

Steel Girder Bridges

11.2.2—Erection Drawings

The Contractor shall submit drawings illustrating fully the proposed method of erection. The drawings shall show details of all falsework bents, bracing, guys, dead-men, lifting devices, and attachments to the bridge members: sequence of erection, lo[illegible]es and barges, crane capacities, l[illegible] the bridge members, and weigh[illegible] drawings shall be complete in [illegible]ases and conditions during erectio[illegible]y be required to demonstrate that [illegible]ces are not exceeded and that member cap[illegible]inal geometry will be correct.

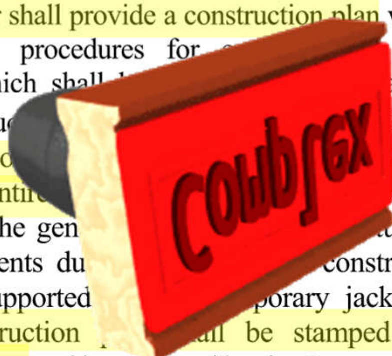
Comm. Ave Bridge, Boston, MA

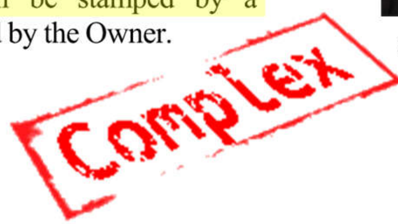
Curved Steel Girder Bridges

11.8—ADDITIONAL PROVISIONS FOR CURVED STEEL GIRDERS

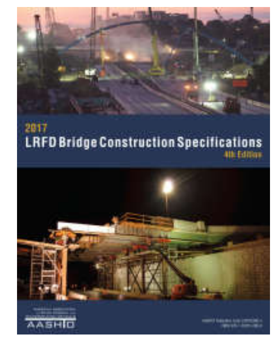
11.8.2—Contractor's Construction Plan for Curved Girder Bridges

The Contractor shall provide a construction plan which details fabrication, procedures for … deck placement, and which shall … as the Contractor's constru… on the plan shown in the co… ded, or may be developed entir… vent, it shall demonstrate the gen… ure and individual components du… construction, including while supported … porary jacks. The Contractor's construction … all be stamped by a Professional Engineer and be accepted by the Owner.





Gateway Interchange Flyovers, Johnson County, KS



Constructability Summary

Structure Classification	Material	Structure Type
Conventional	Concrete	Precast Beams
	Steel	Shorter Straight Spans (< 200-ft)
Complex	Concrete	Spliced Prestressed Beams / Segmental
	Steel	Long Spans (> 200-ft) / Curved / High Skew

Constructability Summary

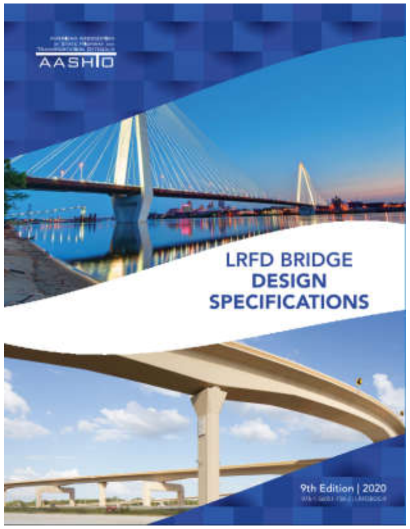
			EOR Responsibility
Structure Classification	Material	Structure Type	Suggested Construction Plan
Conventional	Concrete	Precast Beams	No
	Steel	Shorter Straight Spans (< 200-ft)	No
Complex	Concrete	Spliced Prestressed Beams / Segmental	Yes
	Steel	Long Spans (> 200-ft) / Curved / High Skew	Sometimes

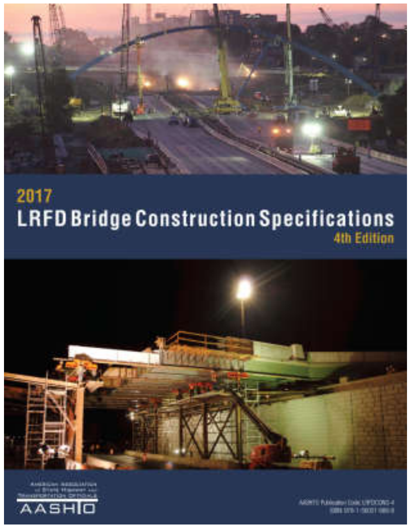
Constructability Summary

			EOR Responsibility	Contractor Responsibility	
Structure Classification	Material	Structure Type	Suggested Construction Plan	Erection Plan Required?	Engineering Required?
Conventional	Concrete	Precast Beams	No	Yes	DOT Dependent
	Steel	Shorter Straight Spans (< 200-ft)	No	Yes	DOT Dependent
Complex	Concrete	Spliced Prestressed Beams / Segmental	Yes	Yes	Yes
	Steel	Long Spans (> 200-ft) / Curved / High Skew	Sometimes	Yes	Yes

Constructability Summary

- AASHTO Specifications clearly distinguish between complex and conventional for concrete girder bridges
- AASHTO Specifications are not as clear for steel girder bridges (I-Girder / Box Girder)
- DOT guides have made effort to address





Constructability Summary

- AASHTO Specifications clearly distinguish between complex and conventional for concrete girder bridges …Mostly out of necessity
- AASHTO Specifications are not as clear for steel girder bridges (I-Girder / Box Girder)
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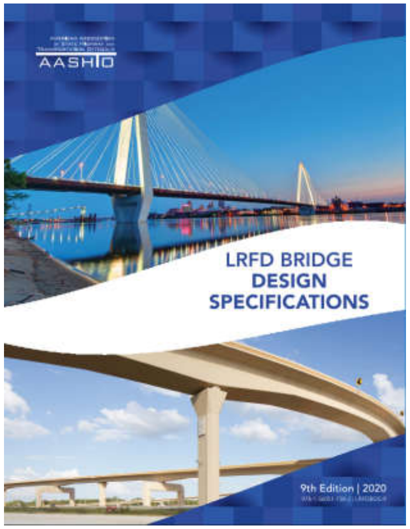

