Approved Changes to the Ninth Edition AASHTO LRFD Bridge Design Specifications

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The 2021 virtual meeting of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Bridges and Structures (COBS) took place July 12–16. This meeting saw the approval of 11 working agenda items (WAIs) prepared by AASHTO Technical Committee for Concrete Design (T-10) that had been developed within the past two years. This article covers those WAIs, which correspond to upcoming changes to the provisions for concrete bridge design in the *AASHTO LRFD Bridge Design Specifications*[1] that will appear in the 10th edition when it is published in a few years. Because the development period was longer than usual, the number of approved WAIs is much larger than what has been typical for Committee T-10. Therefore, this article only summarizes the 11 approved WAIs; detailed discussions of the items will be provided in LRFD articles in upcoming issues of *ASPIRE*®.

1. **WAI 133: Deflection and Camber Calculations**
   The calculation procedure provided in Article 5.6.3.5.2 of the current AASHTO LRFD specifications underestimates instantaneous deflections of reinforced concrete members with low flexural reinforcement ratios. In addition, the current AASHTO procedure does not reflect the reduction of stiffness caused by cracking that is the result of restraints imposed by the structure and loading of early-age concrete during construction. The proposed revisions are intended to improve the estimation of instantaneous deflections under these conditions, while not significantly affecting the predictions at higher reinforcement ratios.

   The design provisions for estimating time-dependent deflections have been modified to reflect what has been specified in the American Concrete Institute's *Building Code Requirements for Structural Concrete* (ACI 318)[2] for many years. Applying a multiplier of 4.0 to the instantaneous deflection to obtain time-dependent deflection, which currently appears in Article 5.6.3.5.2 of the AASHTO LRFD specifications, has been shown to be inaccurate and does not adequately address all concrete strengths, member sizes, and exposure conditions. The implementation of new design provisions improves the accuracy of calculations, including the use of creep and shrinkage coefficients, and results in a better prediction of time-dependent deflections.

2. **WAI 200: Tensile and Compressive Stress Limits and Reinforcement Design for Allowing Higher Tensile Stresses**
   There are three issues addressed in this WAI: inconsistency in tensile stress limits, inconsistency in determining whether bonded reinforcement is sufficient to allow the use of increased tensile stress limits, and providing relief from high concrete strength requirements stemming from calculated compressive stresses at the extremities of the cross section when lateral bending is present and explicitly considered. Implementation of the changes covered by this WAI will establish consistency in tensile stress limits and associated crack-control reinforcement. Furthermore, a slightly increased compressive stress limit will provide relief when checking temporary stresses at the corners of prestressed concrete member cross sections during handling, transportation, and erection.

3. **WAI 202: Seismic Design Rule Clarifications**
   The progression of seismic design provisions over the years inadvertently created language in various articles of Section 5 of the current AASHTO LRFD specifications that can potentially be misinterpreted. More specifically, some design criteria and seismic detailing options do not provide clear direction for best practices and preferred details. Furthermore, minimum or maximum limits of applicability of some details are not explicitly articulated. Within this context, WAI 202 clarifies language in a number of articles in the AASHTO LRFD specifications to improve the seismic design provisions of Section 5.

4. **WAI 203: Confinement Reinforcement: Spirals, Hoops, and Ties**
   Confinement reinforcement can be provided in various forms. Spirals, hoops, ties, and cross ties are used in various applications, as dictated by governing loading conditions and/or geometric design limitations. This WAI provides a clear definition of each type of transverse reinforcement in compression members. Furthermore, it addresses some organizational issues within Section 5.

5. **WAI 204: Regions Where Minimum Transverse Reinforcement Is Required**
   Except for slabs, footings, and culverts, Article 5.7.2.3 of the current AASHTO LRFD specifications requires that a minimum amount of transverse reinforcement be provided when the factored shear exceeds the limit expressed in Eq. (5.7.2.3-1). It is not clear whether this requirement applies to conventional retaining walls. Because Article 5.2 defines a slab as a component having a width that is at least four times its effective depth, retaining walls typically meet the definition for a slab. As a result, they are exempt from the minimum transverse reinforcement requirements of Article 5.7.2.3. WAI 204 clarifies minimum transverse reinforcement requirements for walls.

6. **WAI 206: Strut-and-Tie Modeling (STM) vs. Sectional Design of Sections Near Supports**
Load transfer near structural supports is a function of the loading type (concentrated or distributed loads) and structural geometry. This WAI provides clarification on what types of loads impose additional demands on stirrups near the supports and what types of loads directly flow into the supports via the formation of direct struts. Through the clarifications provided by WAI 206, the confusion between use of sectional design methods and STM should be reduced or eliminated.

