ISSN: 2754-4982

Journal of Civil Engineering Research & Technology

Research Article

Open Access

Bending Moment Multiplication Factor for Aashto Live Loads Adopted In Jordan for Four Equal Spans with Two Lanes

Samih Qaqish*, Maher S Qaqish[1], Obada Ibrahim Hatamleh[2]

[1]Dean of Engineering, AL-Balqa Applied University, Salt, Jordan

[2]Graduate Student University of Jordan

ABSTRACT

The main objective of this study is to determine a fixed multiplication factor for Aashto Lfd 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 CSi Bridge software. This study contains twenty finite element bridge models, with two lanes. Models are subjected to Aashto LFD and Aashto LRFD loadings, to obtain the girders moments. For two-lane models, bending moments, values increase with increase of span length. The maximum factors for two lane models were obtained when span length equals to 20 m at fourth interior girder, such that bending moment factor is 1.43. In case of live loads, the maximum factor for two lane models are obtained in span length of 20 m at second interior girder, where the bending moment factor is 1.72.

***Corresponding author**

Samih Qaqish, EX-Dean Faculty of Engineering, Engineering Advisor for the President, Director Center of Consultation, Fellow ASCE, The University of Jordan, Amman, Jordan, Tel: 962-777427511, E-Mail: Samihka-lish@yahoo.com

Received: March 13, 2020; **Accepted:** March 24, 2020; **Published:** March 27, 2020

Keywords: Aashto Specification, Aashto Lafd Aashto Lfd Loadings

Introduction

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. Is the recent Code in designing bridges. Ministry of public works and Housing and Ministry of Transportation, studied the axle weight in Jordan. Studied the loading adopted for bridge design in Jordan in 1994. Presented load capacity evaluation of T-Beam Bridge. Presented stress distribution at the corners of skew bridge.

Illustrated a comparison between one dimensional and dimensional models of one span box Girder bridge. Illustrated a comparison between one dimensional and three dimensional models of tow continuous span box, Girder Bridge. 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. Illustrated the review of load rating highway bridges in accordance with load and resistance factor rating method. Studied the numerical simulations to study the dynamic Ifs of both simply supported and continuous bridges due to vehicle loading. 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. Examined the HL-39 current traffic load model in the United States. Studied a three-dimensional nonlinear dynamic analyses framework for RC bridges based on the force on the analogy method (FAM). 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. 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 [1-17].

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. 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 [18]. 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.

Live loadsThe 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 LRFD is HL-93 which consist of truck loading and distributed load of 9.3 [2].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

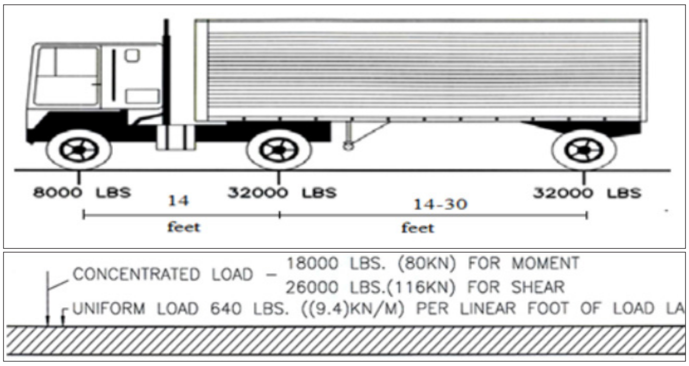
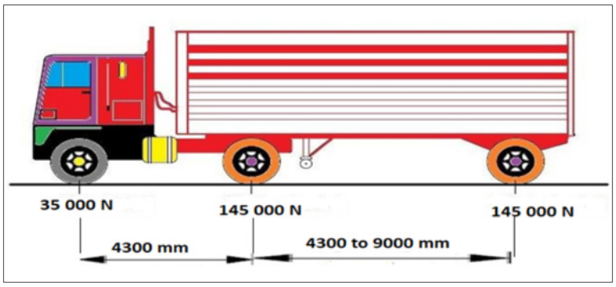
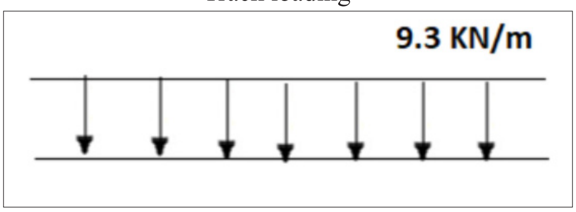