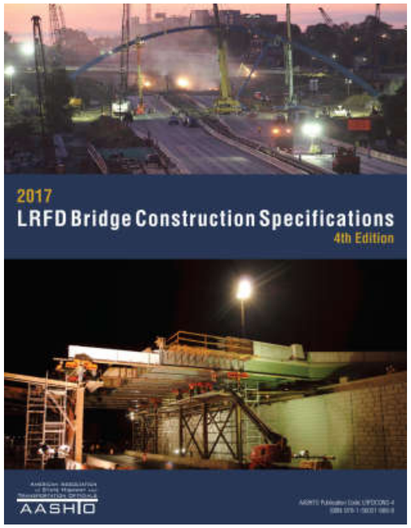

Steel Girder Erection Requirements – Minnesota DOT

DEPARTMENT OF TRANSPORTATION

STANDARD SPECIFICATIONS FOR CONSTRUCTION

2020 EDITION

VOLUME 2

Minnesota 2020 Standard Specifications

2402 STEEL BRIDGE CONSTRUCTION

2402.1 DESCRIPTION

This Work consists of the erection of those portions of Bridges and Structures that are made of structural steel and miscellaneous metals.

E.1 Analysis and Plans

If the Plans show active public access (vehicular, railroad, trails, navigable waters, etc.) beneath the Structure before the complete erection of the beams and transverse members (e.g. diaphragms, cross-frames, lateral bracing) in a span, submit an erection Plan, Specifications, and calculations to the Engineer detailing the temporary works required to maintain structural adequacy and stability of the Bridge system for each step of the erection Plan. Perform design in accordance with *AASHTO LRFD Bridge Design Specifications*, AASHTO *LRFD Bridge Construction Specifications*, and *AASHTO Guide Design Specifications for Bridge Temporary Works*.

Steel Girder Erection Requirements – Minnesota DOT

DEPARTMENT OF TRANSPORTATION

STANDARD

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2402 STEEL BRIDGE CONSTRUCTION

2402.1 DESCRIPTION

This Work consists of the erection of those portions of Bridges and Structures that are made of structural steel and miscellaneous metals.

All Plans, Specifications, and calculations must be prepared and certified by the Contractor's Erection Engineer. The Contractor's Erection Engineer must be a Professional Engineer licensed in the State of Minnesota. All documents included in the submittal must be checked by a second Professional Engineer for completeness and accuracy.

Use struts, bracing, tie cables, and other devices used for temporary restraint of a size and strength capable of withstanding the stresses developed. Erect and brace at least two adjacent beams or girders, including transverse members, in any one span before suspending operations for the day.

Alternate Erection Classification Example - KDOT

- KDOT Section 737 provides erection category system based on complexity
- Accounts for span length, skew and curvature
- Based on category, which designer can indicate on Contract Plans, the level of erection considerations may be required.
- Everyone is on even playing field during bid phase

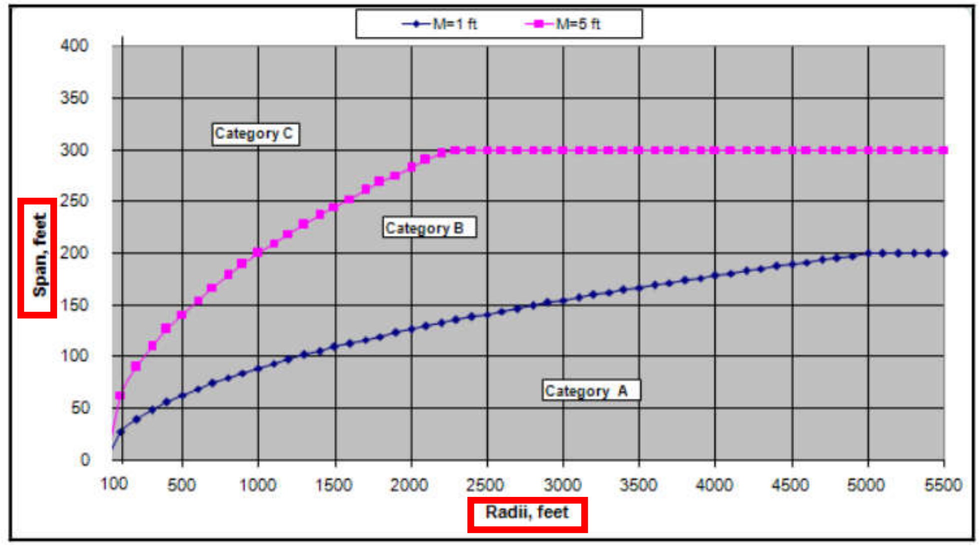


FIGURE 736-1

Special Requirements for Bridge Designers to Designate Erection Plan Categories

The initial Category is based on the chart which considers the length of the longest span, the curvature of the bridge and the skew angle.

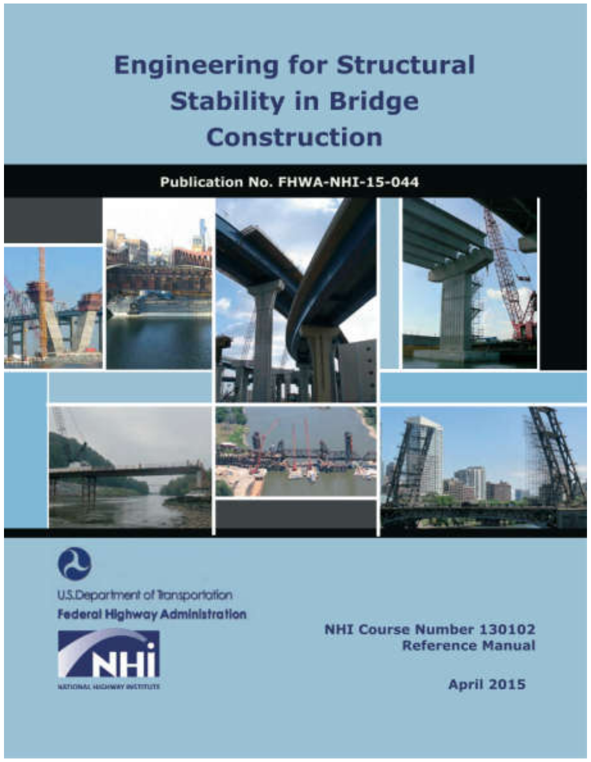
If skew is greater than 30°, move up one Category (A to B or B to C).

