2016 AASHTO LRFD Specification Update

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Why are we here?

- Talk briefly about how the specification change process happens
- Provide an update on changes in the AASHTO specifications
AASHTO Subcommittee Process

- Committees meet throughout the year
- Ballot items are proposed and approved at Committee Level
- AASHTO SCOBS (bridge engineers from the DOT’s) vote annually to approve
AASHTO Subcommittees

- T1 – Security
- T2 – Bearings & Exp. Devices
- T3 – Seismic
- T4 – Construction
- T5 – Loads and Load Distribution
- T6 – FRP
- T7 – Guardrail and Bridge Rail
- T8 – Moveable Bridges
- T9 – Bridge Preservation
- T10 – Concrete Design

- T11 – Research
- T12 – Signs, Luminaires, Signals
- T13 – Culverts
- T14 – Structural Steel
- T15 – Substructures & Walls
- T16 – Timber Structures
- T17 – Welding
- T18 – Bridge Mgmt., Eval, Rehab
- T19 – Computers
- T20 – Tunnels
T5 – Loads and Load Distribution
Guide Specification for Wind Loads on Bridges During Construction

- In 2015 AASHTO changed the format of the wind load design provisions
  - From - The “fastest mile approach”
  - To - The “3 second gust” approach

- The pending construction wind load provisions were tabled until the “completed bridge” provisions could be implemented
What's unique about these provisions?
- Final bridge pressures are based on wind speeds with a 7% probability of exceedance in 50 years.
  - This is not reasonable for the short exposure period (reduced risk) of bridges under construction

New wind design procedures based on a 3-second gust model
3-Second Gust Wind Maps

• For Iowa (and much of the U.S.) the 3-sec gust is given as 115 mph

• Consider wind at various stages

• Ground surface characteristics are important
  • i.e. dense obstructions, limited obstruction, flat open terrain

• Wind exposure categories
  • How prevalent is the obstruction “around” the bridge site
Guide Specification for Wind Loads on Bridges During Construction

- **Wind pressure equation**

\[ P_z = 2.56 \times 10^{-6} V^2 R^2 K_z G C_d \]

- **V** = 3-sec wind speed, ft./sec
- **R** = wind reduction factor
- **K_z** = exposure and elevation coefficient
- **G** = gust factor, typically 1
- **C_d** = drag coefficient

<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>
Guide Specification for Wind Loads on Bridges During Construction

- Wind pressure equation application – assume <6 weeks duration

- \[ P_z = 2.56 \times 10^{-6} V^2 R^2 K_z G C_d \]

- \[ P_z = 2.56 \times 10^{-6} (115)^2 (0.65)^2 (0.71, \text{ or } 1, \text{ or } 1.15)(1)(2.2) \]

  - = 22 psf, 31 psf, 36 psf @ approx. 30’ above ground

- Prior to this Specification there was no value other than 50psf in an AASHTO design specification for bridges
Guide Specification for Wind Loads on Bridges During Construction

WINDWARD

GIRDER NUMBER

S/D > 3

LEEWARD

S/D ≤ 3
T-10 Concrete
Chapter 5 – Concrete

- Q - What changed?
  - A – EVERYTHING
  - A – NOTHING (MUCH)

- Let’s explain
Chapter 5 – Concrete

- AASHTO LRFD Bridge Design Specifications was published in 1994.
- Some frustration about how this affected the usability over time.
- Many felt the organization of the section had become confusing and that there were inconsistencies between articles.
Chapter 5 – Concrete

- AASHTO T-10 funded a pooled fund project
- Modjeski and Masters, along with Dr. Dennis Mertz were selected as the Contractor for the reorganization process
- T-10 invited PCI and ASBI, to participate in the reorganization.
- Past interims were reviewed for accuracy and to make sure no inconsistencies had been introduced into Section 5.
- A revised TOC was recommended
- This is why “EVERYTHING” is different
Chapter 5 - Concrete

- So what did we wind up with?
- As Dr. Kulicki surmised as the effort was near completion...We have “old friends in new places”
Rewrite Goals

- Advancing the concept of B-Regions and D-Regions
- Promote the strut and tie method (STM) for D-Regions
- Keeping the current bending and axial design articles for B-Regions
- Reducing the number of shear design procedures
- Consolidate prestressed, non-prestressed, and seismic details into 3 separate articles
- Have topics and procedures appear only once in the section
- Organize Section 5 such that more common design provisions appear before more unique design provisions
5.1 – Scope (Introduce B and D region concept)

