Wind Loads on Steel Bridges During Construction

Addisu Tilahun, PE – Bridge Division

TxDOT Steel Quality Council Meeting

November 22, 2021
# Table of contents

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Objectives</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Overview of Guide Specifications for Wind Loads on Bridges During Construction</td>
<td>4-17</td>
</tr>
<tr>
<td>3</td>
<td>Wind Loads on Bridges During Construction: PennDOT’s and FDOT’s Guidance</td>
<td>18-28</td>
</tr>
<tr>
<td>4</td>
<td>TxDOT Standard Specifications: Item 441 Steel Structures</td>
<td>29-30</td>
</tr>
<tr>
<td>5</td>
<td>TxDOT’s Preferred Practices: Lateral Bracing Guidance</td>
<td>31</td>
</tr>
<tr>
<td>6</td>
<td>2022 AASHTO Bridge Committee Agenda Item (on Wind Loads)</td>
<td>32-33</td>
</tr>
<tr>
<td>7</td>
<td>Major Takeaways</td>
<td>34</td>
</tr>
<tr>
<td>8</td>
<td>References</td>
<td>35</td>
</tr>
<tr>
<td>9</td>
<td>Questions &amp; Comments</td>
<td>36</td>
</tr>
</tbody>
</table>
Objectives

- Review of national guide specifications and case studies of State DOT’s policy/guidance for wind loads on bridge during construction:
  - AASHTO Guide Specifications for Wind Loads on Bridges During Construction,
  - PennDOT’s and FDOT’s Wind Loads Guidance/Policy on steel bridges during construction,
  - TxDOT’s Current Standard Specifications requirement on steel girders erection.
  - TxDOT’s Preferred Practices for Steel Bridge Design, Fabrication, and Erection guidance on lateral bracing.

Summary

- Take comments/feedback to develop future TxDOT guidance related to wind loads during construction.
Wind Loads on Bridges

- To determine wind loads on partially erected steel girders/ fully erected steel girders without deck slab.
- To be used by contractors/erection engineers and designers.

- To determine wind loads for bridges in service.
- To be used by designers.
Wind Loads on Bridges

- The general wind pressure equation used by both specifications:

\[ P_z = \rho V^2 k_z G C_D \]

- Where:

\[ P_z = \text{design wind pressure}, \]
\[ \rho = \text{constant related to the density of air}, \]
\[ V = \text{wind speed at a set elevation}, \]
\[ k_z = \text{pressure exposure and elevation coefficient}, \]
\[ G = \text{gust effect factor}, \]
\[ C_D = \text{drag coefficient}. \]

- Generally, lower wind speed is specified for construction duration compared to the bridge in service.

- The flow of wind around the structure is different for construction phase & bridge in service, \( C_D \) will be different.
Guide Specifications for Wind Loads on Bridges During Construction

Definitions:

- **Active Work Zone** - work zone during the time workers are on-site and erection of the structure is in progress.

- **Inactive Work Zone:**
  - work zone during the time construction work is not being performed,
  - time between work shifts and overnights,
  - the time between the erection of the girders and the placement of the deck.
Guide Specifications for Wind Loads on Bridges During Construction

- **Temporary Bridge Works** – Temporary components and structures used in the construction of bridges that are meant to be removed during or after the completion of the structure.

- **Wind Speed:**
  - **For active work zones:** 20 mph unless a higher wind load is specified by the owner.
Wind Speed (Contd.):

- For inactive work zones: wind speed shall be taken from Figure 4.1.2-1 and modified using the wind speed reduction factor during construction (R).

- For areas designated as a special wind region in Figure 4.1.2-1: the owner shall approve the 3-second gust wind speed.

