by live loading. Instrumentation on the bridges will be linked to the center via modem so that the environmental and structural conditions during a test will be well defined. These bridges will be critical to evaluating the effects of restricted access, structure geometry, surface conditions, platform stability, and human factors on the application of NDE during normal bridge inspections.

The NDE Validation Center is intended to provide a national resource for the development and application of NDE for the inspection of transportation facilities. The center will provide consistent and reliable evaluation of NDE technologies and methods, and accelerate the implementation of NDE in the condition assessment and inspection process. Questions or comments about the center can be sent to glenn.washer@fhwa.dot.gov.

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New Design Specifications To Promote Uniform Safety

JOHN M. KULICKI

In 1993, after a 5-year concentrated effort, the American Association of State Highway and Transportation Officials adopted the AASHTO LRFD Bridge Design Specifications for load and resistance factor design. In 1997 the AASHTO Subcommittee on Bridges and Structures decided that the LRFD Specifications will become the primary specifications for bridge design in 1999 (see "Research Pays Off," page 35).

Development of New Specifications

The *AASHTO LRFD Bridge Design Specifications* is the first complete rewrite of U.S. bridge design specifications. It is based on a radical departure—LRFD—in establishing bridge safety and structural integrity, but maintains many of the current mechanics of the design process. This shift in philosophy represents a major improvement over the traditional Standard Specifications. The new philosophy facilitates future maintenance and development of the specifications in a rational, consistent way.

There were several operational objectives in the development of the new specifications:

- Develop technically state-of-the-art specifications that will position U.S. practice at or near the leading edge of bridge design.
- Make the specifications as comprehensive as possible.
- Make the specifications more readable and easier to use.
- Encourage a multidisciplinary approach to bridge design.
- Place increased emphasis on concepts of redundancy and ductility of structures.

To achieve these objectives, many changes had to be made in both the content and format of the Standard Specifications. In addition to the introduction of a new philosophy of safety, LRFD, these changes include the identification of design limit states; the development of new load and resistance factors; improved load models, including a new live load model; revised techniques for analysis and calculation of component loads; and incorporation of applicable guide specifications.

To make the design process more rational, a combined presentation on plain, reinforced, and prestressed concrete was developed, as were limit-state-based provisions for foundation design and soil mechanics. Expanded coverage of hydraulics and scour was added, consistent with today's heightened awareness of their destructive nature. The earthquake provisions were changed to eliminate the Seismic Performance Category concept by making the method of analysis a function of the importance of the structure. Large portions of the Guide Specifications for Segmental Concrete Bridge Design were adopted, as were many provisions of the AASHTO Guide Specifications for ship collision design. The coverage of bridge railings was expanded to include methods of analysis for designing the specimen for crash testing. Finally, a parallel commentary was introduced to provide rationale, references, nonprescriptive guidance, and insight into how various provisions were developed.

The new philosophy facilitates future maintenance and development of the specifications in a rational, consistent way.

Ongoing Specification Maintenance

In 1995 AASHTO asked the National Cooperative Highway Research Program to initiate a project that would provide support to the technical committees of the Subcommittee for Bridges and Structures in maintaining the LRFD Specifications. This support consists of responding to questions and requests for clarification and interpretation, reviewing ongoing research for incorporation in the LRFD Specifications, assisting in the development of the annual agenda of potential changes, and recommending potential research topics related to the specifications.

Agenda items have been prepared for consideration at each of the meetings of the Subcommittee on Bridges and Structures since 1995. Interestingly, relatively few of these items have pertained to the reliability features of the specifications. Most have dealt with the annual routine of updating provisions for new research findings and adding interpretations and clarifications developed by the states. Significant additions have been made in foundation design and design of segmental concrete bridges.

Training and Implementation

The issue of training engineers to use the new specifications received early consideration by the National Highway Institute, a division of FHWA. A 36-hour course on use of the LRFD Specifications was developed and made available to the states. By the summer of 1997, 31 courses had been given on site to about 1,200 engineers. Two televised presentations available to the states and others that could receive the signal reached about another 1,200 engineers in the spring of 1995. During October 1996 the course was televised throughout the State of Kansas.

Training is not limited to the FHWA-sponsored courses. Several 1-day workshops have been given at national conferences, and the National Steel Bridge Alliance offers a set of steel bridge sample calculations. The Prestressed Concrete Institute is also preparing a set of example designs.

Software development is moving forward as well. All new AASHTO bridge software will be based on the LRFD Specifications. The Pennsylvania Department of Transportation is developing a complete suite of LRFD programs for steel girders, prestressed girders, piers, abutments, retaining walls, and culverts. Several programs are available on the Internet, including some by the Washington State Department of Transportation. Commercial software developers are also developing new or adapting existing software to implement the LRFD Specifications.

A enemigo que huye puente de plata. [If your enemy turns to flee, give him a silver bridge.]

Spanish proverb

Development of Other AASHTO LRFD-Based Specifications

The *AASHTO LRFD Bridge Design Specifications* are just one part of the envisioned complete AASHTO LRFD-based specifications. This complete set of specifications would include specifications pertaining to construction, condition evaluation, and specialty bridges. To this end, AASHTO initiated projects through NCHRP to rewrite the construction specifications, then known as Division II of the Standard Specifications, so they will be compatible with the International System of Units (SI) version of the LRFD Specifications; to develop a new specification for movable bridges that will be LRFD compatible to the extent possible; and to develop an evaluation manual for existing bridges, which is expected to be as consistent with the LRFD Specifications as possible. Thus a complete suite of new specifications will soon fully implement the rational LRFD approach.

Research continues to fill gaps in our knowledge of bridge behavior and design methodologies. The LRFD Specifications will be under development for years to come, just as the Standard Specifications evolved over seven decades.

Summary

With the adoption of the *AASHTO LRFD Bridge Design Specifications*, bridge design has moved to a new level, one that provides a solid physical and mathematical basis for establishing safety and a logical framework for future developments. The general design process is similar to load factor design, but the detailed provisions are often quite different and considerably updated. With the new LRFD aproach, U.S. design practice joins the leadership of modern national bridge design specifications.

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