If a structure crosses traffic or a railroad, require Category B as a minimum.

If the Contractor uses falsework bents or strong-backs for the field erection, Category C Erection Plans are required.

The designer may elevate a structure to the necessary Category based upon engineering judgment and unique circumstances.

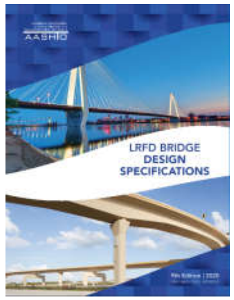
Erection Classification - Survey

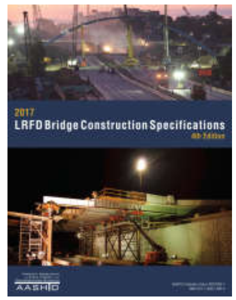


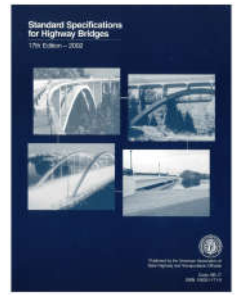
- Survey of AASHTO member states for engineering requirements for structural safety during erection
- 33 states responded to survey
- Past issues related to girder erection
- Threshold for when submittal of erection plans required for review

Construction Engineer’s Literature Review

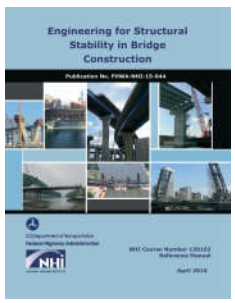
Design Specifications

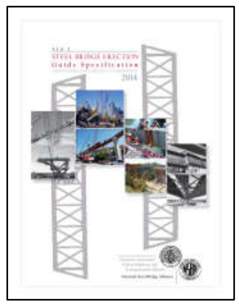


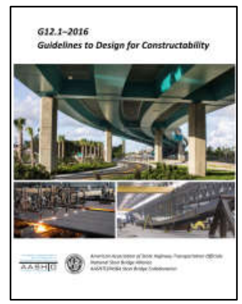


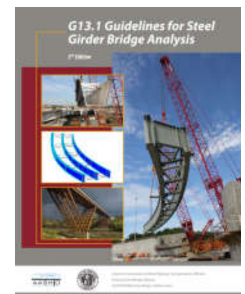


Erection
Guides/Specifications

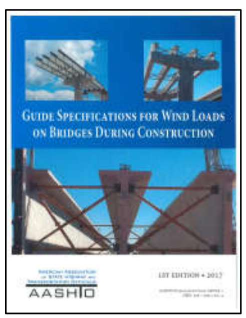


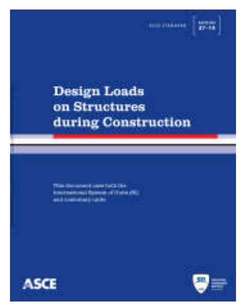


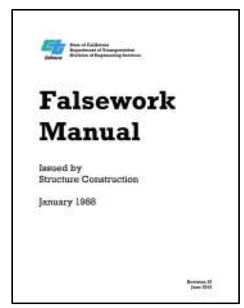




Design Loads

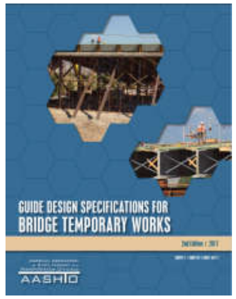


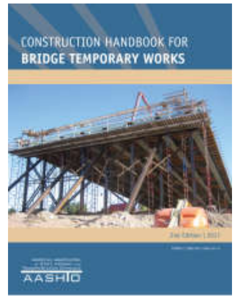


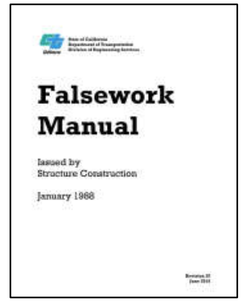


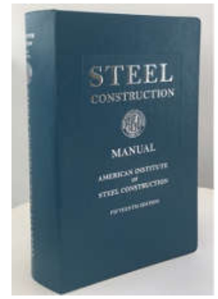
Construction Engineer’s Literature Review