Figure 4.2.1-1 from Guide Specifications for Wind Loads on Bridges During Construction (1st edition, 2017).
The wind pressure shall be determined using Eq 4.2.1-1:

\[ P_z = 2.56 \times 10^{-6} V^2 R^2 k_z G C_D \]  (4.2.1-1)

Where:

- \( P_z \) = design wind pressure (ksf),
- \( V \) = design 3-second gust wind speed,
- \( R \) = Wind speed reduction factor during construction of the superstructure taken as 1.0 for active work zones and from Table 4.2.1-1 for inactive work zones,
- \( k_z \) = pressure exposure and elevation coefficient,
- \( G \) = gust effect factor determined using a structure-specific study,
- \( C_D \) = drag coefficient, minimum allowed for inactive work zone = 0.77.
Table 4.2.1-1—Wind Speed Reduction Factor During Construction, $R$

<table>
<thead>
<tr>
<th>Superstructure Construction Duration</th>
<th>Wind Speed Reduction Factor during Construction, $R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 weeks</td>
<td>0.65</td>
</tr>
<tr>
<td>6 weeks to 1 year</td>
<td>0.73</td>
</tr>
<tr>
<td>&gt;1-2 years</td>
<td>0.75</td>
</tr>
<tr>
<td>&gt;2-3 years</td>
<td>0.77</td>
</tr>
<tr>
<td>&gt;3-7 years</td>
<td>0.84</td>
</tr>
</tbody>
</table>

Table C4.2.1-2—Pressure Exposure and Elevation Coefficients, $K_z$

<table>
<thead>
<tr>
<th>Structure Height, $Z$ (ft)</th>
<th>Wind Exposure Category B</th>
<th>Wind Exposure Category C</th>
<th>Wind Exposure Category D</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;33</td>
<td>0.71</td>
<td>1.00</td>
<td>1.15</td>
</tr>
<tr>
<td>40</td>
<td>0.75</td>
<td>1.05</td>
<td>1.20</td>
</tr>
<tr>
<td>50</td>
<td>0.81</td>
<td>1.10</td>
<td>1.25</td>
</tr>
<tr>
<td>60</td>
<td>0.85</td>
<td>1.14</td>
<td>1.29</td>
</tr>
<tr>
<td>70</td>
<td>0.89</td>
<td>1.18</td>
<td>1.32</td>
</tr>
<tr>
<td>80</td>
<td>0.92</td>
<td>1.21</td>
<td>1.35</td>
</tr>
<tr>
<td>90</td>
<td>0.95</td>
<td>1.24</td>
<td>1.38</td>
</tr>
<tr>
<td>100</td>
<td>0.98</td>
<td>1.27</td>
<td>1.41</td>
</tr>
<tr>
<td>120</td>
<td>1.03</td>
<td>1.32</td>
<td>1.45</td>
</tr>
<tr>
<td>140</td>
<td>1.07</td>
<td>1.36</td>
<td>1.49</td>
</tr>
<tr>
<td>160</td>
<td>1.11</td>
<td>1.40</td>
<td>1.52</td>
</tr>
<tr>
<td>180</td>
<td>1.15</td>
<td>1.43</td>
<td>1.55</td>
</tr>
<tr>
<td>200</td>
<td>1.18</td>
<td>1.46</td>
<td>1.58</td>
</tr>
<tr>
<td>250</td>
<td>1.24</td>
<td>1.52</td>
<td>1.63</td>
</tr>
<tr>
<td>300</td>
<td>1.30</td>
<td>1.57</td>
<td>1.68</td>
</tr>
</tbody>
</table>

Table 4.2.1-1 and Table C4.2.1-2 from Guide Specifications for Wind loads on Bridges During Construction, 1st edition, 2017.
Drag coefficient ($C_D$), for any of the girders in the cross section during the period between girder erection and deck placement, depends on:

- **The position of the girder** in the girder group. Windward girder is usually subjected to higher wind loads than other girders.
- **Type of Girder**: steel I-girders, concrete I-girders and box-girders.
- **Geometry of the Girder cross-section**.
- **Cross slope or superelevation**.

