15-20 LIVE LOAD DISTRIBUTION BY THREE DIMENSIONAL ANALYSIS

General

Three dimensional analysis of a bridge superstructure explicitly considers the lateral stiffness and load transfer characteristics of the superstructure elements. The technique produces more accurate girder live load distribution factors and, in most cases, is less conservative than the AASHTO-LRFD empirical equations. The application of this refined method for production work is limited. It is typically used when the bridge does not meet the geometric requirements for approximate methods in LRFD 4.6.2.2 or when refined analysis provides justification for significant cost savings.

Background

AASHTO-LRFD live load distribution formulas, presented in Article 4.6.2, were developed based on extensive parametric study of straight single span bridges with uniform girder spacing (see NCHRP Research Results Digest 187). AASHTO-LRFD skew correction factors were developed based on a more limited parametric study of various single span bridge types with equal skews at the abutments. As a result, a range of applicability is shown in the specifications that reflect the limits of the parametric study. AASHTO-LRFD recommends lever rule analysis or a more refined analysis when the bridge parameters fall outside the range of applicability. The lever rule is generally a conservative procedure, while a more refined analysis, such as three-dimensional grillage or finite element, is more accurate.

NCHRP 12-26 presents guidelines for grillage and finite element analysis. Following the NCHRP procedure, a single-span, simply-supported model of a fictitious bridge with similar parameters may be used to calculate live load distribution factors. The design would then proceed with these factors using the normal design process with a spine model.

Analysis

AASHTO-LRFD section 4.6.3 provides guidance on refined methods of analysis. Modern bridge analysis tools, such as CSiBridge, are used to create a single span or multiple span bridge model with the same characteristics (cross section, span length, etc.). Multiple cases must be analyzed with different numbers of trucks, considering multiple presence factors as defined in current AASHTO-LRFD Bridge Design Specifications, and the controlling responses calculated. In addition, the load must be placed on the girders (along the length of

the girder) in such a way as to maximize the response under consideration, i.e., ends of the span for shear and near mid-span for positive moment. This may or may not be available as an automated feature in the analysis tool being used. The analysis tool may utilize a grillage, shell, or plate with eccentric beam (PEB) model, all of which are acceptable.

The live load distribution factor for a specific girder is obtained by finding the maximum response (shear or moment) in that girder from the three dimensional analysis and dividing the result by the response of the girder line from the spine model analysis loaded with a single lane of live load.

Design Recommendations

In lieu of full three-dimensional analysis, refined live load distribution factors, calculated based on this memo, may be used for the following conditions:

- The transverse location of live load is relatively fixed such as for rail/transit or construction loads.
- The live load capacity of an existing structure is to be determined with more accuracy.
- The girder spacing varies considerably throughout the section, or parameters are outside the range of applicability given in AASHTO-LRFD section 4.6.2.
- More accurate girder shear distribution factors are desired for obtuse corner shear in bridges with skewed supports.

CSiBridge has the capability to place live loads as moving loads within defined lanes. Lanes must be located in such a way as to maximize the response in a specific girder. These responses are used to calculate the live load distribution factor. Questions regarding the use of CSiBridge may be directed to the Structural Analysis Committee.

According to AASHTO-LRFD 4.6.3.1, "When refined analysis is used, a table of load distribution coefficients for extreme force effects in each span shall be provided in the contract documents..." A sample of such a table is shown below. The table may also include separate columns for positive and negative moments.

Table 1 Live Load Distribution for Span 1

Girder	Moment		Shear	
	One Design Lane Loaded	Two or More Design Lanes Loaded	One Design Lane Loaded	Two or More Design Lanes Loaded
1	0.56	1.10	0.75	1.23
...	...	...	...	...
n	0.58	1.15	0.79	1.35

Reference

Following references are found on http://des.onramp.dot.ca.gov/structure-policy-innovation/structural-analysis-committee

National Cooperative Highway Research program, Research Results Digest 187, Distribution of Live Loads on Highway Bridges, May 1992.

National Cooperative Highway Research program, Distribution of Live Loads on Highway Bridges, Final Report, March 1991.

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