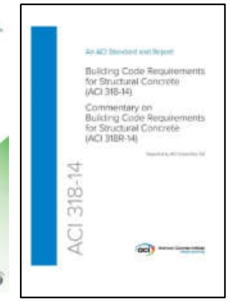
Temporary Works



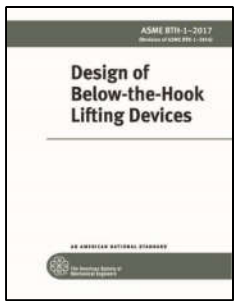


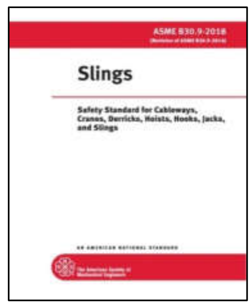




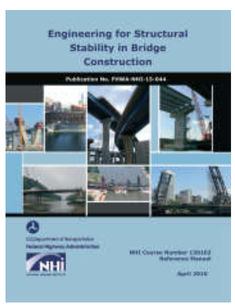


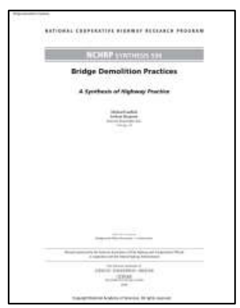
Rigging Hardware

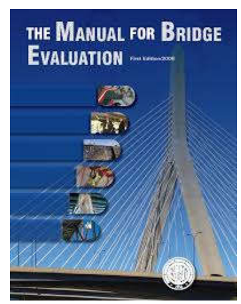




Demolition Guides







Age old question…

Constructibility

6.10.3—Constructibility

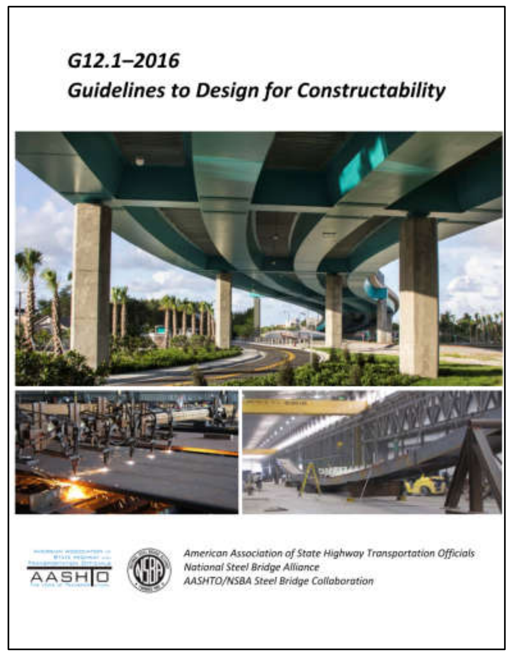
6.10.3.1—General

The provisions of Article 2.5.3 shall apply. In addition to providing adequate strength, nominal yielding or reliance on post-buckling resistance shall not be permitted for main load-carrying members during critical stages of construction, except for yielding of the web in hybrid sections. This shall be accomplished by satisfying the requirements of Articles 6.10.3.2 and 6.10.3.3 at each critical construction stage. For sections in positive flexure that are composite in the final condition, but are noncomposite during construction, the provisions of Article 6.10.3.4 shall apply. For investigating the constructibility of flexural members, all loads shall be factored as specified in Article 3.4.2. For the calculation of deflections, the load factors shall be taken as 1.0.

Potential uplift at bearings shall be investigated at each critical construction stage.

Webs without bearing stiffeners at locations subjected to concentrated loads not transmitted through a deck or deck system shall satisfy the provisions of Article D6.5.

Constructability



Design Loads for Temporary Structures

Equipment Loads

- Almost every bridge structure requires some form of temporary works to erect
- All temporary works require design and planning to accommodate construction loads
- Construction loads are not as easily defined as perhaps for a permanent structure
- Construction Engineers must follow a set of base guidelines and principles but many times work together with their contractor clients to properly educate them on the pro's/con's of a minimum design level vs. risk

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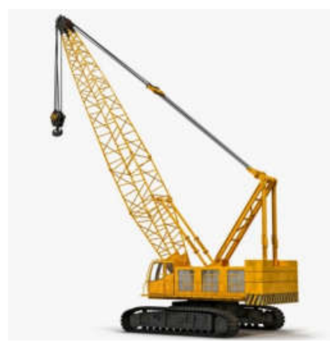
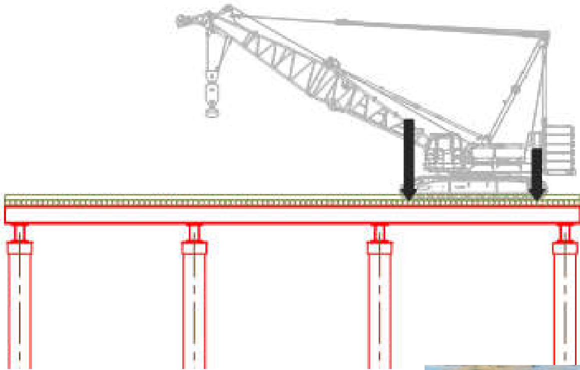
Equipment Loads

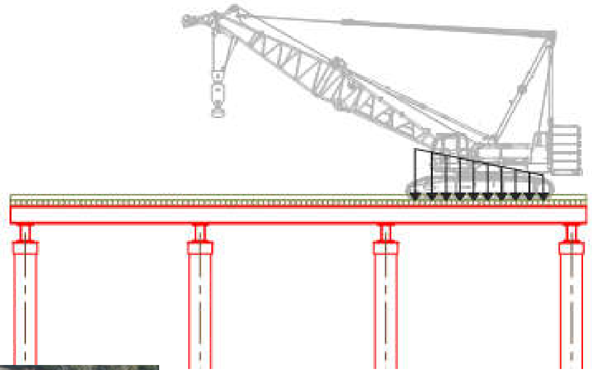
Equipment Loads Manufacturer's Provide Data ….. Right?



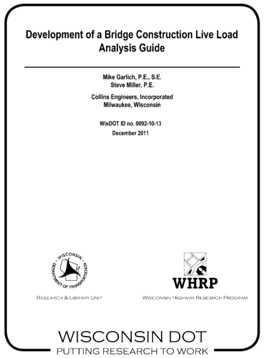
Equipment Loads Manufacturer’s Provide Data ….. Right?

Track Loads >>> Uniform Load or Point Loads



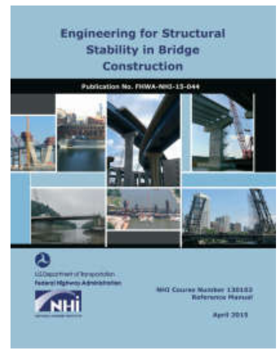


IMPACT



Excavator
Vertical = Silent
Lateral = 10% Equip Wt

Crane
Vertical = 10% Load New
Vertical = 20% Load Demo
Lateral = None



Excavator
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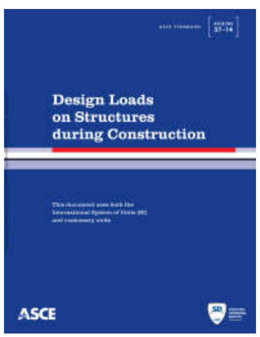

Excavator
Vertical = 30% *
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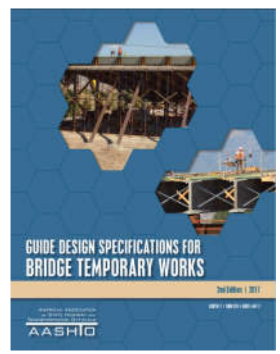
* Or Per Manuf



