FINAL LRFD SPECIFICATIONS FOR NONCOMPOSITE BOX SECTION MEMBERS CONTAINING LONGITUDINALLY UNSTIFFENED AND/OR STIFFENED PLATES

BALLOT ITEM No. ITEM 31

T-14 – Structural Steel Design
Montgomery, AL | June 25th, 2019
INTRODUCTION

- FHWA Task Order 5011: “LRFD Specifications for Noncomposite Steel Box Sections”
  - “A more general and consistent approach is needed for the LRFD design of thin unstiffened and stiffened compression elements in all box sections subject to uniform stress (compression) or nonuniform stress (e.g. compression plus bending or compression plus bending plus shear, etc.)...The outcome should lead overall to simpler and more easily understood AASHTO design provisions pertaining to all types of noncomposite steel box sections, and more economical and effective use of these member types in bridges.”

- Project Team:
  - HDR – Contract Manager
  - Georgia Tech (Dr. Don White)
  - M.A. Grubb & Associates, LLC (Mike Grubb)
  - COWI (Dr. Charles King)
  - Dr. Frank Russo (Michael Baker)
HISTORY

- FHWA Task Order – August, 2014

- Incremental Changes:
  - 2018 Interims: Flexural resistance of longitudinally unstiffened boxes

- August 2018: Presented final draft ballot to T-14
  - T-14/FHWA/SME review and December 5th, 2018 workshop
  - Refined commentary and specifications
  - Referred to FHWA report (White et al., 2019) for specialized items
  - Shifted longitudinally stiffened specifications to new Appendix E6 to reduce impact on Chapter 6
CURRENT BALLOT

- **Current Ballot:**
  - Evolution of earlier ballot items
  - Compression capacity of stiffened flanges (axial and flexural capacity)
  - Interaction for axial force, biaxial bending, and torsional and flexural shear
  - Modernize solid web arch provisions (Article 6.14.4)

- **Modified ballot on portal to address CBS comments**
THE NUMBERS

- **I-Girder Flexure and Shear:**
  - Article 6.10 (77 pages)

- **Composite Box Girder Flexure and Shear:**
  - Article 6.11 (28 pages with significant reliance on 6.10)

- **Ballot Item No. 31:**
  - Axial, flexural and Service/Fatigue/Construction resistances of longitudinally stiffened and unstiffened boxes
  - Articles 6.9.4, 6.12.2.2. and E6.1 (~55 pages – removing strikethroughs)
  - Count does not include upfront matter, revised interaction specifications and flowcharts
SUPPLEMENTAL INFORMATION

- “Proposed LRFD Specifications for Noncomposite Steel Box-Section Members”
  - FHWA-HIF-19-063 | July 2019
  - (NCHRP 20-07/415)
- Expanded Commentary
- Additional provisions for specialized situations
- 3 Examples:
  - Longitudinally Unstiffened Truss End Post
  - Longitudinally Stiffened/Slender Tie Girder
  - Longitudinally Stiffener Arch Rib
- 2 Flowcharts coordinated with Examples
  - Compression & Flexural Resistance
  - Shortest Path – Unstiffened, Compact, no Interaction
Current noncomposite box provisions are scattered and incomplete (unlike Articles 6.10 & 6.11)

Focus on HSS and solid web arches

Requires designers to interpret, adapt and augment current specifications:
  - Biaxial bending – what’s a flange/web?
  - Service checks?
  - Maximum or prudent b/t or w/t limits?

Potentially inconsistent results and inefficiency for Owners
WHY?

- Article 6.14.4 – Solid web arch based on conservative b/t limit equations & inconsistent stiffening requirements compared with Article 6.11

- Specifications are “naked” when it comes to stiffened plates
  - Article 6.11 for up to 2 stiffeners
  - Prohibitive transverse stiffener requirements for n > 2

- Inability to rate existing structures where steel weight was at a premium
  - Slender and/or stiffened elements
  - Small stiffeners that do not fully develop nodes
BENEFITS OF BULLET ITEM No. 31

- **Consistent Design Methodology**
  - Stiffened or Unstiffened
  - Slender or Compact
  - HSS or Built-up
  - Interaction of forces
  - Service, Fatigue and Construction considerations

- **More Efficient Capacities**
  - Eliminate reliance on LFD Truss Guide Specifications
  - More efficient b/t limits for solid web arches
BENEFITS OF BULLET ITEM No. 31

- Obtain accurate and sufficient ratings for existing structures outside the slenderness limits of the current Specifications

- Methods provided for rating structures with stiffeners outside the slenderness limits of the current Specifications

- Future potential to apply slender and stiffened provisions to compression flanges of composite box girders in Article 6.11 for more accurate and efficient designs \((n > 2)\)

- More accurate sizing of longitudinal and transverse stiffeners where needed
These types structures (truss, tied arch, edge girder, cross girder, etc.) provide cost-effective and constructable solutions for long spans and site constraints

Stiffened slender boxes have the potential to reduce weight for large structures, such as steel tower legs for cable stayed bridges

Stiffened provisions:

- Provide same set of equations for any number of stiffeners, transversely stiffened or not
- Take advantage of longitudinal stiffener, transverse stiffener and stiffened plate contributions to compression capacity
- Allow designer to easily determine from equations if longitudinally and/or transverse stiffening is effective
SUMMARY

- Proposed specifications are not radical
  - Similar, but better prediction results relative to current AASHTO & AISC, in cases where the current AISC & AASHTO are actually applicable … and similar, but better, predictions compared to Eurocode, BS5400 (pre Eurocode), and Wolchuk & Mayrbaurl (1980)
  - Existing complex structures have been designed with provisions based on similar assumptions

- Proposed specifications are more streamlined and user-friendly

- “These standards, when adopted, will be the premier standards in the world for noncomposite box members - the most general, and usable for general structures.”