Status of Implementation of SHRP2 Specifications to the AASHTO LRFD: Recommendations from Service Limit State Design for Bridges

This brief report summarizes the service limit states investigated in the second Strategic Highway Research Program (SHRP2) project, Service Limit State Design for Bridges (R19B), and their implementation status as of March 2017. The agenda items attached to this report show the proposed revisions as they appeared in the annual meeting agenda of the 2015 and 2016 American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Bridges and Structures (SCOBS). The meetings were held on April 20 to 23, 2015, in Saratoga Springs, New York, and on June 27 to 30, 2016, in Minneapolis, Minnesota, respectively. The final revisions may be slightly different due to minor changes that may have been approved during the meeting. In order to ensure that any revisions be understood and considered for implementation beyond the initial states engaged in implementing Service Limit State Design, it is recommended that additional training for the broader bridge engineering community be considered. This training would best be accomplished via multiple webinars covering the topics of Live-Load Calibration, Service Limit States and Geotechnical/Foundations.

Service III Load Combination: Cracking of Prestressed Concrete

Service Limit State Design for Bridges and the National Cooperative Highway Research Program (NCHRP) 12-83 project recommended revisions to the load factor for live load for the Service III load combination. Instead of using a 0.8 load factor for all cases, the recommended load factor is dependent on the method used to estimate prestressing losses. The recommended load factors are 1.0 or 0.8. See Attachment 1 for the agenda item.

Status: The proposed revisions were adopted during the 2015 SCOBS annual meeting.

Future implementation work suggested: Training is recommended for the broader bridge engineering community regarding the background and history of the limit state.

Fatigue Limit State

An agenda item, including several revisions related to the fatigue limit state in the AASHTO load and resistance factor design (LRFD), was included in the agenda for the 2015 SCOBS annual meeting. Following are the AASHTO LRFD proposed revisions in the agenda item:

- An increase in the live load factor for Fatigue I from 1.5 to 2.0 and for Fatigue II from 0.75 to 0.8.
• Some revisions associated with the increase in load factor (e.g., the table for average daily truck traffic [ADTT] beyond which infinite fatigue life should be considered).

• Revisions to the table for number of load cycles per truck passage.

• Revisions to the equations for fatigue of reinforcement in reinforced concrete.

The original recommendations of Service Limit State Design also included revisions to the fatigue S-N curves for some fatigue categories for structural steel details. These recommendations were not included in the agenda item due to the desire of the AASHTO SCOBS Technical Committee on Structural Steel Design (T14) to keep the existing curves that match those used by the American Institute of Steel (AISC).

Please see Attachment 2 for the 2015 agenda item. The agenda item was withdrawn during the meeting due to concerns that the 2.0 load factor for live load for Fatigue I is too high. More specifically, the concern is that the higher factor will cause some fatigue categories to control the design where they previously did not control the design.

Additional research was performed and resulted in recommending the load factor for Fatigue I to be 1.75 (instead of 1.5 currently in the specifications and 2.0 originally recommended by Service Limit State Design).

Status: An agenda item has been included for the 2016 SCOBS annual meeting that is similar to the 2015 item except that the proposed load factor for live load for Fatigue I is 1.75. The agenda item was balloted and it will be incorporated in the AASHTO LRFD.

See Attachment 3 for the proposed 2016 agenda item covering the revisions to the Fatigue Limit State.

Future implementation work suggested: Training for the broader bridge engineering community is recommended for the following areas:

• Background of the revisions to the fatigue provisions.

• Background of the original recommendation for changing the S-N curves for some structural steel fatigue categories to produce uniform reliability.

• Background of the recommendation to revise the equations for fatigue of reinforcement in reinforced concrete to produce uniform reliability.

Service I: Control of Cracking of Reinforced Concrete Components through the Distribution of Reinforcement

The research indicated that the current specification provisions produce uniform reliability. In the absence of reasons to increase or decrease the level of reliability index produced by these
provisions, it was concluded that revisions to these provisions are not needed at this time. No revisions to the specifications were recommended.

