Details on Two Upcoming Changes to the *AASHTO LRFD Bridge Design Specifications*: Strut-and-Tie Modeling versus Sectional Design, and Struts Crossing Cold Joints

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My article in the Fall 2021 issue of *ASPIRE*® summarized 11 working agenda items that were approved by the American Association of State Highway and Transportation Officials' (AASHTO's) Committee on Bridges and Structures (COBS) at its summer 2021 meeting. That article provides sufficient explanations for the adopted revisions to the *AASHTO LRFD Bridge Design Specifications*[1] that are limited in scope, but others warrant additional discussion. To that end, my article in the Winter 2022 issue and this article each focus on two of the items in greater detail.

Working Agenda Item 206: Strut-and-Tie Modeling versus Sectional Design

Working agenda item 206 provides clarification to Article 5.7.3.2 regarding 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. Sections near supports are subjected to a complex state of stress influenced by the location (that is, the distance from the support) and the type (concentrated or distributed) of loads. In the absence of a concentrated load within the effective shear depth d_v, and where the reaction force in the direction of the applied shear introduces compression into the end region of a member, the location of the critical section for shear is to be taken at a distance d_v from the internal face of the support, and the shear reinforcement required at the critical section shall be extended to the support. This is because the externally applied uniform loads and the self-weight of the member in the immediate vicinity of the support are directly transferred into the support by a compression strut and do not impose an additional demand on stirrups located within d_v of the support. Loads away from supports create a compression field, and the vertical component of the forces generated in the compression field does introduce an additional demand on stirrups (see Fig. C5.7.3.2-1b in the AASHTO LRFD specifications).

It is important to recognize that loads both near and away from supports introduce stresses in the compression-compression-tension node that forms above the supports, and those stresses should be checked in accordance with the requirements of Article 5.8.2 of the AASHTO LRFD specifications. Alternatively, the complex state of stress that results from the presence of a concentrated force near a support may be accounted for using sectional design models by making conservative assumptions for shear design. In the context of sectional design, calculating capacity and demand at the face of the support conservatively considers the complex state of stress that results from the load introduction into the member near a support.

If there is a concentrated load within d_v of the support, or the reaction force in the direction of the applied shear introduces tension into the end region of a member, the location of the critical section should be at the internal face of the subject support. Accordingly, the design section shear load and shear resistance are to be calculated at the internal face of the support. Furthermore, if the beam-type structural member extends to both sides of the reaction area, the design section on each side of the reaction shall be determined separately based on the loads on each side of the reaction and whether their respective contribution to the total reaction introduces tension or compression into the end region.

Working Agenda Item 215: Struts Crossing Cold Joints

Working agenda item 215 provides new requirements for struts crossing cold joints when designs use the strut-and-tie method. These requirements will avoid unconservative capacity predictions for this situation and bring the AASHTO LRFD specifications into better alignment with international design guidance. Accelerated bridge construction, repair and retrofit of existing bridge structures, foundation retrofits, segmentally constructed bridges, and spliced-girder bridges, as well as other innovative bridge solutions involving complex geometries, result in structural details that contain cold joints. Furthermore, recent events have highlighted the importance of properly checking and detailing cold joints.[2] This technical item was initially discussed in a Concrete Bridge Technology article in the Fall 2020 issue of *ASPIRE*.

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Article 5.8.2.2 of the current AASHTO LRFD specifications does not explicitly require that struts crossing cold joints must be checked for shear-friction at that interface. With the upcoming changes to the specifications, this check will become mandatory. This modification will ensure that such cases are checked in design or assessment, or both, and it will help prevent unconservative capacity predictions.

According to the forthcoming AASHTO LRFD specifications, if a D-region is built in stages, the forces imposed by each stage of construction on previously completed portions of the structure are to be carried through appropriate strut-and-tie models. Where a strut passes through a cold joint in the member, the joint shall be investigated to verify that it has sufficient shear-friction capacity. The strut force may be resolved into a normal and shear force at the interface, and the capacity of the interface shall be calculated in accordance with the interface shear resistance requirements of Articles 5.7.4.3 and 5.7.4.4.

In this context, the reader's attention is directed to the discussion in the current commentary to Article 5.7.4.1:

> *Shear displacement along an interface plane may be resisted by cohesion, aggregate interlock, and shear-friction developed by the force in the reinforcement crossing the plane of the interface. Roughness of the shear plane causes interface separation in a direction perpendicular to the interface plane. This separation induces tension in the reinforcement balanced by compressive stresses on the interface surfaces.*
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> *Any reinforcement crossing the interface is subject to the same strain as the designed interface reinforcement. Insufficient anchorage of any reinforcement crossing the interface could result in localized fracture of the surrounding concrete.*

Proportioning, detailing, and anchorage of the reinforcement crossing cold joints are all important to mobilizing the calculated capacity at the cold joint. It is also important to recognize that the cohesion and friction factors listed in Article 5.7.4.4 vary substantially depending on the type and condition of the cold joint interfaces.

Future articles will keep our readership informed about additional upcoming changes to the next edition of the AASHTO LRFD specifications, which is to be published in 2023.

References

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

2. 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.