Modern and Comprehensive Bridge Design Specifications

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Efforts to compile highway bridge design specifications began in 1921. The first edition of the *Standard Specifications for Highway Bridges* was published by the then American Association of State Highway Officials in 1931. Since that time the specifications have evolved through 16 editions. Although the specifications initially incorporated only an allowable-strength design philosophy, an approach that considers load variability was introduced in 1970.

Problem

In 1986 state bridge engineers from California, Colorado, Florida, Michigan, and Washington submitted a letter to the AASHTO Highway Subcommittee on Bridges and Structures (the Bridge Committee) expressing their concern that the AASHTO *Standard Specifications for Highway Bridges* was falling behind the times, and that the 13th edition contained many gaps and inconsistencies. In addition, the specifications did not incorporate the load and resistance factor design (LRFD) philosophy used in Canadian and European bridge design codes and in other areas of structural engineering.

Solution

In response to these concerns, a National Cooperative Highway Research Program study was initiated to explore the feasibility of developing probability-based AASHTO bridge specifications. In 1987 the findings of this study were presented to the Bridge Committee with the following recommendations:

- Develop probability-based limit-states specifications.
- Fill as many of the gaps and correct as many of the inconsistencies as possible.
- Develop a commentary to accompany the specifications.

The Bridge Committee accepted these recommendations, and a second NCHRP project was initiated to develop the comprehensive specifications and accompanying commentary.

In 1990 the first draft of the proposed specifications was released and reviewed by state departments of transportation, the Federal Highway Administration, an NCHRP panel, the Bridge Committee's technical committees and task groups, and private organizations. Overall, 250 engineers reviewed the document and provided more than 4,000 comments, which were reviewed and considered for subsequent drafts. The second and third drafts were released in April 1991 and April 1992, respectively. These drafts were also widely circulated for review. These reviews were supplemented by two rounds of trial designs performed by various states and industry groups on a voluntary basis, so that designs using the 14th edition of the AASHTO Standard Specifications and the proposed LRFD Specifications could be compared. The trial designs helped ensure that the new specifications were basically sound, comprehensive, and easy to use. Another important aspect of the trial designs was enabling practicing bridge engineers to gain familiarity with and confidence in the LRFD Specifications.

Application

Since the first edition of the AASHTO *LRFD Bridge Design Specifications* was published in 1994, many states have provided training to bridge designers, developed or purchased computer software, and designed bridges based on the new specifications. These activities are paving the way for full implementation of the new specifications. After 1999 the AASHTO *LRFD Bridge Design Specifications* will be the only bridge specifications maintained by AASHTO.

Benefits

The LRFD Specifications are based on new developments in bridge engineering; sound principles; and a logical approach to ensuring constructibility,

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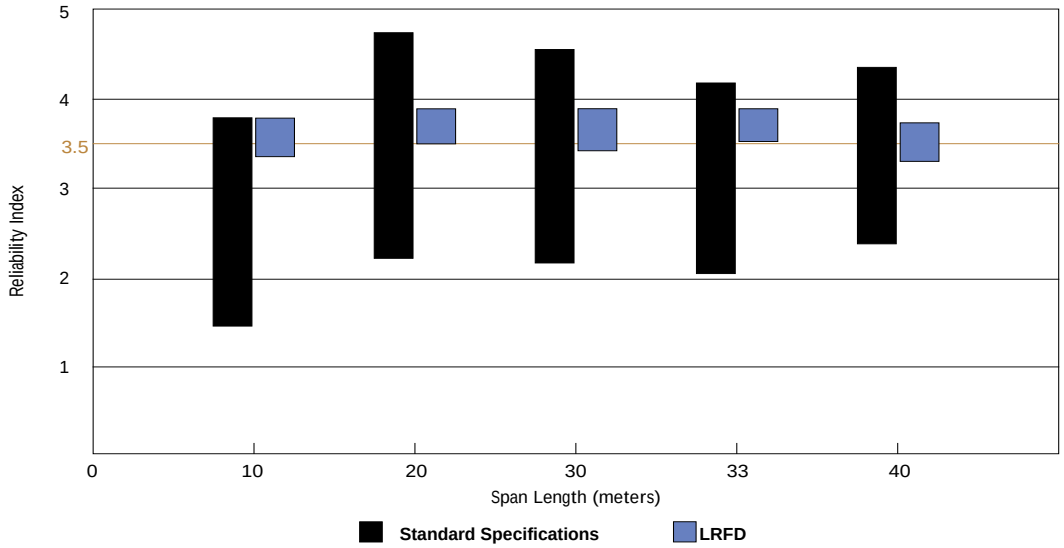

FIGURE 1 Realibility index for Standard Specifications and LRFD Specifications.

safety, serviceability, inspectability, economy, and aesthetics.

The LRFD Specifications have been calibrated to provide a high level of safety in new bridges. This safety is expressed by a reliability index. The specifications provide a reliability level of approximately 3.5 for different types and configurations of bridges (see Figure 1). A significant benefit is that bridges designed in accordance with the LRFD Specifications provide more uniform safety. As shown in Figure 1, the current AASHTO allowable stress design (ASD) and the load factor design (LFD) do not provide for a consistent and uniform safety level. The uniform level of safety of bridges designed in accordance with the LRFD Specifications is achieved through a process of calibrating load and resistance factors by trial designs. In the future, economy may be improved by adjusting the load and resistance factors to meet the specific design requirements and safety level of a particular type, size, and location of bridge.

The new LRFD Specifications define four limit states that must be satisfied by the design to achieve safety, serviceability, and constructibility. The limit states serve as a systematic approach to structural design to ensure trouble-free short- and long-term bridge performance.

The new LRFD Specifications also allow designers to take advantage of high-performance concrete and steel. For example, the provisions for concrete structures in the LRFD Specifications are applicable to concrete strengths up to 10,000 psi. In addition, the LRFD Specifications allow the use of rational methods in computing the time-dependent prestress losses in prestressed members, resulting in lower calculated losses than those computed by the Standard Specifications.

The fatigue load specified in the steel structures section of the LRFD Specifications also produces a lower calculated stress range than that of the Standard Specifications. The fatigue provisions of the new specifications are more reflective of the fatigue loads experienced by highway bridges.

Finally, the parallel commentary provided with the new LRFD Specifications is a great help in understanding and implementing the specifications.

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