**Future implementation work suggested:** Training for the broader bridge engineering community is recommended regarding the background of the specification requirements to allow future revisions when further research determines whether the current level of reliability is the correct one or whether changing the level of reliability is needed.

**Service I: Deflection**

The research indicated that there were no widely accepted criteria on dynamic response to live load. The criterion used by the CAN/CSA S6 Canadian Bridge Design Code was investigated. This criterion is based on varying the allowed static deflection based on the first natural frequency of the structure—not the span length as in AASHTO LRFD. The research indicated that the deflection limits in AASHTO produce the same trend as is produced by the CSA provisions.

**Status:** During the 2015 SCOBS annual meeting, the subcommittee voted to include commentary to the deflection provisions to indicate that other criteria based on deflection-frequency-perception requirements exist and made a reference to the *Service Limit State Design* report. See Attachment 4 for the 2015 agenda item.

**Future implementation work suggested:** Training for the broader bridge engineering community is needed regarding the deflection-frequency-perception requirements. This will decrease the concern regarding changing the long-used deflection criteria for a more rational criteria based on frequency and accelerations in the future.

**Service I: Foundations Deformations**

The calibration of foundations deformations is the topic of a paper produced under the *Service Limit State Design* implementation effort. For further details, see *Incorporation of Foundation Deformations in AASHTO LRFD Bridge Design Process*, available at [http://shrp2.transportation.org/Pages/R19B_ServiceLimitStateDesignforBridges.aspx](http://shrp2.transportation.org/Pages/R19B_ServiceLimitStateDesignforBridges.aspx).

This work produced new concepts and represents pioneering work. To allow ease of application, the proposed specification revisions were developed such that the general conventional processes used in determining foundation deformations are also used in the proposed revisions.

**Status:** The Agenda item was not presented to the full SCOBS in 2015. Following the 2015 SCOBS meeting, the agenda item was updated and it was the subject of several discussions between T-15, AASHTO SCOBS Technical Committee on Loads (T-5), and the SHRP2 R19B team. Following the update, an agenda item was proposed for the 2016 SCOBS annual meeting. The item did not ballot and the AASHTO SCOBS Technical Committee on Substructures and Retaining Walls (T-15)
asked for additional information. The agenda item was revised for discussion at the T-15 2016 mid-year committee meeting. See Attachment 5 for the revised agenda item as of November 2016. It is unknown if the agenda items will be balloted in 2017 or in a future year.

**Future implementation work suggested:** An additional white paper has been requested to document the database evaluated in 2016 for the effects that the proposed agenda item would have on the data. This database included data provided by Tony Allen, chair of T-15, based on WSDOT projects. In addition, work with T-15 is needed to finalize the agenda item and the presentation to SCOBS. Finally, a major training effort for the broader bridge engineering community is needed regarding the new concepts introduced by the research and the proposed revisions. This training will ease the concerns that usually surrounds the introduction of new concepts and will increase the chances of SCOBS voting for the proposed revisions.

**Service II Load Combination: Premature Yielding of Steel Structures**

The validity of the existing load factor for the Service II load combination was investigated in *Service Limit State Design*. The research suggested that the current load factor is justifiable given the limited background of this limit state. The research also suggested that it may be possible to use the distribution factors for a single lane loaded for this limit state except for areas with heavy truck traffic. Discussions with some members of AASHTO technical committees indicated that using the distribution factor for one lane will not be desirable particularly with the current drive to increase the legal loads. See Attachment 6 for the agenda item.

**Status:** SCOBS approved an agenda item that included additions to the description of the limit state and the commentary. See Attachment 6 for the agenda item.

**Future implementation work suggested:** Training for the broader bridge engineering community is needed regarding the background of the limit state and the research as well as for recognizing the situations that may require considering site-specific conditions.