Figure 1: Truck HS 20-44 and Equivalent lane loading



Track loading



Distributed loading

Figure 2: HL – 39 Loading

Structural Idealization

Fig (3) and Fig (4) show the cross section and plan respectively of the bridge which consists of one lane.Computer program was used for finite element mech of the bridge model [19].

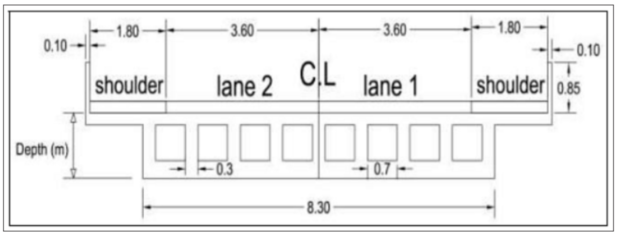


Figure 3: Cross section of the bridge consists of two lanes

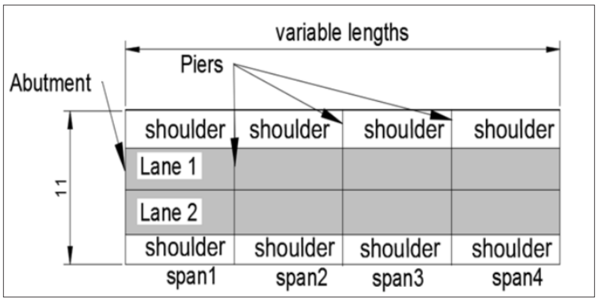


Figure 4: Bridge model top view with two lanes (not to scale)

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

LFD results for two lanes models

Fig. (5) Shows cross section of two lanesTables 1 to 5 show maximum LFD moments for spans 20m, 25m, 30m, 35, and 40m,Respectively

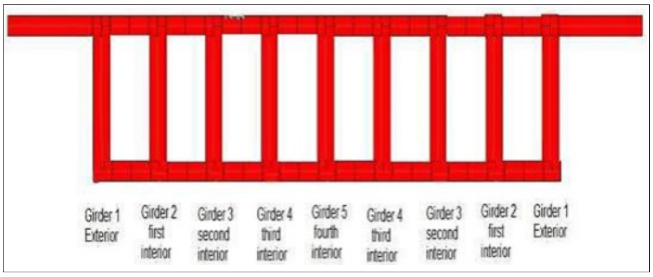


Figure 5: Two- lanes bridge cross section for girders

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), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1522	973	1522	1170
First interior	1626	1061	1726	1331
Second interior	1639	1076	1727	1329
Third interior	1604	1049	1712	1316
Fourth interior	1680	1122	1721	1326

Table 2: Maximum LFD moments for span length of 25 m

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	2205	1397	2293	1750
First interior	2316	1491	2600	1986
Second interior	2328	1506	2614	1998
Third interior	2293	1475	2603	1974
Fourth interior	2368	1547	2609	1980

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

Maximum LFD Moment (kN.m), two -lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	4162	2516	4811	3600
First interior	4277	2617	5278	3952
Second interior	4294	2635	5324	3971
Third interior	4261	2604	5324	3961
Fourth interior	4343	2683	5334	3968

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	4162	2516	4811	3600
First interior	4277	2617	5278	3952
Second interior	4294	2635	5324	3971
Third interior	4261	2604	5324	3961
Fourth interior	4343	2683	5334	3968

