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Simplified Load Distribution Factor for Use in LRFD Design

Introduction

The "S-over" equation for the load distribution factor (LDF) was first introduced in the 1930s in the AASHTO Standard specifications. Finite element studies, however, have shown it to be unsafe in some cases and too conservative in others. AASHTO LRFD specifications introduced a new LDF equation as a result of the NCHRP 12-26 project. This equation is based on elastic finite element analysis (FEA). It is considered to be a good representation of bridge behavior. However, this equation involves a longitudinal stiffness parameter, which is not initially known in design. Thus, an iterative procedure is required to correctly determine the LDF value. This need for an iterative design procedure is perceived by practicing engineers as the major impediment to widespread acceptance of the AASHTO LRFD equation.

Meanwhile, the FE model used in developing the LRFD LDF equation did not include some important features of bridges which may affect lateral load distribution. First, despite the presence of the secondary elements such as cross bracing, diaphragms, and parapets in bridges, these elements were not considered in the development of the AASHTO LRFD LDF equation. Second, previous research revealed a widespread presence of pre-existing cracks in concrete bridge decks. These cracks usually form even before the bridge is open to traffic. Even though deck cracking is a well-known phenomenon, the effect of deck cracking on the live load distribution has not yet been assessed.

The main objective of this study is to propose a new simplified equation that is based on the AASHTO LRFD formula and does not require an iterative procedure. The new simplified equation is intended to be at least as conservative as the LRFD equation. Additional objectives of the study are (1) to investigate the influence of secondary elements on the lateral load distribution of typical steel girder bridges; and (2) to examine the effects of deck cracking on the load distribution mechanism through nonlinear analyses.

Findings

A total of 43 steel girder bridges and 17 prestressed concrete girder bridges in the state of Indiana are selected and analyzed using a sophisticated finite element model. The LDF obtained from the FE analyses are compared with those obtained using AASHTO LRFD equation, AASHTO Standard equation, and the proposed Simplified equation. It has been found that the new simplified equation produces LDF values that are always conservative when compared to those obtained from the finite element analyses and are generally greater than the LDF obtained using AASHTO LRFD specification. Therefore, the simplified equation provides a simple yet safe specification for LDF calculation.

The effects of secondary elements and deck cracking on the LDF are investigated through case studies of several Indiana bridges. The presence of secondary elements can result in a load distribution factor up to 40 % lower than the AASHTO LRFD value. Longitudinal cracking has been found to increase the load distribution factor; the resulting load distribution factor can be up to 17 % higher than the LRFD value. Transverse cracking does not significantly influence the transverse distribution of moment. Finally, for one of the selected bridges, both concrete deck cracking and secondary elements are considered to investigate their combined effect on lateral load distribution. The increased LDF due to deck cracking is offset by the contributions from the secondary elements. The result is that the proposed Simplified equation is conservative and is recommended for determination of LDF.

Implementation

The proposed, Simplified equation is expected to streamline the determination of LDF for bridge design without sacrificing safety. The simplified LDF equation eliminates the increased level of complexity introduced by the AASHTO LRFD equation, which has precluded its acceptance by the bridge engineering community, by removing iterative parameters. Thus, the simplified LDF minimizes undue burden on the bridge designer as well as reduce the likelihood for misinterpretation and error within the framework of the LRFD specifications. Initial, trial implementation of the Simplified LDF equation will be undertaken by the INDOT Design Division.

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