Figure C4.2.1-1 from Guide Specifications for Wind Loads on Bridges During Construction (1st edition, 2017).
Table 4.2.1-2—Base Drag Coefficient for Bridge Superstructures During Construction

<table>
<thead>
<tr>
<th>Superstructure Type</th>
<th>Base Drag Coefficient ($C_{D,\text{base}}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Plate Girders</td>
<td>2.2</td>
</tr>
<tr>
<td>Rolled I-Beams</td>
<td>2.2</td>
</tr>
<tr>
<td>Concrete I-Beams</td>
<td>2.0</td>
</tr>
<tr>
<td>Closed and Open Box-Girders</td>
<td>2.1</td>
</tr>
<tr>
<td>Round Members</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 4.2.1-3—Drag Coefficient for Different Girders of Bridge Superstructures During Construction Before the Deck is Constructed

<table>
<thead>
<tr>
<th>Girders</th>
<th>Drag Coefficient ($C_D$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windward girders in multi-girders I-girders and box-girders systems</td>
<td>$C_{D,\text{base}}$</td>
</tr>
<tr>
<td>Second girders, windward side in multi-girders systems</td>
<td>$0.5 C_{D,\text{base}}$</td>
</tr>
<tr>
<td>In two-box-girders systems with a clear distance between the two boxes of no more than twice the girders depth</td>
<td></td>
</tr>
<tr>
<td>In all other systems</td>
<td>0.0</td>
</tr>
<tr>
<td>Third, fourth, and fifth girders, windward side in multi-girders systems</td>
<td>$0.25 C_{D,\text{base}}$</td>
</tr>
<tr>
<td>In multi-girders systems with ratio of girders spacing to girders depth is not greater than 3</td>
<td></td>
</tr>
<tr>
<td>In multi-box-girders systems</td>
<td>$0.5 C_{D,\text{base}}$</td>
</tr>
<tr>
<td>All other girders</td>
<td>$0.5 C_{D,\text{base}}$</td>
</tr>
</tbody>
</table>

Table C4.2.1.3—Base Drag Coefficient for Box-Girders of Different Geometry During Construction

<table>
<thead>
<tr>
<th>Box Geometry</th>
<th>Base Drag Coefficient ($C_{D,\text{base}}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>2.05</td>
</tr>
<tr>
<td>D</td>
<td>1.66</td>
</tr>
<tr>
<td>2D</td>
<td>1.35</td>
</tr>
<tr>
<td>4D</td>
<td>1.39</td>
</tr>
</tbody>
</table>

Table 4.2.1-2, Table 4.2.1-3 and C4.2.1.3

Guide Specifications for Wind Loads on Bridges During Construction

- **Wind Loads on Superstructure:**
  - In lieu of performing refined analysis, the lateral moment at any point along a girder due to transverse wind pressure shall be taken as the sum of two components (section 4.2.2.1):
    \[ M = M_G + M_L \]
  - **Global moment** - the moment calculated assuming the girder to act as a horizontal cantilever or a simple or continuous beam, supported laterally at the points of support existing at this stage of construction.

---

Girder modeled as a horizontal beam laterally supported at permanent & temporary support locations. (Plan view)
Wind Loads on Superstructure (contd.):

- **Local moment** - the local moment shall be determined assuming the girder to act as a horizontal continuous beam supported at the locations of cross-frames and at support locations existing at the stage of construction being analyzed.

- **Local positive and negative moments, \( M_L \):**

\[
M_L = \frac{P_z h S^2}{10} (C4.2.2.1 - 1)
\]

Where:

- \( P_z \) = design wind pressure for a girder (ksf),
- \( h \) = girder height (ft),
- \( S \) = spacing between points.

Girder modeled as a horizontal continuous beam laterally supported at the locations of cross-frames and at supports. (Plan view)
Wind Loads on Cross-Frames, Diaphragms and Braces:

- The wind load used to design a panel of the cross-frames, diaphragms, or temporary braces shall be taken as 1.5 times the wind load on the area of the fascia girder contributing to the load in the component being designed. (Section 4.2.2.2)

- For design of the cross-frame members, one half of the force on the panel shall be applied at the level of the top chord of the cross frame and the other half will be applied at the level of the bottom chord.
Wind Loads on Substructure (from superstructure):

- Transverse and longitudinal wind load components transmitted from girders to the substructures are calculated by multiplying the wind pressure \( P_z \), girder depth \( h \) and the skew coefficients in Table 4.2.3.1.1 for various angle of attack.

- The wind load from the superstructure transmitted to the temporary bridge works shall be increased by any factors specified in the AASHTO Guide Design Specifications for Bridge Temporary Works (2017).

- Both components of the wind loads shall be applied as line loads at the mid-depth of the girders.