7. **WAI 209: Continuity Design of Prestressed Concrete Beams**
Creating continuity over the piers for precast, prestressed concrete girder bridges is preferred by some owners because this detail minimizes moisture penetration through the deck onto the ends of the beams and reduces maximum positive moment in the girder. The continuity detail where some of the girder bottom strands are extended into cast-in-place concrete diaphragms at the piers is preferred by some owners and used routinely in bridge construction. Proper structural details have been shown to be effective in controlling bottom fiber cracking caused by restraint moments due to volume changes such as creep, shrinkage, and temperature gradient. That being said, analysis for these effects can be complex. The purposes of this WAI are to provide simplified equations for the value of the restraint moment at the diaphragms and the required reinforcement to control cracking, and to remove the requirement that the age of the girder at continuity be at least 90 days.

8. **WAI 210: Post-Installed Anchors**
ACI 318-19[2] includes changes to the anchor design section. ACI 318-19 provisions now include design provisions for shear lugs comprising a steel element welded to a base plate and for post-installed concrete screw anchors, as well as qualification testing for anchors. In a reorganization of ACI 318-19 anchor design, Chapter 17 specifies all design, material, testing, anchor, anchor spacing, edge distances, and acceptance requirements, as well as geometry and depth limitations. Information concerning specification and inspection has been moved to the appropriate sections of Chapter 26 in ACI 318-19. WAI 210 establishes consistency between the AASHTO LRFD specifications and ACI 318-19 provisions.

9. **WAI 212: Mechanical Coupler Use for A1035 Material**
Reinforcement and mechanical connections using ASTM A1035/A1035M[3] material have been successfully tested by the Concrete Reinforcing Steel Institute and have been used by owners. The test results show that the material meets the criteria set in National Cooperative Highway Research Program Project 10-35.[4] This WAI revises the AASHTO LRFD specifications to allow the use of mechanical couplers for ASTM A1035/A1035M reinforcement.

10. **WAI 215: Struts Crossing Cold Joints**
Recent events have highlighted the importance of properly evaluating and detailing cold joints;[5] however, Article 5.8 of the current AASHTO LRFD specifications, Design of D-Regions, does not explicitly require that struts crossing cold joints be checked for shear friction at that interface. This modification will require that such cases are checked in design and/or assessment, and will help prevent unconservative capacity predictions from being made where struts cross cold joints. In this way, WAI 215 brings the AASHTO LRFD specifications into better alignment with international design guidance.[6]

11. **WAI 216A: Concrete Creep and Shrinkage**
This WAI provides clarification on creep and shrinkage estimations. While different creep and shrinkage estimation techniques may be appropriate for different bridge types, this WAI makes it clear that for segmentally constructed bridges, estimates of shrinkage and creep may be made using the provisions of the *fib Model Code for Concrete Structures 2010*[7] or the *CEB-FIP Model Code 1990*.[8]

These 11 working agenda items are intended to improve structural design of concrete bridges by simplifying the design process, reducing ambiguity in design provisions, and establishing consistency. Upcoming articles will cover these items in greater detail to provide the background and context for these changes. Until then, stay in good health during these challenging times!

References

1. American Association of State Highway and Transportation Officials (AASHTO). 2020. *AASHTO LRFD Bridge Design Specifications*, 9th ed. Washington, DC: AASHTO.

2. American Concrete Institute (ACI) Committee 318. 2019. *Building Code Requirements for Structural Concrete* (ACI 318-19) *and Commentary* (ACI 318R-19). Farmington Hills, MI: ACI.

3. ASTM Subcommittee A01.05. 2020. *Standard Specification for Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement.* ASTM A1035/A1035M. West Conshohocken, PA: ASTM International.

4. Paulson, C., and J. M. Hanson. 1991. "Fatigue Behavior of Welded and Mechanical Splices in Reinforcing Steel." Final Report. National Cooperative Highway Research Program Project 10-35. http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP10-35_FR.pdf.

5. National Transportation Safety Board (NTSB). 2019. *Pedestrian Bridge Collapse Over SW 8th Street, Miami, Florida, March 15, 2018*. Highway Accident Report NTSB/HAR-19/02 PB2019-101363. Washington, DC: NTSB. https://www.ntsb.gov/investigations/AccidentReports/Reports/HAR1902.pdf.

6. International Federation for Prestressing (FIP). 1999. *Practical Design of Structural Concrete*. London, United Kingdom: SETO.

7. *fib* (International Federation for Structural Concrete). 2013. *fib Model Code for Concrete Structures 2010*. Berlin, Germany: Ernst & Sohn.

8. Comité Euro-International du Béton (CEB) and FIP. 1993. *CEB-FIP Model Code 1990*. CEB Bulletin 213/214. Lausanne, Switzerland: CEB.