Approved Changes to the Ninth Edition *AASHTO LRFD Bridge Design Specifications*

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The 2022 annual meeting of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Bridges and Structures took place June 20–23 in Pittsburgh, Pa. During that meeting, six working agenda items prepared by the AASHTO Technical Committee for Concrete Design (T-10) were approved. These agenda items were developed within the past several years and follow the 11 agenda items that were approved at the July 2021 virtual meeting (see the article in the Fall 2021 issue of *ASPIRE*®). Committee T-10 has one more year to prepare several additional agenda items, after which the revised version of the *AASHTO LRFD Bridge Design Specifications*[1] will be published as the 10th edition. This article provides an overview of the six recently approved agenda items.

1. **Lightweight Concrete Clarifications**
   The structural design provisions in Section 5 of the current AASHTO LRFD specifications are based on design concrete compressive strengths ranging from 2.4 to 10.0 ksi for normalweight and lightweight concrete, except where higher strengths not exceeding 15.0 ksi are allowed for normalweight concreteand are noted in the relevant articles. However, it has come to the attention of Committee T-10 that the language used to note the exceptions can be misconstrued and taken to mean that the section is only applicable to normalweight concrete. Additionally, some sections provide extra requirements for lightweight concrete that have been shown to be unnecessary. This agenda item clarifies the intent of the specifications and makes lightweight concrete and normalweight concrete designs more consistent.

2. **Concrete Anchors**
   In 2019, the American Concrete Institute modified the section on anchors in *Building Code Requirements for Structural Concrete* (ACI 318-19).[2] This agenda item makes changes to the *AASHTO LRFD Bridge Construction Specifications*[3] to make them consistent with the changes made in 2021 to Article 5.13 of the AASHTO LRFD specifications to address the modifications in the ACI 318-19 design provisions.

3. **Minimum Bar Bend Diameter**
   This change addresses an increase in the minimum bar bend radius for ties or stirrups published by the reinforcement fabrication industry for Grade 60 or lower reinforcement, and it provides clarity on minimum bend diameters for higher-strength bars when used as ties or stirrups. For reference, this modification was developed after a state department of transportation project received Grade 60 stirrup bars that were specified in contract documents to be bent to "CRSI [Concrete Reinforcing Steel Institute] criteria." The larger bend diameter (about 5 bar diameters) in conjunction with the precaster's standard strand template would have resulted in reduced concrete cover (see the Winter 2022 issue of *ASPIRE*®).

   ASTM A615[4] gives minimum pin diameters for bend testing of bent bars that are grade dependent for no. 3, 4, and 5 bars. For Grade 60 bars, the minimum pin diameter is 3.5 times the bar diameter d_b. For Grades 75, 80, and 100 bars, the minimum pin diameter is $5d_b$. The *CRSI Manual of Standard Practice*[5] provides stirrup and tie hook tables that include "finished bend diameters." The "finished bend diameter" is defined as the bend diameter measured after the bar is bent around a pin, which includes the "spring back" of bars after bending. CRSI chose to include only one value of "finished bend diameter" that will cover all grades of reinforcement. For Grade 60 stirrups, use of the larger diameter bend required for the higher reinforcement grades may result in inadequate cover or other modifications to standard details. A new article, C5.10.2.3, and indicates that the previously used smaller bends can still be obtained as a "special order."
   The clarifications offered by this agenda item are intended to eliminate confusion for detailing ties and stirrups and higher-strength reinforcing bars of all sizes.

4. **Reinforcing Bar Anchorage**
   Recent changes to the development length provisions of ACI 318-19[2] have resulted in a notable discrepancy between the AASHTO LRFD specifications and ACI 318-19. Moreover, the current AASHTO LRFD specifications do not have expressions for headed deformed bars, and the expressions for hooked bars frequently result in very different estimates from those given in ACI 318-19. The changes offered by this agenda item are intended to reduce the discrepancy between ACI 318-19 and AASHTO LRFD provisions while adopting a unified approach for tension anchorage design that is rooted in the concepts described in the *fib Model Code for Concrete Structures 2010*.[6] Overall, the new approach for reinforcing bar anchorage employs fewer equations. The empirical factors required to address a variety of common development length problems are also minimized. Finally, these revisions include provisions that apply to the anchorage of no. 14 and 18 straight reinforcing bars previously absent from the AASHTO LRFD specifications.