- The provisions of this Section characterize regions of concrete structures by their behavior as:

  B- (beam or Bernoulli) Regions or
  D- (disturbed or discontinuity) Regions

The characterization of regions into B-Regions and D-Regions is discussed in Article 5.5.1.
Chapter Reorganization

- The next 3 sections

  - 5.2 – Definitions
  - 5.3 – Notation
  - 5.4 – Material properties

  are virtually unchanged
Chapter Reorganization

- 5.5 – Limit states and design methodologies (further clarification of B and D regions)
- Regions of a concrete structure shall be characterized by their behavior as B- (beam) or D- (disturbed) Regions.
Chapter Reorganization

- **5.6 (old 5.7)** – Design for flexural and axial force effects – B Regions (clarifies these articles only apply to B regions)

- **5.7 (old 5.8)** – Shear and torsion B Regions
  - Vcw and Vci removed (again)
  - Segmental moved to 5.12.5
Chapter Reorganization

- 5.8 (old 5.6) Design of D Regions
  - 5.8.2 Includes S&T Method enhancements introduced in 2016 interims (old 5.10.9.4)
  - 5.8.3 Includes recommendations for elastic analysis of anchor zones (old 5.10.9.5)
  - 5.8.4 Approximate methods of analysis (old 5.10.9.6)
    - Deep beams, brackets and corbels, ledges, local zones, general zones etc.
Chapter Reorganization

- **5.9 Prestressing**

- **5.10 Reinforcement**
  - Only RC structures
  - Pieces from old 5.10 and 5.11

- **5.11 Seismic Details**
  - Old 5.10.11 but pushed “out” in the structure to be more prominent
Chapter Reorganization

- 5.12 Provisions for components and structure types (old 5.13)
  - Deck slabs
  - Superstructures
  - Beams and girders
  - Diaphragms
  - Segmental
  - Arches
  - Culverts
  - Footings
  - Piles
Chapter Reorganization

- 5.13 Anchors (new borrowed from ACI 318-14)
Chapter Reorganization

- 5.13 Anchors (new borrowed from ACI 318-14)
- 5.14 Durability
  - Design concepts
  - Chemical and mechanical factors
  - Cover
  - Coating
  - Protection for tendons
T-14 Steel Structures
New load factors for the Fatigue 1 and 2 Limit States.

Based on calibration performed as part of SHRP2 Project R19B, 100-yr service life

Consequences
- Harder to meet infinite life check
- Finite life check stresses increase slightly

<table>
<thead>
<tr>
<th></th>
<th>Fatigue I</th>
<th>Fatigue II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.50</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>1.75</td>
<td>0.80</td>
</tr>
<tr>
<td>Detail Category</td>
<td>75-yrs (ADTT)$_{SL}$ Equivalent to Infinite Life (trucks per day)</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>530 690</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>860 1120</td>
<td></td>
</tr>
<tr>
<td>B’</td>
<td>1035 1350</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>1290 1680</td>
<td></td>
</tr>
<tr>
<td>C’</td>
<td>745 975</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>1875 2450</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>3530 4615</td>
<td></td>
</tr>
<tr>
<td>E’</td>
<td>6485 8485</td>
<td></td>
</tr>
</tbody>
</table>
CAT C vs ADTTsI

Finite Life

Constant Amplitude Threshold

Old cutoff with 1.5 & 0.75 factors
1290 trucks

New cutoff with 1.75 & 0.8 factors
1685 trucks

1.5 / 0.75 = 2

1.75 / 0.8 = 2.2
### T-14, Steel Structures

- **New “cycles per passage” table**
- **Simplified (eliminated under / over 40 ft. distinction)**
- **Generally lesser cycles per passage (lowers finite life cycles)**
- **These new factors come from WIM data calibration**

<table>
<thead>
<tr>
<th>Longitudinal Members</th>
<th>Span Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥40.0 ft</td>
</tr>
<tr>
<td>Simple Span Girders</td>
<td>1.0</td>
</tr>
<tr>
<td>Continuous Girders</td>
<td></td>
</tr>
<tr>
<td>1) near interior support</td>
<td>1.5</td>
</tr>
<tr>
<td>2) elsewhere</td>
<td>1.0</td>
</tr>
<tr>
<td>Cantilever Girders</td>
<td></td>
</tr>
<tr>
<td>Orthotropic Deck</td>
<td></td>
</tr>
<tr>
<td>Plate Connections</td>
<td></td>
</tr>
<tr>
<td>Subjected to Wheel</td>
<td></td>
</tr>
<tr>
<td>Load Cycling</td>
<td></td>
</tr>
</tbody>
</table>
Load-Induced Fatigue
Continuous Span Bending Time Histories