Table 4.2.3.1-1—Skew Coefficients for Various Skew Angles of Attack

<table>
<thead>
<tr>
<th>Skew Angle (degree)</th>
<th>Trusses, Columns, and Arches</th>
<th>Girders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transverse Skew Coefficient</td>
<td>Longitudinal Skew Coefficient</td>
</tr>
<tr>
<td>0</td>
<td>1.000</td>
<td>0.000</td>
</tr>
<tr>
<td>15</td>
<td>0.933</td>
<td>0.160</td>
</tr>
<tr>
<td>30</td>
<td>0.867</td>
<td>0.373</td>
</tr>
<tr>
<td>45</td>
<td>0.627</td>
<td>0.547</td>
</tr>
<tr>
<td>60</td>
<td>0.320</td>
<td>0.667</td>
</tr>
</tbody>
</table>

Guide Specifications for Wind Loads on Bridges During Construction

- Wind Loads applied directly to the substructure:
  - The transverse and longitudinal forces to be applied directly to permanent substructures shall be calculated using Eq. 4.2.1-1:

  \[ P_z = 2.56 \times 10^{-6} V^2 R^2 k_z GC_D \]  (4.2.1-1)

  - The wind pressure shall be resolved into components perpendicular to the end and front elevations of the substructure.
  - Apply the substructure wind load components and the wind loads from the superstructure simultaneously.
Wind Loads on Bridges During Construction: PennDOT’s Policy

BD-620M Standard (Lateral Stability Bracing Criteria and Bracing Details)
PennDOT’s Steel Girder Bridges Lateral Bracing Criteria and details

- PennDOT requires contractors/erection engineers to use Guide Specifications for Wind Loads on Bridges During Construction (as stated in Publication 408/2020 Specifications Section 10503.(c)).

- During erection, the contractor is to evaluate partially completed girders.

- PennDOT requires designers to follow BD-620M Standard, Steel Girder bridges Lateral Bracing Criteria and Bracing details.

- BD-620M Standard applies only to completely erected steel superstructure without the deck.

- The design criteria in BD-620M Standard:
  - Permissible lateral deflection of steel superstructure is given as \( \frac{L}{150} \), where \( L \) = span length (ft).
  - Analysis method:
    - Hand calculation for a single fascia girder,
    - A grid analysis for the entire steel superstructure.
### PennDOT’s Steel Girder Bridges Lateral Bracing Criteria and details

- The design criteria in BD-620M Standard (Contd.):
  - This table, developed based on PennDOT’s BD-620M standard, summarizes the current lateral bracing recommendations based on span length and deflection.

<table>
<thead>
<tr>
<th>Span, Length (ft.)</th>
<th>Lateral Bracing Recommended</th>
<th>Lateral Deflection Limit, L (ft.)</th>
<th>Recommendation (to limit lateral deflection)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 200 ft.</td>
<td>No</td>
<td>L/150</td>
<td>Use wider flanges or additional cross-frames.</td>
</tr>
<tr>
<td>200 ft. – 300 ft.</td>
<td>Yes / No</td>
<td>L/150</td>
<td>Use permanent horizontal plane lateral bracings.</td>
</tr>
<tr>
<td>Greater than 300 ft.</td>
<td>Yes</td>
<td>L/150</td>
<td>Use permanent horizontal plane lateral bracings near top (preferred for curved plate girders) or bottom flange (preferred for straight plate girders).</td>
</tr>
</tbody>
</table>
PennDOT’s Steel Girder Bridges Lateral Bracing Criteria and details

- The design criteria in BD-620M Standard (Contd.):
  - Use the minimum design wind pressure specified in the table except for bridges over traffic, increase these pressures by 5 PSF.
  - Evaluate girder stresses for combined dead load and wind loads using the following load combinations:
    - Strength I – 1.25*DC+1.5*CDL+1.5*CLL
    - Strength III – 1.25*DC+1.25*CDL+1.0*CW
    - Strength IV – 1.4*DC+1.4*CDL+1.4*CLL
    - Service I – 1.0*DC+1.0*CDL+1.0*CLL+1.0*CW
    - UPLIFT (MIN.) – 0.9*DC+0.9*CDL+1.0*CW
    - UPLIFT (MAX.) – 1.35*DC+1.35*CDL+1.0*CW

NOTE:
DC = PERMANENT DEAD LOAD, CDL = CONSTRUCTION DEAD LOAD
CLL = CONSTRUCTION LIVE LOAD, CW = WIND LOAD

Table extracted from BD-620M Standard
**Lateral bracing recommendations:**

- Design bolted connection of the lateral bracing to girder.
- Provide oversized or slotted holes and design the connection for wind forces only.
- Use permanent lateral bracing arrangement.
- Preferred arrangement is to attach lateral bracing to bottom flange.

