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RELIABILITY VALIDATION OF HIGHWAY BRIDGES DESIGNED BY LRFD

PROBLEM STATEMENT

The commencement of AASHTO *LRFD Specifications* (1998) is an important development in bridge design philosophy. The AASHTO *LRFD* (1998) introduced a design conception and approach different from AASHTO *Standard* Specifications (1996) for highway bridges. The advantages of a design based on load and resistance factor design (LRFD) method include the consideration of variability in both resistance and load, obtainable uniform levels of safety for different limit states and bridge types without performing complex probability or statistical analysis, and rationality and consistence in the design.

In the development of new code, uniform safety margins among the highway bridges of various types, span lengths, and girder spacings were achieved. The concept of girder distribution factor was used and the bridge structure was simplified into an isolated single girder. The reliability analysis is based on the advanced first order and second moment (AFOSM) approach. Recently, a more advanced reliability analysis, namely stochastic finite element method (SFEM), has been used for the structural reliability analysis. The SFEM approach was employed to validate the steel structures designed in accordance with AISC *LRFD* (1986) approach. The SFEM is capable of involving the consideration of the element in an actual structural configuration and the effect of statistical correlation among the random parameters of the system.

OBJECTIVES

The objective of this study is to investigate the reliabilities of steel girder highway bridges using the extensive SFEM. There are 275 bridges designed in accordance with AASHTO *LRFD* (1998) Strength I limit state. The following aspects are studied:

- the effects of the randomness of design variables of other members on the reliability of the critical member
- the effects of load lateral distribution on the reliability of the critical member
- the actual safety margins corresponding to the specified load modification factor η.

FINDINGS AND CONCLUSIONS

The following are among the conclusions:

1. Based on the reliability analysis of noncomposite steel girder bridges, it can be concluded that the reliability index, β, is very sensitive to the lateral distribution of dead and live loads including the self-weight of barrier, slab, and girder as well as truck loading. However, the reliability index, β, is not sensitive to the randomness of design variables on other members. Therefore, a practical procedure is suggested for the reliability analysis of this kind of bridges. Refine the laterally distributed dead, surface wearing, lane, and truck loads, using an

deliberate model such as the 3D model with plate/shell/beam elements. Put the refined loads on the controlling girder; and Perform reliability analysis using the conventional AFOSM. This procedure avoids the complicated computation inherent in SFEM yet achieves good accuracy. In the examples given, it is found that AFOSM produces slightly conservative results compared with SFEM.

2. For noncomposite steel girder bridges, based on the extensive SFEM, the calculated reliability indices are generally much higher than the target. The load modifier, η, which is 0.05 less than the specified value may be used for the design of noncomposite steel girder bridges using AASHTO *LRFD* Strength I limit state for flexure.

3. For composite steel girder bridges, using the extensive SFEM, the calculated reliability indices are generally much higher than the target. The load modifier, η, which is 0.05 less than the specified value may be used for the design of composite steel girder bridges using AASHTO *LRFD* Strength I limit state for flexure.

4. For multigirder bridges, using the extensive SFEM, the calculated reliability indices are generally higher than the target. The load modifier specified by AASHTO *LRFD* Specifications, η, should be used for the design of steel girder bridges using Strength I limit state for shear to achieve the target safety level.

BENEFITS

AASHTO LRFD Bridge Specifications developed based on the advanced first order and second moment theory of reliability are completely new bridge design specifications. Recently, it was decided that the new specifications would be used in Florida. However, the bridge engineers do not know if the new specifications can provide a safe and economic bridge design. For this project, the research team used a more advanced theory of reliability and examined the reliabilities of several steel bridges designed by LRFD Specifications. It was determined that (1) the design load modifier, which is 0.05 less than LRFD specified value, may be used for the design of steel girder bridges for Strength I limit state for flexure; and (2) the design based on Strength I limit state for shear achieves the target safety level. Consequently, the findings of this research are useful and may result in more economic bridge design--although further research may be still necessary to modify the current LRFD Specifications.

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