- Truck passages were simulated
- Cycles and stress range were counted
- Miner’s rule was used to convert real “damage” to AASHTO “damage”
- Result – new “cycles per passage” table
T-14, Steel Structures

- Improved details and descriptions for detailing to avoid constraint-induced fracture (CIF), i.e. “Hoan” details
- Example – Longitudinal Stiffeners
T-14, Steel Structures

- Example – Bearing Stiffeners
T-14, Steel Structures

- Example – Gusset Plates
T-14, Steel Structures

- Fit & geometry changes to Art 6.7.2
- Numerous new definitions added to Ch. 6 glossary
  - Contiguous cross frame
  - Discontinuous cross frame
  - Fit condition
  - Locked-in forces
  - NLF, SDLF, TDLF Detailing
  - Phased construction
  - Staged deck placement
T-14, Steel Structures

- Fit & geometry changes to Art 6.7.2
  - Suggest engineers consider effect of slab placement and staged construction of camber
  - Requires the contract to plans to state a fit condition for certain bridges
    - NLF, SDLF, TDLF
  - Allows for a reduction on DL crossframe forces for bridges detailed as TDLF
    \[
    \left( \gamma_p \right)_{\text{red}} = \left( \gamma_p - 0.4 \right)
    \]
  - For further information see NCHRP Project 12-79 and 20-07 Task 355 reports
C6.7.4.2 Commentary changes to address detailing highly skewed steel bridges with staggered cross frames

To reduce high crossframe forces, recommend to have no crossframe closer than 4 * b.f and 0.4*L.b from a support location
6.10.3.4.2 Global Displacement Amplification

Changes

- Added $C_{bs}$ factor to buckling capacity

$$M_{gs} = C_{bs} \frac{\pi^2 W_g E}{L^2} \sqrt{I_{eff} I_x}$$

- $C_{bs}=1.1$ for simple spans, $=2.0$ for fully erected continuous spans

- Suggests that the point at which more refined analysis be conducted be raised to 70% of this predicted capacity
Shear Studs (6.10.10.1.2)

- Revises shear stud spacing to not exceed 48” (up from the prior limit of 24”)
- Spacing is still required to meet Fatigue and Strength Limit State Requirements
- Facilitates precast deck panel installation
Bolt shear strength

- Updated shear strength equations for HS bolts
  - i.e. old $0.48 = 0.6 \times 0.8$
  - Now $0.56 = 0.625 \times 0.9$

- Also revised “long lap splice” reduction to a 0.83 factor for lap splices longer than 38in. (was $0.8 \ @ \ 50\text{in.}$)

\[
R_n = 0.48A_b F_{ub} N_s
\]

\[
R_n = 0.56A_b F_{ub} N_s
\]

- Where threads are excluded from the shear plane:

\[
R_n = 0.28A_b F_{ub} N_s
\]

\[
R_n = 0.45A_b F_{ub} N_s
\]

- Where threads are included in the shear plane:
Bolt shear strength

- New slip coefficients
- Some coefficients modified
- Class D added for inorganic zinc coatings that could not meet Class B

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Class</th>
<th>Surface</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td></td>
<td></td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>Class B</td>
<td></td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td>Class C</td>
<td></td>
<td></td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>Class D</td>
<td></td>
<td></td>
<td>0.45</td>
</tr>
</tbody>
</table>
New Bolt Designation

- ASTM F3125 replaces A325, A490, F1852, F2280
New Column Strength Approach

- Eliminated “Q” approach for slender elements.
- All local buckling effects are treated using an effective width concept in lieu of the various local buckling and Q checks.
# New Column Strength Approach

