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Bending Moment Multiplication Factor for AASHTO Live Loads Adopted in Jordan for Four Equal Spans with One Lane

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Abstract

The main objective of this study is to determine a fixed multiplication factor for AASHTO LRFD that will be recommended to give the same result of bending moments due to 1.8 AASHTO LFD for four equal continuous spans with various span lengths of 20, 25, 30, 35 and 40 m.
The bridge models will be analyzed using the CSiBridge software. This study contains twenty finite element bridge models with one lane. Models are subjected to AASHTO LFD and AASHTO LRFD loadings to obtain the girders moments.

For one-lane models, bending moments, values -at exterior and interior girder - increase when the span length increases. Whereas, bending moment values for AASHTO LFD are higher than those for AASHTO LRFD. The maximum multiplication factors for one lane were obtained when span length equals to 20 m at second interior girder, such that bending moment factor is 1.35.

In case of live loads, the maximum factor for one lane are obtained in span length of 20 m at second interior girder, where the bending moment factor is 1.70

Keywords: *AASHTO specification, AASHTO LAFD LFD Loadings.*

I. INTRODUCTION

AASHTO LFD (1) live loads are used in Jordan, most of the Arab countries and USA.

In Jordan the AASHTO LFD live load is increased to encounter the unexpected live loads. This increase is a multiplication factor of 1.8 to the live loads of AASHTO LFD.

AASHTO LRFD (2) is the recent Code in designing bridges .

Ministry of public works and Housing and Ministry of Transportation (3, 4) studied the axle weight in Jordan.

AL foqaha'a (5) studied the loading adopted for bridge design in Jordan in 1994.

Qaqish (6) presented load capacity evaluation of T – Beam bridge.

Qaqish (7) presented stress distribution at the corners of skew bridge.

Qaqish (8) illustrated a comparison between one dimensional and dimensional models of one span box Girder bridge.

Qaqish (9) illustrated a comparison between one dimensional and three dimensional models of tow continuous span box, Girder bridge.

Qaqish (10) illustrated the finite element analysis of two continuous skew spans of box, Girder bridge and the reaction distribution at the edges with 49 degrees skew angle.

Campisi (11) illustrated the review of load rating highway bridges in accordance with load and

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resistance factor rating method.

Deng (12) studied the numerical simulations to study the dynamic Ifs of both simply supported and continuous bridges due to vehicle loading.

Deng (13) studied the impact factors for different bridge responses, including deflection, bending moment and shear. The results showed that the impact factors due to vehicle braking could be notably larger than

Those due to the vehicles moving at constant speeds and could exceed the impact factor specified in the AASHTO bridge deign code.

Leahy (14) examined the HL-39 current traffic load model in the United States.

Li (15) studied a three – dimensional nonlinear dynamic analyses framework for RC bridges based on the force on the analogy method (FAM).

Qaqish (16) studied the determination of the factor, by which the LRFD live loads must be multiplied , to give the same moment as 1.8 LFD live loads produced. This research conducted a comparison of 1.8 AASHTO LFD and AASHTO LRFD live loads for bending moment of simply supported 30 m bridge span with one lane in each direction showed that the LRFD HL–93 loadings should be multiplied by 1.35 to have the same moment as 1.8 multiplied by HS20–44 in LFD.

Zaki (17) studied live load distribution factors for horizontally curved concrete box girder bridges. The purpose of this study was to determine Live Load Distribution Factors (LLDFs) in both interior and exterior girders for straight box girder bridges and horizontally curved concrete box girder bridges.

Straight box girder bridges and horizontally curved concrete box girder bridges were analyzed by two methods:

- The AASHTO LRFD formulas.

- The Finite element analysis software.

For the straight bridge, various span lengths of (80, 90, 100, 115, 120, and 140 ft) were used. While for the horizontally curved concrete box girder bridges, the span lengths were (80, 90, 100, 115, 120, and 140 ft) with central angles of (5º, 38º, 45º, 50º, 55º, and 60º).

For straight bridges, it can be concluded that the magnitude of the distribution factors, that were obtained from the finite element analysis decreases when increasing the span length. The current AASHTO LRFD formulas for box-girder bridges provide a conservative estimate of the design bending moment.

For curved bridges, the refined analysis showed that the distribution factor increases as the central angle increases, and the current AASHTO LRFD formula is valid up to the central angle of 38º.

Deng, et al. (18) : in this study, numerical simulations were performed to study the dynamic (Impact Factor- IM) of both simply supported and continuous bridges due to vehicle loading, impact factors for both shear and bending moment were investigated.

In this study, numerical simulations were performed to study the IMs of six concrete girder bridges, including four simply supported bridges and two three-span continuous bridges, due to vehicle loading.