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	5451	3228	6579	3600
First interior	5562	3326	7110	3952
Second interior	5583	3348	7110	3971
Third interior	5551	3317	7176	3961
Fourth interior	5636	3400	7188	3968

LRFD Results for Two 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), two -lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1177	705	1343	1020
First interior	1249	762	1514	1150
Second interior	1251	766	1505	1137
Third interior	1231	751	1488	1121
Fourth interior	1266	787	1489	1127

Table 7: Maximum LRFD Moments for Span Length of 25m

Maximum LFD Moment (kN.m), two -lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1764	1049	2035	1528
First interior	1842	1114	2297	1724
Second interior	1843	1116	2303	1718
Third interior	1823	1099	2294	1706
Fourth interior	1858	1133	2292	1704

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

Maximum LFD Moment (kN.m), two -lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	2549	1492	2984	2220
First interior	2631	1558	3321	2470
Second interior	2631	1560	3340	2470
Third interior	2613	1542	3336	2460
Fourth interior	2648	1578	3335	2459

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

Maximum LFD Moment (kN.m), two -lane bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	3549	2031	4222	3106
First interior	3631	2105	4620	3398
Second interior	3633	2108	4649	3402

Third interior	3613	2090	4649	3390
Fourth interior	3652	2127	4649	3389

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	4766	2694	5753	4188
First interior	4843	2762	6205	4517
Second interior	4846	2766	6245	4526
Third interior	4827	2748	6249	4517
Fourth interior	4867	2787	6250	4514

It is concluded that the values of moments on a two-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.

Positive and Negative Moments Due to Live Loads
LFD live loads results for two 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), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	814	653	588	533
First interior	882	715	683	623
Second interior	901	737	695	636
Third interior	871	711	688	633
Fourth interior	950	785	699	645

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1092	884	852	773
First interior	1161	949	978	890
Second interior	1180	970	991	903
Third interior	1153	942	985	895
Fourth interior	1227	1016	993	907

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1371	1118	1172	1062
First interior	1440	1184	1318	1197
Second interior	1463	1207	1335	1212
Third interior	1438	1180	1329	1208
Fourth interior	1516	1254	1336	1215

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1652	1353	1549	1401
First interior	1722	1420	1706	1546
Second interior	1749	1446	1726	1564
Third interior	1723	1422	1719	1559
Fourth interior	1805	1501	1707	1567

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	1936	1590	1978	1786
First interior	2004	1656	2142	1938
Second interior	2035	1686	2166	1959
Third interior	2009	1661	2161	1954
Fourth interior	2095	1747	2169	1962

LRFD live loads results for two lane models

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

Table 16: Maximum LRFD Moments for Span Length of 20m

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	Span 1	Span 2	Pier1	Pier2
	M+	M+	M-	M-
Exterior	484	389	425	393
First interior	520	422	492	456
Second interior	528	432	495	458

Third interior	514	419	487	451
Fourth interior	551	455	491	459

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	**Span 1**	**Span 2**	**Pier1**	**Pier2**
	M+	**M+**	**M-**	**M-**
Exterior	673	546	621	569
First interior	711	581	707	649
Second interior	719	589	714	655
Third interior	706	576	710	651
Fourth interior	741	612	710	652

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	**Span 1**	**Span 2**	**Pier1**	**Pier2**
	M+	**M+**	**M-**	**M-**
Exterior	879	715	822	759
First interior	918	751	919	849
Second interior	927	760	925	855
Third interior	914	748	920	850
Fourth interior	950	783	920	851

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	**Span 1**	**Span 2**	**Pier1**	**Pier2**
	M+	**M+**	**M-**	**M-**
Exterior	1100	898	1033	955
First interior	1138	933	1131	1046
Second interior	1149	944	1137	1051
Third interior	1136	931	1131	1044
Fourth interior	1175	1038	1130	1044