**Table 6.9.4.1.1-1—Selection Table for Determination of Nominal Compressive Resistance, \( P_n \)**

<table>
<thead>
<tr>
<th>Cross-Section</th>
<th>Without Slender Elements ((Q = 1.0))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Potential Column-Buckling Mode</td>
</tr>
<tr>
<td></td>
<td>FB</td>
</tr>
<tr>
<td></td>
<td>and if ( K_{z}\ell_z &gt; K_3\ell_y ):</td>
</tr>
<tr>
<td></td>
<td>TB</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>With Slender Elements ((Q &lt; 1.0))</td>
</tr>
<tr>
<td></td>
<td>Potential Buckling Mode</td>
</tr>
<tr>
<td></td>
<td>FB</td>
</tr>
<tr>
<td></td>
<td>and if ( K_{z}\ell_z &gt; K_3\ell_y ):</td>
</tr>
<tr>
<td></td>
<td>TB</td>
</tr>
<tr>
<td></td>
<td>and: FLB</td>
</tr>
<tr>
<td></td>
<td>and/or: WL-B</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable Equations for ( P_e ) and ( Q )</td>
</tr>
<tr>
<td></td>
<td>(6.9.4.1.2-1)</td>
</tr>
<tr>
<td></td>
<td>(6.9.4.1.3-1)</td>
</tr>
<tr>
<td></td>
<td>(6.9.4.2.2-1 or 2 or 7 or 8)</td>
</tr>
<tr>
<td></td>
<td>(6.9.4.2.2-11)</td>
</tr>
</tbody>
</table>
End Connections

- For members subjected to combined loading, when designing for forces at the end of the member, the procedure for designing the end of the member connection is greatly simplified.

  Connections and splices for primary members subjected to combined force effects, other than splices for flexural members, shall be designed at the strength limit state for the larger of:

  - The calculated combined factored force effects, or
  - 75 percent of the factored axial resistance of the member determined as specified in Articles 6.8.2 or 6.9.2, as applicable.
Bolted Field Splices – “Rock the World Item”

- The 75% rule is gone as is the “average of the load and member strength” criteria
- Develop the web shear strength
- Develop the flange capacity
  - Is it enough to carry $\varphi M_n$?
  - If so --- done
Bolted Field Splices – “Rock the World Item”

- If not, carry the balance of the moment through a web force

\[ A_w = \frac{D}{2} + t_{haunch} + \frac{t_s}{2} \]

\[ H_w \]

\[ P_{fy} = F_{yf} A_e \]
Current LRFD

- Top Flange = 24 bolts
- Bottom Flange = 28 bolts
- Web = 102 Bolts
Adopted LRFD

- Top Flange = 24 bolts
- Bottom Flange = 24 (28) bolts
- Web = 50 (102) Bolts

- Will this work?
Current LRFD (Left) vs New LRFD (Right)
Elimination of Mandatory Preassembly

- As a minimum, the preassembly procedure shall consist of assembling three contiguous panels adjusted for line and camber.
  - CNC drilling, virtual assembly, and other techniques may be used to ensure fit-up.
  - It can be physically or practically impossible to attain three-panel fit-up.

- Field connections of main members ...shall be preassembled prior to erection as necessary to verify the geometry of the completed structure or unit and to verify or prepare field splices.
Construction Information

- Engineer to state on plans for curved segments if heat curving is allowed
- Shop drawings must show detailing for the intended fit condition
- “Main member” exemption for CVN testing of crossframes and diaphragms
Guide Design Specifications for Bridge Temporary Works, 2nd Ed.

- Design oriented temporary works guide
- ASD and LRFD included
- Section 2 ( Loads) significantly updated since last edition
  - New load combinations
  - New basic loads
Construction Handbook for Bridge Temporary Works, 2nd Ed.

- Construction oriented temporary works guide
- Focuses on quality and means / methods
- Addresses falsework, formwork and temporary retaining structures
T-17 Welding - Brief Update

- T-17 Welding is going to be reconfigured to address fabrication in general
- New name = T-17 Technical Committee for Metals Fabrication

Vision Statement
- To be the Subject Matter Experts on welding and metals fabrication within the AASHTO Subcommittee on Bridges and Structures.
T-17 Technical Committee for Metals Fabrication

- T-17 wants to establish a new fabrication specification that would
  - Incorporate the fabrication (versus welding) items of D1.5 AND move fabrication out of D1.5 and into this spec
  - Supplant other fabrication specifications, including the fabrication aspects of the AASHTO Construction Specifications
  - Be a fabrication specification that owners could adopt directly

- NSBA has agreed generally to support the effort

- T-17 is still looking for final agreement from SCOBS to pursue this spec.
Conclusions

- **Concrete Design**
  - Few technical changes but a new organization

- **Steel Design**
  - Continuation of incremental technical changes

- **Construction**
  - Various new documents and new technologies