

Analysis of Live Load Distribution Factors for Curved Box Girder Bridges

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ABSTRACT: Live load distribution factors are used to determine the live-load moment for bridge girder design when a two-dimensional analysis is conducted. A simple, analysis of bridge superstructures is considered to determine live-load factors that can be used to analyse different types of bridges. The distribution of the live load factors distributes the effect of loads transversely across the width of the bridge superstructure by proportioning the design lanes to individual girders through the distribution factors. This research study consists of the determination of live load distribution factors (LLDFs) in both interior and exterior girders for horizontally curved concrete box girder bridges that have central angles, with one span exceeding 34 degrees. This study has been done based on real geometry of bridges designed by a company for different locations. The goal of using real geometry is to achieve more realistic, accurate, and practical results.

KEYWORDS: AASTHO, CURVED BOX GIRDER, BOX GIRDER BRIDGE.

I. INTRODUCTION

The live load dissemination factors (LLDF) portrayed in the AASHTO-LFD details had been utilized for over 50 years preceding their refresh in the AASHTO-LRFD Bridge Design Specification. The equations represent in AASHTO-LRFD depend on the girder dividing just and are typically exhibited as S/D , where S is the separating and D is a consistent in view of the bridge type. This technique is suited to straight and non-skewed bridges as it were. While the recipes spoke to in AASHTO-LRFD are more valuable and exact since they consider more parameters, for example, connect length, piece thickness, and number of cells for the crate girder connect typ. The change in AASHTO-LRFD conditions has produced some enthusiasm for the extension building world and has brought up a few issues. Skewed Bridges will be picked up by utilizing AASHTO-LRFD Specification. AASHTO LRFD gives equations to decide live load distribution factors for a few normal bridge super - structure types. In any case, there is a limitation of utilizing these conditions for bended extensions having focal edges that surpass 34 degrees.

II. RELATED WORK

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III. METHODOLOGY

To study the importance of Live Load Distribution Factor in Curved Concrete Box Girder Bridges we have to compare the results of analysis for straight bridges and curved bridges under AASHTO-LRFD specifications. By comparing the set of results obtained for straight bridge model and curved bridge model we will be able to identify the complications that occur in case of the curved bridges as compared to straight bridges. Since IRC doesn't have any solid reference to the scenario of live load distribution factor we are bound to analyse it with the help of AASHTO-LRFD. Also by comparing the results of the straight and curved bridge models we will also be able to identify which among the two is a more efficient and safe option to provide given the choice. Since now we will have the data of live load distribution factor for both straight and curved bridges we will now compare the results and can determine the best option to provide if and when necessary.

IV. MODEL AND ANALYSIS

(1) Straight Bridge Model And Analysis

3-D demonstrating examinations have been led for straight bridges, for various traverse lengths (80, 90, 100, 115, 120, and 140 ft) and afterward the outcomes contrasted and AASHTO LRFD, 2012 conditions. This will get a sign and origination about the LLDF got from AASHTO LRFD recipes, 2012 to those acquired from limited component investigations for this kind of bridge (Concrete Box Girder).

EXPERIMENTS & RESULTS

Live Load Distribution Factors (LLDF) for Straight Bridges

Tables 4.1 to Table 4.6 show LLDF for all cases of loading. The bold numbers in the columns represent the maximum moments for interior and exterior girders, for each span length.

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Table 4.1: LLDF for Negative Moment Due to HL-93S- One Lane Loaded

Span Length (ft)	Interior Girder 1	AASHTO LRFD	Interior Girder 2	AASHTO LRFD	Left Exterior Girder	AASHTO LRFD	Right Exterior Girder	AASHTO LRFD
80	0.30	0.51	0.33	0.51	0.16	0.46	0.30	0.45
90	0.29	0.49	0.32	0.49	0.17	0.45	0.29	0.45
100	0.28	0.47	0.31	0.47	0.18	0.45	0.29	0.45
115	0.26	0.45	0.3	0.45	0.19	0.45	0.28	0.45
120	0.26	0.44	0.29	0.44	0.2	0.44	0.28	0.44
140	0.25	0.42	0.28	0.42	0.21	0.44	0.27	0.43

Table 4.2: LLDF for Negative Moment Due to HL-93S- Two Lanes Loaded

Span Length (ft)	Interior Girder 1	AASHTO LRFD	Interior Girder 2	AASHTO LRFD	Left Exterior Girder	AASHTO LRFD	Right Exterior Girder	AASHTO LRFD
80	0.58	0.69	0.58	0.69	0.42	0.56	0.42	0.56
90	0.57	0.67	0.57	0.67	0.45	0.55	0.45	0.55
100	0.56	0.65	0.56	0.65	0.46	0.55	0.46	0.55
115	0.55	0.63	0.55	0.63	0.47	0.55	0.47	0.55
120	0.54	0.62	0.54	0.62	0.47	0.54	0.47	0.54
140	0.52	0.60	0.52	0.60	0.48	0.54	0.48	0.54