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

Maximum LFD Moment (kN.m), two-lane Bridge				
Girder	**Span 1**	**Span 2**	**Pier1**	**Pier2**
	M+	**M+**	**M-**	**M-**
Exterior	1336	1091	1258	1162
First interior	1372	1126	1355	1252
Second interior	1384	1139	1361	1257
Third interior	1373	1125	1355	1250
Fourth interior	1413	1167	1353	1249

Conclusions

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 two-lane Bridge is found when the span length is 20 m with a value of 1.43.
4. In case of live loads, the maximum value of multiplication factor for two-lane Bridge is found when the length of span length is 20 m with a value of 1.72.

References

1. American Association of State Highway and Transportation Officials (2002), ASHTO, Standard Specification for Highway Bridges, 17th edition, Washington.
2. American Association of State Highway and Transportation Officials, AASHTO LRFD, Washington (2007)
3. Ministry of Public Works and Housing (1983, 1998), Axle-Wight Records, Jordan.
4. Ministry of transportation (1993), A Report on A GrossVehicle Weights on The Jordanian Road Network for the Year 1993, Jordan.
5. Al-Foqahaa A (1994) Study of Recent Loading Adopted for Bridge Design in Jordan. M Sc Thesis, University of Jordan.
6. Qaqish S (2018) Load capacity Evacuation of T- Beam Bridges. Kerensky conference on Global trends in Structural Engineering 20-22, July 1994, Singapore.
7. Qaqish S (1999) Stress Distribution at the Corners of Skew Bridges. Published in the Conference proceedings 13th American Society of Civil Engineering Mechanics Division, Baltimore June 13-16.
8. Qaqish S (2005) Comparision between One Dimensional and Three Dimensional Models of Box Girder Bridge. 1st international Structural Specialty Conference Society of Civil Engineering Calgary, Alberta, Canada.
9. Qaqish S (2008) Comparision Between One Dimensional and Three Dimensional Models of two Continuous spans of Box Girder Bridge. international conference on construction and building technology, June, 16-20,208 Kuala Lumpur,Malaysia.
10. QaqishS (2012) Finite Element Analysis of two Continuous Skew Spans of Box Grider Bridge and the reaction Distribution at the Edges with 49 Degrees Skew angle. Orlando International Engineering Education Conference, USA.

11. Campisi P (2015) Review of load and Resistance Factor Rating Methed by Lubin Gao. J Bridge Eng, ASCE vol 20: 12.
12. Deng L, He W, Shao Y (2015) Dynamic impact factors for shear and bending moment of simply supported and continuous concrete girder bridges. Journal of Bridge Engineering, ASCE vol 20: 11.
13. Deng, Wang F (2015) Impact Factor of Simply Supported Prestressed concrete Girder Bridge duo to Vehicle Bricking. J Bridge Eng, ASCE.
14. Leahy C, OBrien EJ, Enright B, Hajializadeh D (2014) Review of HL-93 bridge traffic load model using an extensive WIM database, Journal of Bridge Engineering, ASCE.
15. Li G, Zhangm Y, Li H (2014) Nonlinear Seismic Analysis of Reinforced Concrete Bridge Using the Force Analogy Method, J bridge Eng, ASCE.
16. Qaqish S (2018) Multiplication bending moment factor for AASHTO live Loads Adopted in Jordan, MOJ Civil Engineering 4: 104-107.
17. Zaki M (2016) Live load distribution factors for horizontally curved concrete box girder bridges M Sc Thesis, University of Massachusetts Amherst, US.
18. Deng L, He W, Shao Y (2015) Dynamic impact factors for shear and bending moment of simply supported and continuous concrete girder bridges, Journal of Bridge Engineering 20: 04015005.
19. CSI Bridge Computer program, SAP (2014) Integrated Finite Element Analyst Berkeley, California, USA.