The findings from this study suggest that in strength design or capacity evaluation of continuous girder bridges, the use of IMs calculated from the responses of simply supported bridges may not be appropriate or safe. Besides, the IMs for bending moment and shear should be treated differently.

II. Live loads:

The live loads of the AASHTO specification (LFD) consist of standards trucks or of lane loads as shown in Fig (1). While live loads of the AASHTO specifications (2) LRFD is HL-93 which consist of truck loading and distributed load of 9.3 kN/m as shown in Fig (2). The impact factor for LFD is calculated from:

$$I.F. = \frac{50}{L+125}$$ L span of bridge in feet.

While the dynamic load allowance is considered 33% for LRFD

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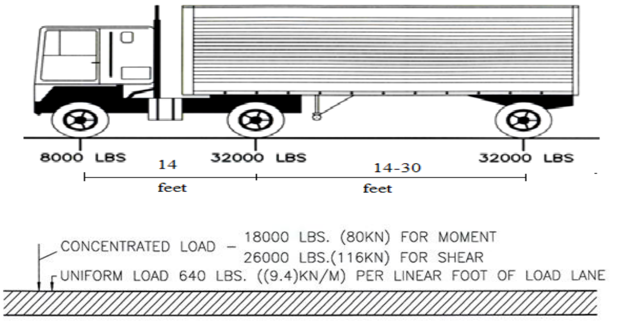
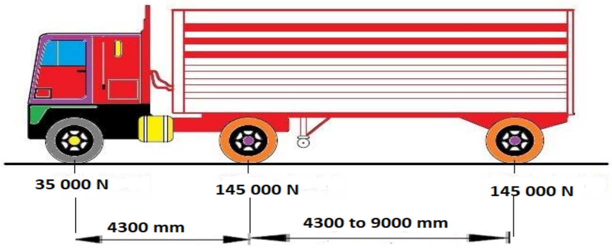
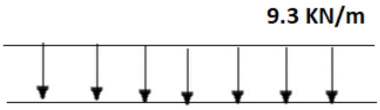


Fig.(1): Truck HS 20-44 and Equivalent lane loading .



A) Track loading



B) Distributed loading

Fig (2): HL – 39 Loading

III. Structural Idealization

Figures 3 and 4 show the cross section and plan respectively of the bridge which consists of one lane.

Csi (19) computer program was used for finite element mech of the bridge model .

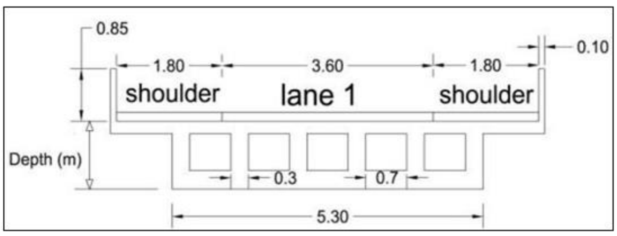


Figure 3: Cross section of the bridge consists of one lane (not to scale)

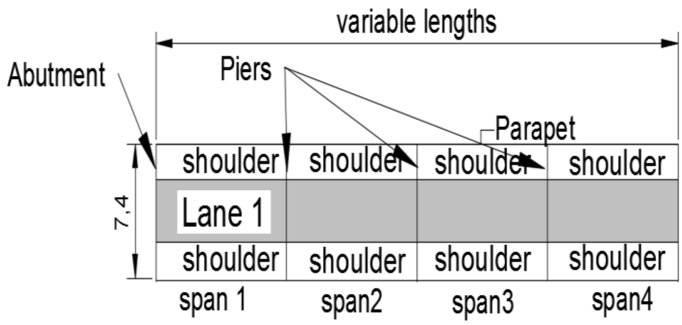


Figure 4: Bridge model top view with one lane (not to scale)

3.1 Positive and Negative Moments Due to Combination of Dead and Live Loads

Figure 5 shows cross section of one lane bridge

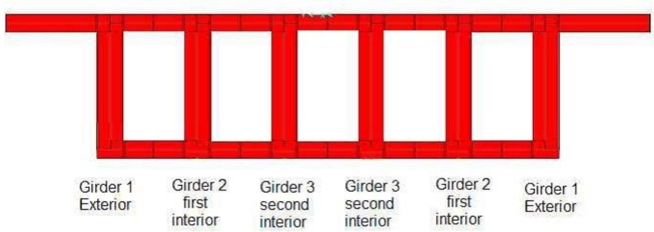


Figure 5: One lane bridge cross section for girders.