Details extracted from PennDOT BD-620M Standard
FDOT’s Wind Load Provisions and Specifications
FDOT’s Wind Load Provisions and Specifications

- FDOT has not adopted the Guide Specifications for Wind loads on Bridges During Construction.
- Per Structures Design Guidelines (SDG) 6.10:
  - FDOT requires designers to investigate the stability of beams/girders subjected to wind loads during construction.
  - Use wind loads, temporary construction loads, and limit states (based on AASHTO LRFD) to evaluate stability during construction.
  - For steel girder bridges, FDOT requires a workable erection scheme that addresses all major phases of erection to be included in the plans.
FDOT’s Wind Load Provisions and Specifications

- FDOT recommends using AASHTO LRFD equation 3.8.1.2.1-1 with Florida specific requirements (per SDG section 2.4.3):

$$P_z = 2.56 \times 10^{-6} V^2 k_z G C_D$$ (3.8.1.2.1-1)

- Where:
  - $P_z =$ design wind pressure (ksf),
  - $V =$ design wind speed given in table 2.4.3-1,
  - $k_z =$ pressure exposure and elevation coefficient, $\geq 0.85$,
  - $G =$ gust effect factor of 0.85 for sound barriers & all other structures,
  - $C_D =$ drag coefficient, given in table 2.4.3-2.
FDOT’s Wind Load Provisions and Specifications

Table 2.4.3-1 Load Factors and Design Wind Speed During Construction

<table>
<thead>
<tr>
<th>Load Combination Limit State</th>
<th>( (\gamma_{ws} )</th>
<th>Design Wind Speed, ( V )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength III</td>
<td>1.0</td>
<td>90 mph</td>
</tr>
<tr>
<td>Service I</td>
<td>1.0</td>
<td>90 mph</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Construction Inactive</th>
<th>Construction Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 mph or expected wind speed, if higher</td>
<td>30 mph or expected wind speed, if higher</td>
</tr>
</tbody>
</table>

(Structures Design Guidelines (SDG) FDOT, Table 2.4.3-1)

- **Construction Inactive** = periods during which construction activities associated with the superstructure do not take place.
- **Construction Active** = periods during construction activities take place. It can be assumed that the construction active period for deck placement is in effect until the deck concrete hardens.
- Check limit states separately for Construction Inactive and Construction Active wind speeds.
FDOT’s Wind Load Provisions and Specifications

- FDOT has a modified drag coefficient, $C_D$, based on wind tunnel research and post-processing conducted by FDOT.

*(Structures Design Guidelines (SDG) FDOT, Table 2.4.3-2 & Table 2.4.3-3)*
FDOT’s Wind Load Provisions and Specifications

- FDOT Standard specifications state the following wind load requirements at the construction phase (sections 5-1.4.5.7 and 5-1.4.5.8):

  - The contractor is solely responsible for ensuring stability of beams & girders during all handling, storage, shipping and erection.

  - The contractor shall adequately brace beams & girders to resist wind, weight of forms & other temporary loads during all stages of erection and deck construction.

  - Develop the required bracing designs in accordance with AASHTO LRFD Bridge Design Specifications (LRFD) and chapter 11 of the Structures Design Guidelines (SDG).

(Standard Specifications for Road and Bridge Construction, FDOT, Section 5-1.4.5.8)
TxDOT’s Standard Specifications: Item 441 Steel Structures

- TxDOT’s Standard Specifications Item 441 Steel Structures require erection drawings:
  - to be submitted for structural steel erection (usually not required for rolled-I beams).
  - To be signed and sealed by a licensed professional engineer.
  - To be prepared in accordance with Section 2.2 of the AASHTO/NSBA Steel Bridge Collaboration S10.1 (Steel Bridge Erection Guide Specification).