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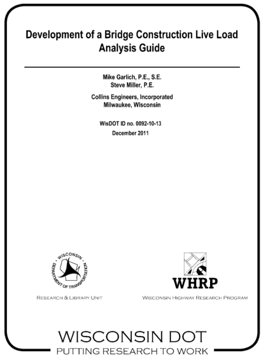

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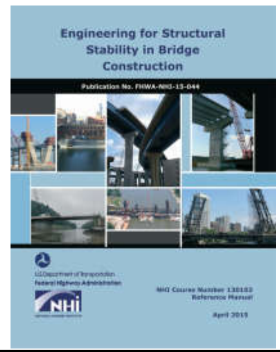

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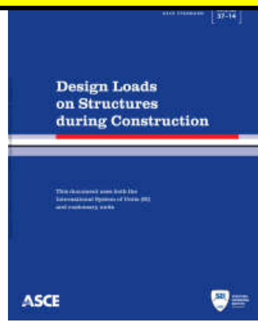
IMPACT >>> Ideal vs…. Actual >>> Up to Operations



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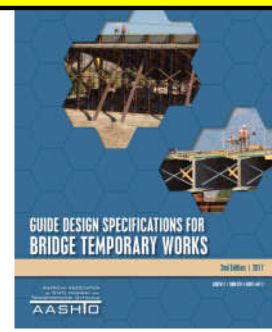

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Environmental Loads

- Mother Nature
  - Affects Permanent Structures
  - Affects Temporary Structures
- All temporary works require design and planning to accommodate environmental loads
  - Unless specified, what level of design is required?
  - Duration vs. Risk Assessment?
- Construction Engineers must follow a set of base guidelines and principles but many times work together with their contractor clients to properly educate them on the pros/cons of a minimum design level vs. risk

Wind
Temperature
Seismic
Stream Flow
Ice
Debris
Scour

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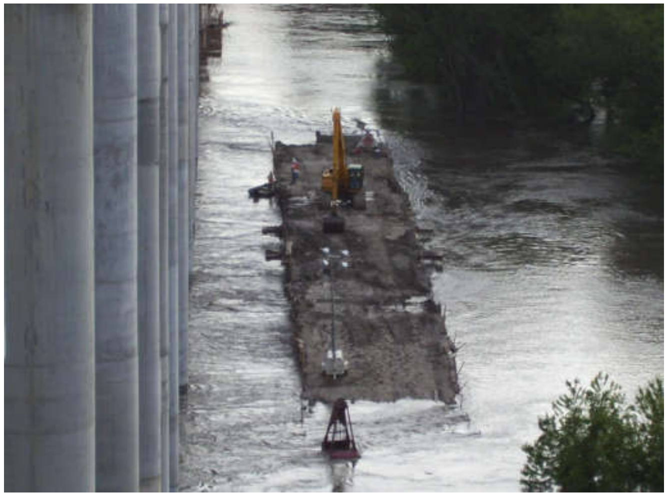

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Bridge Demolition and Re-Decking

Bridge Demolition and Re-Decking

- Thousands of bridges in our current infrastructure need to be replaced and/or rehabilitated
- This *"need"* for bridge replacement generates a need for safe demolition practices
- Currently is no "formal" code that specifically addresses any minimum design criteria to properly analyze a structure that is being taken out of service.
- Genesis is part of a group of engineers and contractors working towards the development of a "Best Practices" guideline for starters

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Lewis and Clark Viaduct, Kansas City, MO

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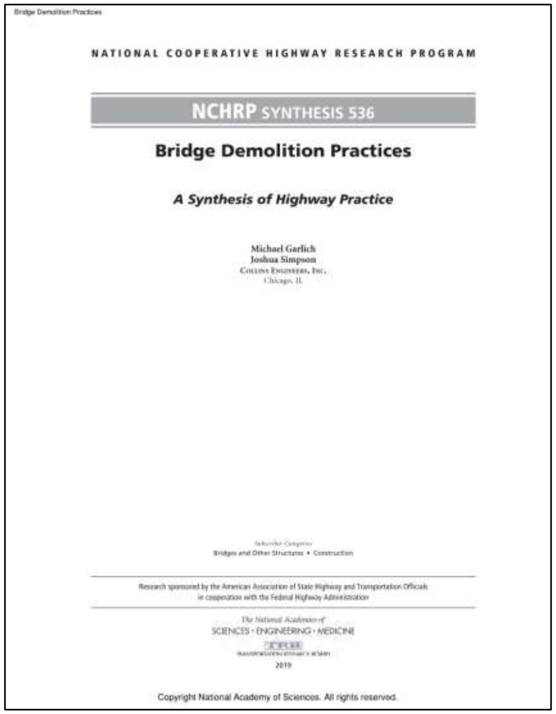
Bridge Demolition Practices

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 536

Bridge Demolition Practices

A Synthesis of Highway Practice

Michael Garlich
Joshua Simpson
Collins Engineers, Inc.
Chicago, IL

Bridges and Other Structures • Construction

Research sponsored by the American Association of State Highway and Transportation Officials in cooperation with the Federal Highway Administration

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2019

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NCHRP Demo Practice Guides

Bridge Demolition and Re-Decking

- Thousands of bridges in our current infrastructure need to be replaced and/or rehabilitated
- This *"need"* for bridge replacement generates a need for safe demolition practices
- Currently is no "formal" code that specifically addresses any minimum design criteria to properly analyze a structure that is being taken out of service.
- Genesis is part of a group of engineers and contractors working towards the development of a "Best Practices" guideline for starters

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

CONSTRUCTION INSTITUTE

Steel Girder Demolition Requirements – Minnesota DOT

DEPARTMENT OF TRANSPORTATION

STANDARD

SPECIFICATIONS

FOR

CONSTRUCTION

2020 EDITION

VOLUME 2

Minnesota 2020 Standard Specifications

2442 REMOVAL OF EXISTING BRIDGES

2442.1 DESCRIPTION

This Work consists of removing and disposing of existing Bridges.