3.1.1 LFD results for one lane models

Tables 1 to 5 show maximum LFD moments for spans 20m, 25m, 30m, 35m and 40m, respectively

The abbreviations of the moments are as follows:
M+ = Maximum Positive Moment (kN.m)
M- = Maximum Negative Moment (kN.m)

Table 1: Maximum LFD moments for span length of 20 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1314	813	1392	1053
First interior	1400	884	1550	1172
Second interior	1394	879	1541	1160

Table 2: Maximum LFD moments for span

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length of 25 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1920	1162	2106	1602
First interior	2021	1244	2348	1784
Second interior	2014	1238	2349	1777

Table 3: Maximum LFD moments for span length of 30 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	2715	1623	3142	2328
First interior	2822	1708	3444	2551
Second interior	2816	1702	3450	2545

Table 4: Maximum LFD moments for span length of 35 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	2724	2171	4506	3308
First interior	3826	2253	4846	3558
Second interior	3821	2250	4856	3553

Table 5: Maximum LFD moments for span length of 40 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	4941	2825	6193	4512
First interior	5029	2901	6561	4783
Second interior	5026	2898	6573	4778

3.1.2 LRFD results for one lane models

Tables 6 to 10 show Maximum LRFD Moments for spans 20m, 25m, 30m, 35m and 40m respectively

Table 6: Maximum LRFD moments for span length of 20 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1053	610	1241	925
First interior	1112	657	1376	1025
Second interior	1107	652	1366	1011

Table 7: Maximum LRFD moments for span length of 25 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1584	910	1906	1405
First interior	1656	965	2120	1558
Second interior	1650	960	2119	1550

Table 8: Maximum LRFD moments for span length of 30 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	2313	1309	2824	2062
First interior	2391	1366	3091	2254
Second interior	2385	1360	3096	2247

Table 9: Maximum LRFD moments for span length of 35 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	3256	1809	4032	2910
First interior	3329	1864	4332	3126
Second interior	3324	1858	4340	3119

Table 10: Maximum LRFD moments for span length of 40 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	4410	2416	5528	3954
First interior	4472	2466	5852	4186

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Second interior	4467	2462	5862	4180

It is concluded that the values of moments on a one-lane bridge, when the AASHTO LFD loads are applied, is greater than the values of moments when the AASHTO LRFD loads are applied on the same bridge in span 1, span 2, pier 1,and pier 2, for both external and internal girders.

3.2 Positive and Negative Moments Due to Live Loads

3.2.1 LFD live loads results for one lane models

Tables 11 to 15 show Maximum LFD moments for spans 20m, 25m, 30m, 35m and 40m, respectively

Table 11: Maximum LFD moments for span length of 20 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	613	491	464	423
First interior	668	542	520	475
Second interior	665	540	515	471

Table 12: Maximum LFD moments for span length of 25 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	819	663	666	606
First interior	879	718	743	677
Second interior	876	716	739	672

Table 13: Maximum LFD moments for span length of 30 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1030	838	914	830
First interior	1090	894	1000	908
Second interior	1088	892	996	903

Table 14: Maximum LFD moments for span length of 35 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1243	1017	1206	1091
First interior	1301	1072	1292	1171
Second interior	1300	1071	1287	1165

Table 15: Maximum LFD moments for span length of 40 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1458	1198	1536	1388
First interior	1512	1249	1621	1466
Second interior	1513	1249	1613	1458

3.2.2 LRFD live loads results for one lane models

Tables 16 to20 show Maximum LRFD moments for spans 20m, 25m, 30m, 35m and 40m, respectively

Table 16: Maximum LRFD moments for span length of 20 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	364	292	328	304
First interior	392	319	364	341
Second interior	390	317	359	335

Table 17: Maximum LRFD moments for span length of 25 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	505	409	485	445
First interior	536	438	538	494
Second interior	534	436	533	489

Table 18: Maximum LRFD moments for span length of 30 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	659	535	638	590
First interior	691	566	694	642
Second interior	690	564	688	636

Table 19: Maximum LRFD moments for span length of 35 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	826	674	798	737
First interior	857	703	851	787
Second interior	855	701	844	780

Table 20: Maximum LRFD moments for span length of 40 m

Maximum LFD Moment (kN.m), one-lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1005	821	969	895
First interior	1032	847	1018	940
Second interior	1031	846	1011	933

IV. Conclusion

The following points can be extruded from this research.

1. The fixed multiplication factors decrease when the lengths of spans increase.
2. Bending moment values resulting from AASHTO LFD loads are higher than those resulting from AASHTO LRFD loads.
3. In case of load combination, the maximum value of multiplication factor for one-lane Bridge is found when the length of span equals to 20 m at second interior girder with a value of 1.35.
4. In case of live loads, the maximum value of multiplication factor for one-lane bridge is found when the length of span equals to 20 m at second interior girder with a value of 1.70.

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