5. **Tensile Force in Concrete for Determining the Tensile Stress Limit**
   Article 5.9.2.3.1b of the current AASHTO LRFD specifications provides temporary tensile stress limits in prestressed concrete before losses. Tensile stress limits are provided for areas with bonded reinforcement sufficient to resist the tensile force in the concrete and for areas without bonded reinforcement. Larger tensile stresses are permitted in areas with sufficient bonded reinforcement. The tensile stress limit for areas without bonded reinforcement is generally construed to include areas where bonded reinforcement is not sufficient to resist the tensile force.

   The commentary to Article 5.9.2.3.1b prescribes a computational procedure for sizing the bonded reinforcement to permit the application of the larger tensile stress limit. However, the procedure is only accurate when the tensile stress zone is confined to a rectangular region, as illustrated in Fig. C5.9.2.3.1b-1. For nonrectangular regions, the description of the computation creates a conflict with the provided equation. The equation estimates the tensile force as the product of the top flange width and the average tensile stress, and the text of the commentary indicates the tensile force is the product of the average tensile stress and the tension area.

Contemporary wide-flange girders have thinner top flanges than older AASHTO Type I–IV girders. In wide-flange girders, the tensile zone often extends below the rectangular portion of the wide top flange and may extend into the web. The currently prescribed procedure significantly over- or underestimates the tensile force, depending on whether the computation is carried out using the commentary equation or the description provided in the specification. The prescribed calculation procedure also incorrectly estimates the tensile force in the concrete for other sections with top flanges and any type of section with internal voids when the neutral axis extends into the voided region.

The proposed revisions to C5.9.2.3.1b provide a general method for estimating the tension force in the concrete that is applicable to all girder section types regardless of the location of the neutral axis.

6. **Use of 0.7-in.-Diameter Strands in Precast Pretensioned Girders**
National Cooperative Highway Research Program (NCHRP) Project 12-109 proposed modifications to the AASHTO LRFD specifications to incorporate the use of 0.7-in.-diameter strands in precast, pretensioned concrete girders[7] and, based on NCHRP research, implement the use of 0.7-in.-diameter strands in practice. In this context, it is worth noting that AASHTO M 203/M 203M (ASTM A416/A416M)[8,9] includes 0.7-in.-diameter strands.

A 2.0-in. spacing between 0.7-in.-diameter strands has been shown to be adequate for the transfer of the force in the strands to the concrete without damage in the end regions of pretensioned girders. Therefore, the specification will permit the use of 0.7-in.-diameter strands on a 2-in. grid.

This agenda item covers the debonding rules that apply to 0.7-in.-diameter strands as well as the confinement reinforcement necessary in the end regions of pretensioned girders by employing an intuitive technique based on the strut-and-tie method.

These six agenda items are intended to improve the structural design and construction of concrete bridges by simplifying the design process, reducing ambiguity in design provisions, and establishing consistency where needed. Upcoming articles will look at each of these items in greater depth.

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. AASHTO. 2017. *AASHTO LRFD Bridge Construction Specifications*, 4th ed. Washington, DC: AASHTO.
4. ASTM Subcommittee A01.05. 2020. *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement*. ASTM A615/A615M-20. West Conshohocken, PA: ASTM International.
5. Concrete Reinforcing Steel Institute (CRSI). 2018. *Manual of Standard Practice,* 29th ed. Schaumburg, IL: CRSI.
6. *fib* (International Federation for Structural Concrete). 2013. *fib Model Code for Concrete Structures 2010*. Berlin, Germany: Ernst & Sohn.
7. Shahrooz, B. M., R.A. Miller, K.A. Harries, and R.W. Castrodale. 2022. *Use of 0.7-in. Diameter Strands in Precast Pretensioned Girders*. National Cooperative Highway Research Program (NCHRP) Research Report 994. Washington, DC: Transportation Research Board.
8. AASHTO. 2020. Standard Specification for Steel Strand, Low-Relaxation Uncoated Seven-Wire for Concrete Reinforcement. AASHTO M 203/M 203M. Washington, DC: AASHTO.
9. ASTM International. 2021. Standard Specification for Steel Strand, Low-Relaxation Uncoated Seven-Wire for Concrete Reinforcement. ASTM A416/A416M-18. West Conshohocken, PA: ASTM International.