B Structural Steel

Dismantle salvaged structural steel in sections, individual members, or parts as shown on the Plans or as directed by the Engineer. Unless otherwise required by the Contract, remove structural steel in the reverse sequence of the original erection. Remove structural steel without damaging any structural members. Only cut field driven rivets. Use pilot nuts to draw pins.

Remove rivets with a pneumatic chipping tool. Do not use torches unless specifically required by the Contract.

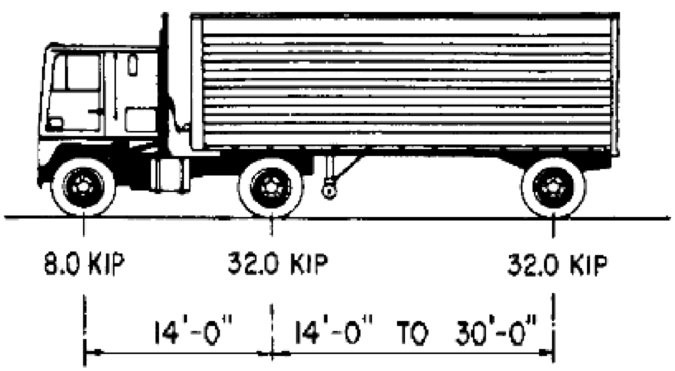
Complications of Bridge Demolition

- Similar to erecting a bridge, structure stiffness and resistance change depending on stage

Lewis and Clark Viaduct, Kansas City, MO

I-75 Deck Replacement, Detroit, MI

Demolition Equipment - Weight



Axle Length 28-ft to 44-ft

AASHTO 3.6.1.2.2 - DESIGN TRUCK

(72,000 lbs)

On a composite structure

Tumbler Spacing
14-ft to 16-ft

EXCAVATOR

CAT 349 (120,000 lb)

On a partially composite to noncomposite structure

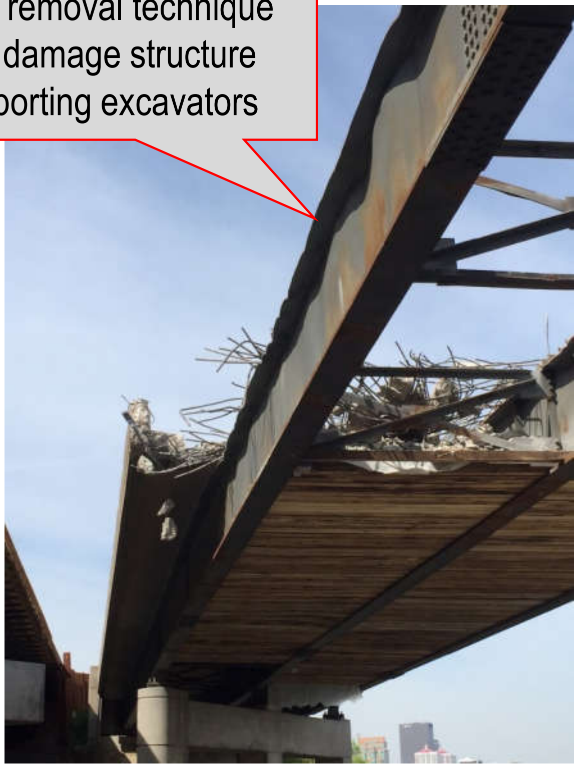
Changing Structural Integrity – Intentional

Comm. Ave Bridge, Boston, MA

I-75 Deck Replacement, Detroit, MI

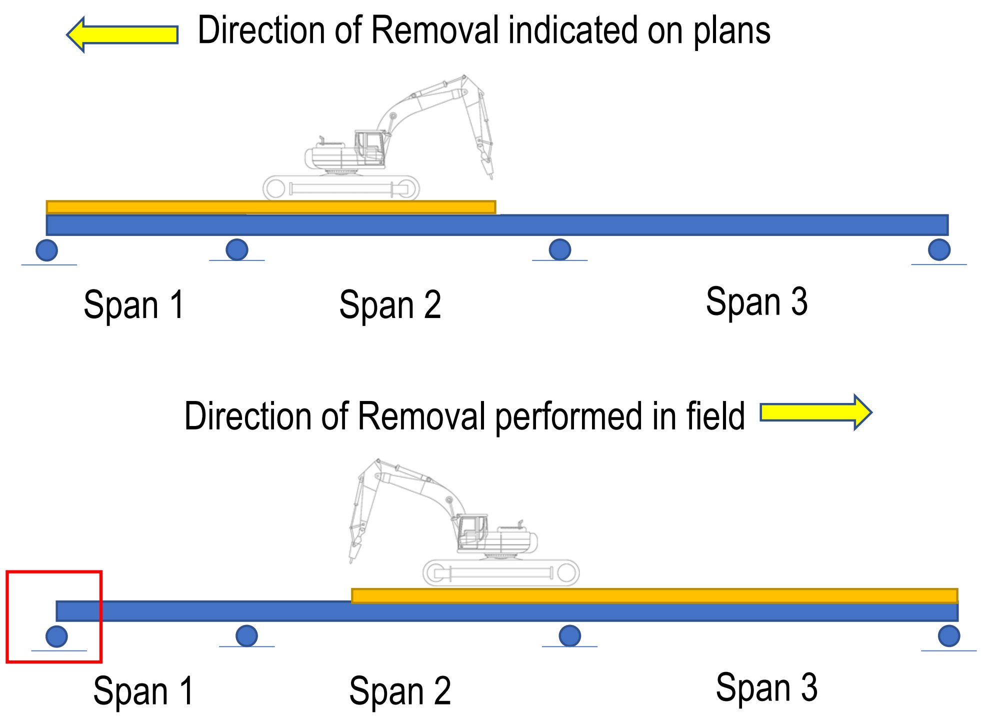
Changing Structural Integrity – Unintentional