- AASHTO/NSBA Steel Bridge Collaboration S10.1 Section 2.2.9 states that Erection Plans and Procedures shall include restrictions on wind loading, construction dead and live loads.
SP441-03 (SP441-003) is recently issued Special Provision to Item 441 Steel Structures, effective with the September 2021 letting, for Statewide Use.

Section 441.3.1.6.1., “Erection Drawings,” the third paragraph is voided and replaced with the following:

- Perform erection engineering evaluation of the structural adequacy and stability of constructing the bridge system for each step of the steel girder erection.
Preferred Practices for Steel Bridge Design, Fabrication, and Erection have following guidance related to lateral bracing (Section 2.2.1 & Section 2.2.2.5):

- Increase flange thickness and flange width to keep lateral bending stresses within the limit:
  - For straight girders, use a flange width ≥ Web Depth/5
  - For curved girders, use a flange width ≥ Web Depth/4
- Use lateral bracing only where it is absolutely necessary
- Disadvantages of using lateral bracing: can create fatigue-sensitive details, costly to fabricate, and difficult to install

Currently TxDOT does not have requirement/guidance for designers to consider wind Loads on Bridges During Construction at the design phase. Thus, the third wind load path, inactive work zone wind load case of fully erected steel girders without deck slab and with no wind bracing in the plane of the flanges, as stated in AASHTO 4.6.2.7 will be applicable.
2022 AASHTO BRIDGE COMMITTEE AGENDA ITEM

- Subject: LRFD Bridge Design Specifications: Section 4, Articles C4.6.2.7.1 and 4.9,
- Technical Committee: T-5 Loads and Load Distribution/ T-14 Structural Steel Design
- For the third wind load path, the maximum wind moment on the loaded flange may be computed as (AASHTO LRFD, 9th Edition, 2020):

\[ M_w = \frac{WL_b^2}{10} + \frac{WL^2}{8N_b} \]  
(C4.6.2.7.1 - 3)

- Where: \( M_w \) = total lateral moment in the flange due to the factored wind loading (kip-ft)
  
  \( W \) = factored wind force per unit length applied to the flange (kip/ft)
  
  \( L_b \) = spacing of cross-frames or diaphragms (ft)
  
  \( N_b \) = spacing of cross-frames or diaphragms (ft), \( L \) = span length (ft)

- The second term in Eq. C4.6.2.7.1-3 results in significantly conservative results when used for continuous-span girders.
Technical Committee T-5 Loads and Load Distribution/ T-14 Structural Steel Design proposes the following addition into Article C4.6.2.7.1:

- Alternatively, for the third wind load path, the maximum wind moment at any point along the girder may be computed as the sum of a global moment and a local moment calculated as specified in Article 4.2.2.1 of the AASHTO Guide Specifications for Wind Loads on Bridges During Construction.

- Local and global moment calculation based on Article 4.2.2.1 of the AASHTO Guide Specifications for Wind Loads on Bridges During Construction has been discussed in Slide 13 & 14 of this presentation.
Major Takeaways

- Investigate the stability of steel girders subjected to wind loads during construction as follows:
  - Designers may need to check the stability of fully erected girders without the deck slab if defined as inactive work zone.
  - Conduct research to get more field data and develop more refined analysis approach.

  Define Active and Inactive Work Zones

  Calculate loads for each Work Zone: Wind, Dead and Construction Loads

  Define acceptable analysis method: Line girder analysis / a grid analysis

  Evaluate girder stresses for combined loads during all stages of construction

  Set lateral deflection limit, if exceeded:
    - Modify girder size
    - Modify cross frame spacing
    - Provide lateral bracing
References

- Bridge Design Standard BD-620M (April 2016 Edition with Change 2) (state.pa.us)
- State DOT's response to Illinois DOT survey on the implementation of the Guide Specifications for Wind Loads on Bridges During Construction.
- S10.1-2019, Steel Bridge Erection Guide Specification (aisc.org)
- 2014 Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges (txdot.gov)
- Preferred Practices for Steel Bridge Design, Fabrication, and Erection (state.tx.us)
Questions/ Comments?