Table 4.3: LLDF for Positive Moment Due to HL-93K- One Lane Loaded

Span Length (ft)	Interior Girder 1	AASHTO LRFD	Interior Girder 2	AASHTO LRFD	Left Exterior Girder	AASHTO LRFD	Right Exterior Girder	AASHTO LRFD
80	0.27	0.51	0.31	0.51	0.19	0.48	0.27	0.48
90	0.27	0.49	0.3	0.49	0.19	0.47	0.26	0.47
100	0.26	0.47	0.29	0.47	0.2	0.46	0.25	0.46
115	0.25	0.45	0.28	0.45	0.21	0.45	0.24	0.45
120	0.25	0.44	0.27	0.44	0.21	0.45	0.24	0.45
140	0.24	0.42	0.25	0.42	0.22	0.44	0.23	0.43

Table 4.4: LLDF for Negative Moment Due to HL-93K- One Lane Loaded

Span Length (ft)	Interior Girder 1	AASHTO LRFD	Interior Girder 2	AASHTO LRFD	Left Exterior Girder	AASHTO LRFD	Right Exterior Girder	AASHTO LRFD
80	0.29	0.51	0.33	0.51	0.16	0.48	0.3	0.48
90	0.28	0.49	0.32	0.49	0.17	0.47	0.29	0.47
100	0.28	0.47	0.31	0.47	0.18	0.46	0.29	0.46
115	0.26	0.45	0.3	0.45	0.19	0.45	0.28	0.45
120	0.26	0.44	0.29	0.44	0.19	0.44	0.28	0.45
140	0.25	0.42	0.27	0.42	0.20	0.44	0.28	0.43

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Table 4.5: LLDF for Positive Moment Due to HL-93K- Two Lanes Loaded

Span Length (ft)	Interior Girder 1	AASHTO LRFD	Interior Girder 2	AASHTO LRFD	Left Exterior Girder	AASHTO LRFD	Right Exterior Girder	AASHTO LRFD
80	0.58	0.69	0.58	0.69	0.44	0.55	0.44	0.55
90	0.57	0.67	0.57	0.67	0.44	0.55	0.44	0.55
100	0.56	0.65	0.56	0.65	0.45	0.55	0.45	0.55
115	0.54	0.63	0.54	0.63	0.45	0.55	0.45	0.55
120	0.53	0.62	0.53	0.62	0.46	0.54	0.46	0.54
140	0.50	0.60	0.50	0.60	0.47	0.53	0.47	0.53

Table 4.6: LLDF for Negative Moment Due to HL-93K- Two Lanes Loaded

Span Length (ft)	Interior Girder 1	AASHTO LRFD	Interior Girder 2	AASHTO LRFD	Left Exterior Girder	AASHTO LRFD	Right Exterior Girder	AASHTO LRFD
80	0.59	0.69	0.59	0.69	0.46	0.55	0.46	0.55
90	0.58	0.67	0.58	0.67	0.46	0.55	0.46	0.55
100	0.57	0.65	0.57	0.65	0.46	0.55	0.46	0.55
115	0.56	0.63	0.56	0.63	0.46	0.55	0.46	0.55
120	0.55	0.62	0.55	0.62	0.47	0.54	0.47	0.54
140	0.52	0.60	0.52	0.60	0.47	0.53	0.47	0.53

(2) Curved Bridge Model And Analysis

Curved structures are frequently required for thruway spans, particularly when detachments or on exit ramps are included. In the current LRFD determinations AASHTO 2012 there is a cutoff on utilizing the distribution factor recipe for bended extensions. All the more particularly, refined investigations are required for spans with focal points more noteworthy than 34° in any one traverse from help to brandish. This utmost is somewhat prohibitive, as geometric plan frequently requires the development of exceedingly bended structures that surpass this breaking point.