Deck removal technique can damage structure supporting excavators

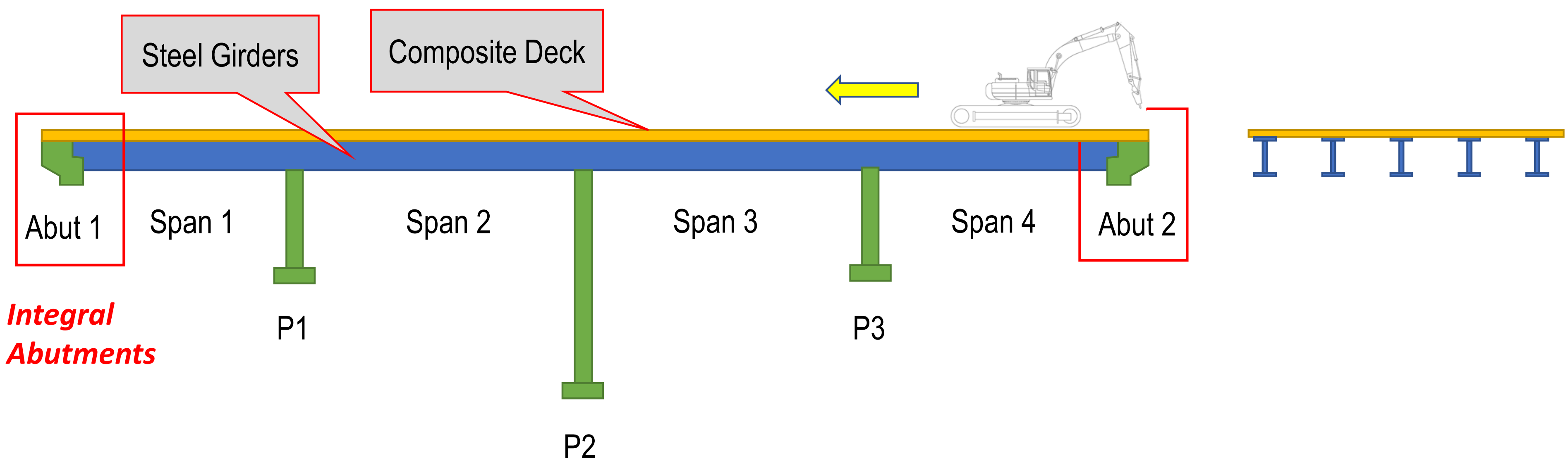


ORB Downtown, Louisville, KY

Direction of Removal Matters!



Changing Structural Integrity – Unintentional



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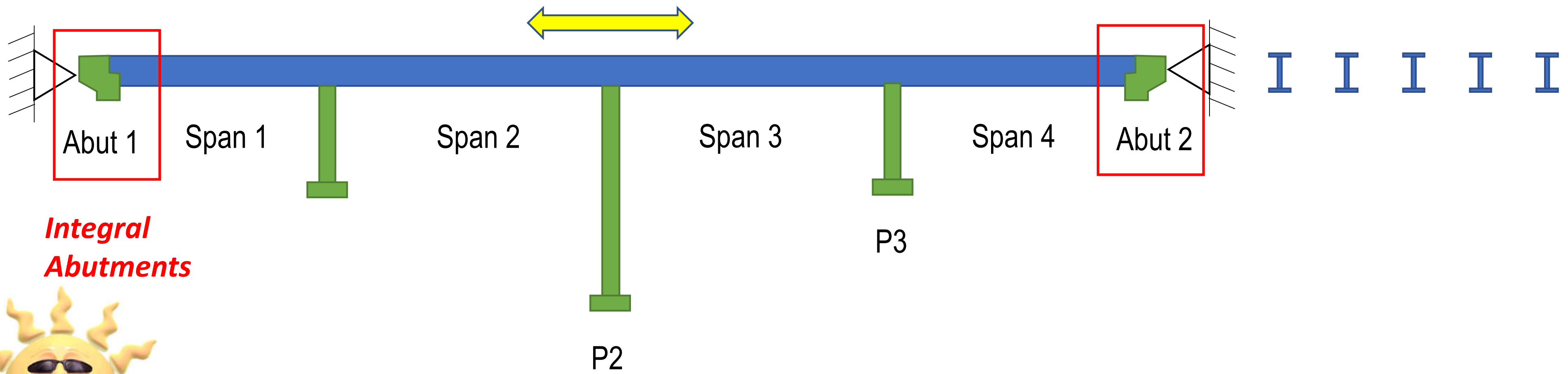

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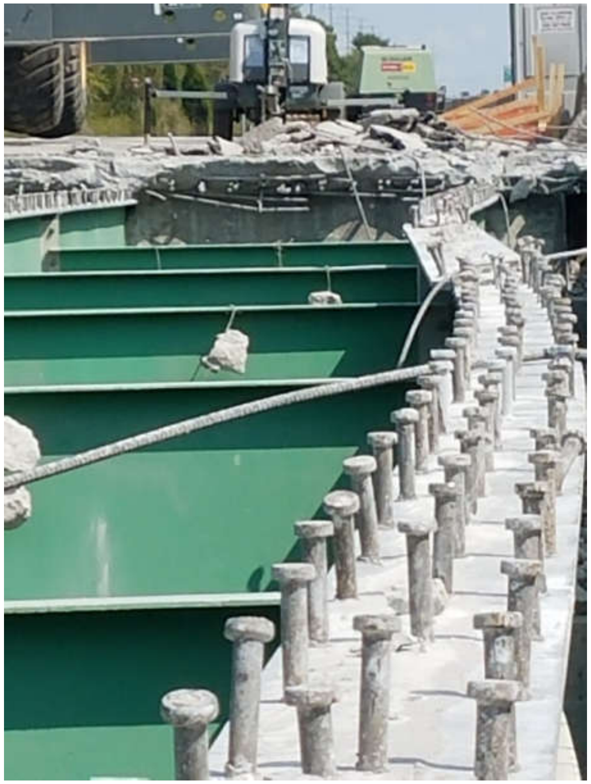

I470 Bridge Re-decking, Kansas City, MO

Demolition Summary

- Demolition is often an overlooked portion of projects with minimal formalized requirements
- Demolition engineering / analysis can be as complicated as erection engineering, and at times can be higher risk
- Goal to establish minimum requirements to increase quality and safety across industry

White River Truss Demolition, Prairie County, AR

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Fore River Lift Span Demolition, Quincy, MA

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K Bridge Lift Span Demolition, New York, NY

Conclusions / Thoughts

Conclusions/Thoughts – Const. Eng. Perspective

- Perfect World
- Design-Bid-Build Contract Plans
- Precast & Steel
- Temporary Works are NOT permanent structures

Conclusions/Thoughts – Const. Eng. Perspective

- Perfect World
  - Design Engineers need to be experts in design and be aware of construction engineering challenges
  - Construction engineers need to be experts in temporary works and maintain an understanding of AASHTO
  - Design Engineers/Owners should not be afraid to reach out to construction engineering firms
  - AASHTO could formally categorize steel girder bridges into erection categories…currently up to DOTs
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  - Design Engineers/Owners should not be afraid to reach out to construction engineering firms
    - The industry can benefit from a front end and back end service
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  - Contractor is responsible for erecting parts and pieces to achieve a fully erected structure
  - Contract plans should provide a design that is stable and safe once the superstructure is fully erected
  - Contract plans should provide a viable “suggested” erection sequence (or at a min deck pour sequence)
  - If the contractor strays from the “suggested”, all engineering is on them
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- Perfect World
- Design-Bid-Build Contract Plans
- Precast & Steel – Similar
- Temporary Works are NOT permanent structures

Conclusions/Thoughts – Const. Eng. Perspective

- Perfect World
- Design-Bid-Build Contract Plans
- Precast & Steel – Similar….. *but Different* (comments from contracting industry)
    - Both commonly used for simple shorter span bridges
    - In some States, precast is challenging longer spans up to 195ft
    - Longer spliced precast spans are possible but require more complex construction engineering
    - Steel bridges are preferred for complex geometries (tight radius ramps and multiple level interchanges)
    - Complex construction (precast or steel) requires advanced erection analysis
- Temporary Works are NOT permanent structures

Conclusions/Thoughts – Const. Eng. Perspective

- Perfect World
- Design-Bid-Build Contract Plans
- Precast & Steel
- Temporary Works are NOT permanent structures
  - Temporary works support the structure in their most unstable periods of time as well as equipment needed to erect the structure
  - Temporary works may only need to work for 15 minutes or could work as long as six to twelve months (or longer in the case of trestles/barges supporting equipment)
  - The design loads/guidelines of temporary works are not as well defined as those for the permanent structures ... This needs to be recognized by the EOR when developing erection submittal specifications and reviewing contractor submittals.

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Questions?

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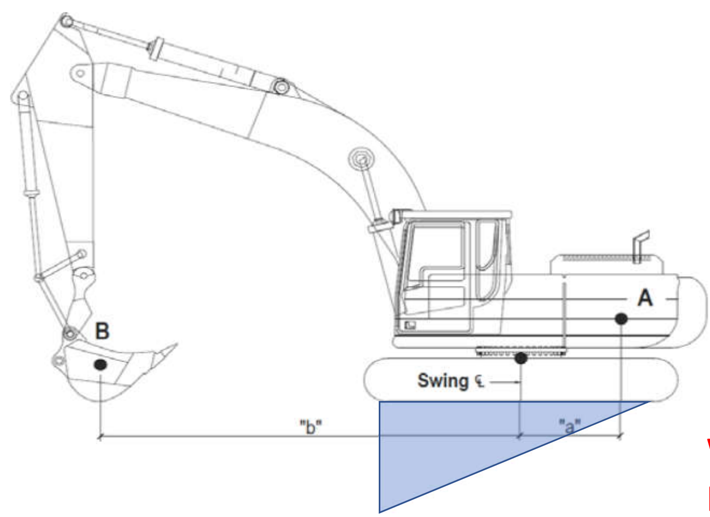
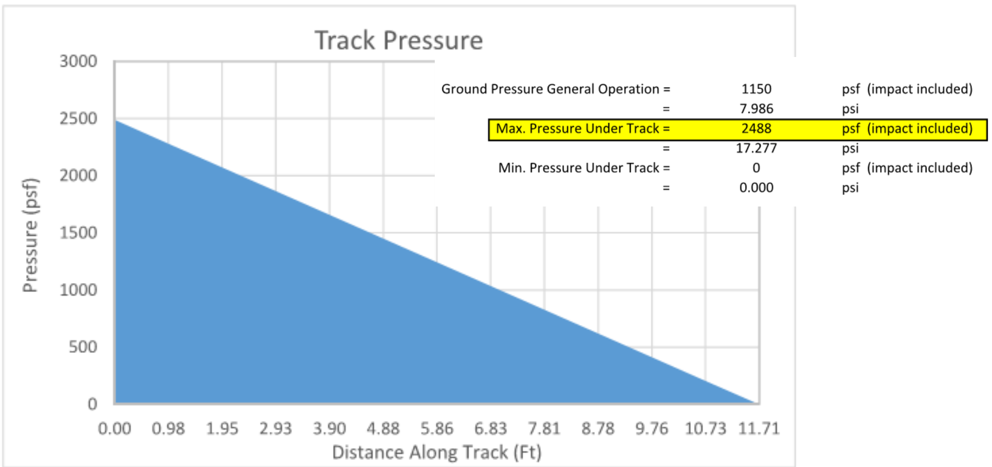
REMOVED

Complications of Bridge Demolition

- Similar to erecting a bridge, structure stiffness and resistance change depending on stage
- Method for determination of load effects from equipment demolishing a structure is not standardized





What level of dynamic effects do you include?
Does it vary by deck removal method?

Deck Removal Methods

- Breaker / Hammer
  - Contractor preference (quick)
  - Can damage flanges / cross frames
  - Protection under bridge may be required

Comm. Ave Bridge, Boston, MA

Deck Removal Methods

- Shear
  - Punch hole in deck with breaker/hammer and shear the rest
  - Multiple Uses:
    - Deck removal
    - Girder/material picking
    - Girder Processing

I40 Fast Fix 8, Nashville, TN
Comm Ave Bridge, Boston, MA

Deck Removal Methods

- Slab Crab / Bucket with Thumb
  - Time Consuming (Deck Cutting)
  - More Controlled
  - Protection under bridge minimal
  - Common for more complex bridges

Slab Crab

Bucket with Thumb

Paseo Suspension Bridge, Kansas City, MO

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