EXPERIMENTS & RESULTS

Live Load Distribution Factors (LLDF) for Curved Bridges

- Central Angle of 5°

Table 5.1: LLDF for HL-93S- One Lane Loaded-Negative Moment

Span Length (ft)	Max Moment Interior Girder 2	AASHTO LRFD
80	0.33	0.51
90	0.32	0.49
100	0.31	0.47
115	0.30	0.45
120	0.29	0.44

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Table 5.2: LLDF for HL-93S- Two Lanes Loaded-Negative Moment

Span Length (ft)	Max Moment Interior Girder 1	AASHTO LRFD
80	0.59	0.69
90	0.58	0.67
100	0.57	0.65
115	0.56	0.63
120	0.55	0.62

Table 5.3: LLDF for HL-93K- One Lane Loaded-Positive Moment

Span Length (ft)	Max Moment Interior Girder 2	AASHTO LRFD
80	0.33	0.51
90	0.32	0.49
100	0.31	0.47
115	0.29	0.45
120	0.28	0.44

Table 5.4: LLDF for HL-93K- One Lane Loaded-Negative Moment

Span Length (ft)	Max Moment Interior Girder 2	AASHTO LRFD
80	0.33	0.51
90	0.32	0.49
100	0.31	0.47
115	0.30	0.45
120	0.29	0.44

Table 5.5: LLDF for HL-93K- Two Lanes Loaded-Positive Moment

Span Length (ft)	Max Moment Interior Girder 2	AASHTO LRFD
80	0.59	0.69
90	0.58	0.67
100	0.57	0.65
115	0.56	0.63
120	0.55	0.62

Table 5.6: LLDF for HL-93K- Two Lanes Loaded-Negative Moment

Span Length (ft)	Max Moment Interior Girder 1	AASHTO LRFD
80	0.60	0.69
90	0.59	0.67
100	0.58	0.65
115	0.57	0.63
120	0.56	0.62

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- Central Angles of 38°, 45°, 50°, 55°, 60°

Table 5.7: LLDF for Curved Bridge with a Central Angle of 38°

LLDF for HL-93K- Two Lanes Loaded-Negative Moment		
Span Length (ft)	AASHTO LRFD	FEA Curved Bridge ($\theta = 38^\circ$)
80	0.69	0.71
90	0.67	0.69
100	0.65	0.67
115	0.63	0.64
120	0.62	0.63
140	0.60	0.61

Table 5.8: LLDF for Curved Bridge with a Central Angle of 45°

LLDF for HL-93K- Two Lanes Loaded-Negative Moment		
Span Length (ft)	AASHTO LRFD	FEA Curved Bridge ($\theta = 45^\circ$)
80	0.69	0.73
90	0.67	0.71
100	0.65	0.68
115	0.63	0.66
120	0.62	0.65
140	0.60	0.62

Table 5.9: LLDF for Curved Bridge with a Central Angle of 50°

LLDF for HL-93K- Two Lanes Loaded-Negative Moment		
Span Length (ft)	AASHTO LRFD	FEA Curved Bridge ($\theta = 50^\circ$)
80	0.69	0.74
90	0.67	0.72
100	0.65	0.70
115	0.63	0.67
120	0.62	0.66
140	0.60	0.63

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Table 5.10: LLDF for Curved Bridge with a Central Angle of 55°

LLDF for HL-93K- Two Lanes Loaded-Negative Moment		
Span Length (ft)	AASHTO LRFD	FEA Curved Bridge ($\theta = 55^\circ$)
80	0.69	0.76
90	0.67	0.74
100	0.65	0.72
115	0.63	0.69
120	0.62	0.68
140	0.60	0.65

Table 5.11: LLDF for Curved Bridge with a Central Angle of 60°

LLDF for HL-93K- Two Lanes Loaded-Negative Moment		
Span Length (ft)	AASHTO LRFD	FEA Curved Bridge ($\theta = 60^\circ$)
80	0.69	0.79
90	0.67	0.77
100	0.65	0.75
115	0.63	0.72
120	0.62	0.71
140	0.60	0.67

The AASHTO LRFD Design Specifications provide a set of live load distribution factor formulas for determining the distribution of bending moment effects in both the interior and exterior girders of highway bridges. However, there are limitations on the use of these distribution factors, such as the central angle that is limited up to 34°. As a result, refined analyses using 3D models are required to design bridges outside of these limits.

V. CONCLUSION

The results indicate that the current AASHTO LRFD formulas for box-girder bridges provide a conservative estimate of the design bending moment. Live load distribution factors obtained from LRFD for exterior girders are generally more conservative than that for interior girders. It was observed from a refined analysis that the distribution factor increases as the central angle increases. The current AASHTO LRFD formulas for multi-cell box girder bridges are applicable for curved bridges that have central angles up to 34° or even until 38°, which is a little out of the LRFD's limits. The maximum moment on the exterior girders increases very significantly due to the effect of centrifugal and braking forces. And, the bending moment generally increases under the braking force.

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