Review Article

Open Access

Multiplication bending moment factor for AASHTO live Loads adopted in Jordan

Abstract

The live load in the American Association of State Highway and Transportation Officials (AASHTO) is used in the design of bridges in Jordan. AASHTO LFD live loads is multiplied by 1.8 and used in Jordan to encounter the unexpected heavy live loads running on these bridges. The new code AASHTO LRFD for live loads is also used in the design of bridges. A Comparison between the bending moment obtained by 1.8 LFD live loads, and LRFD live loads were carried out to determine the coefficient which should the LRFD live loads be multiplied to give the same moment as 1.8 LFD live loads produced. A Comparison of 1.8 AASHTO LFD and AASHTO LRFD live loads for the bending moment of simply supported 30m 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.

This result will be used for the design of highway bridges in Jordan, and it will be a reference number for the Arab Countries also for such subject.

Keywords: AASHTO specification, AASHTO LRFD, AASHTO LFD, loadings, bridges, highway

Volume 4 Issue 2 - 2018

Samih Qaqish
Ex–Dean Faculty of Engineering, University of Jordan, Jordan

Correspondence: Samih Qaqish, Ex–Dean Faculty of Engineering, University of Jordan, Amman, Jordan, Tel: +962–777–427–511, Email samihkakish@yahoo.com

Received: November 20, 2017 | **Published:** April 23, 2018

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 bridges. Qaqish[7] presented stress distribution at the corners of skew bridges. Qaqish[8] illustrated a Comparison between one dimensional and three–dimensional models of one span box Girder Bridge. Qaqish[9] illustrated a Comparison between one dimensional and three–dimensional models of two continuous spans of 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 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 design code. Leahy[14] examined the HL–93 current bridge traffic load model in the United States. Li[15] studied a three–dimensional nonlinear dynamic analysis framework for RC bridges based on the force analogy method (FAM).[16]

Live loads

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

While the Dynamic load allowance is considered 33% for LRFD.

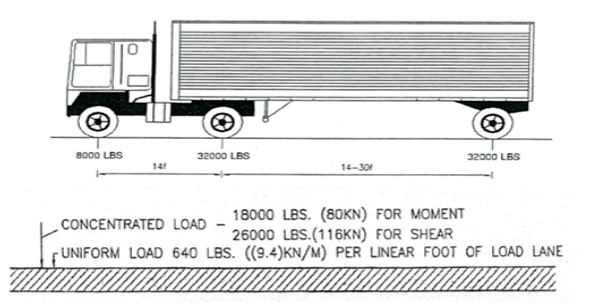

Figure 1 Truck HS20–44 and equivalent.

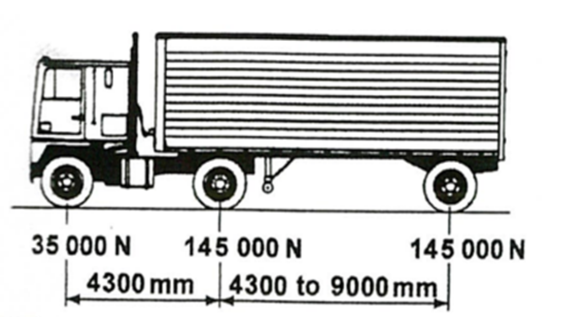

Figure 2(A) Truck loading of HL–93.

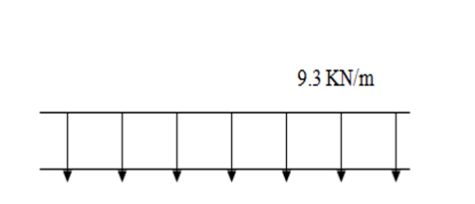

Figure 2(B) Distributed HL–93 loading.

Structural idealization

Figure 3 shows the plan of bridge, section A–A, and section B–B. The span of the bridges is 30m with two lanes, one lane in each direction. Box Type Bridge is considered with 7.8 m total width and 2.2 m total depth.

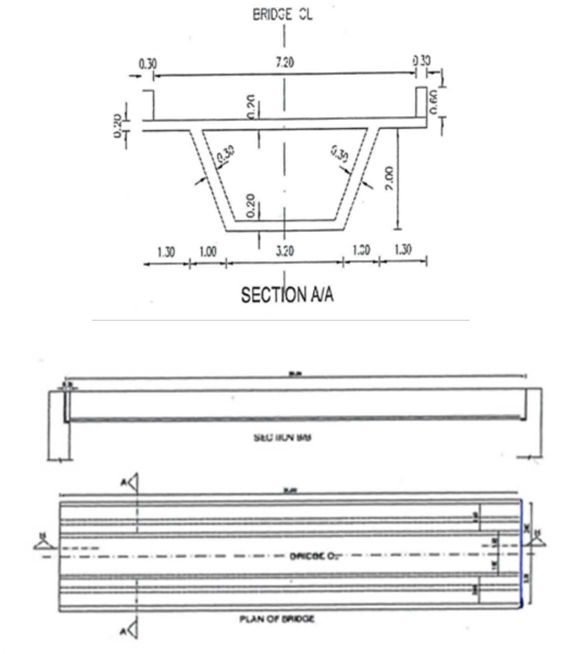

Figure 3 Plan and sections A–A and B–B of the Bridge.

Moment due to HS20–44

Maximum positive moment (Figure 4).

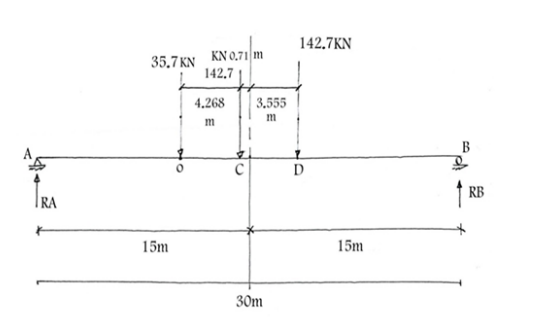

Figure 4 Truck Hs 20–44 location for Max moment.

$$\Sigma MB = 0.0$$

$$R_A \times 30 = 35.7 \times 19.978 + 142.7 \times 142.7 \times 11.445$$

$$R_A = (713.22 + 2241.817 + 1633.2) / 30$$

$$R_A = 152.94KN$$

$$R_B = 168.16KN$$

Max. moment at C

$$M_C = 152.94 \times 14.29 - 35.7 \times 4.268$$

$$= 2185.5 - 152.4 = 2033.1KN.m$$

$$\text{Impact Factor} = \frac{50}{L+125} = \frac{50}{3.28 \times 30 + 125} = 22.4\%$$

Total live load bending moment = 2 x 2033.1 x 1.224 =4977.029 kN.m

Equivalent uniform load (HS 20–44)

Figure 5 shows the maximum moment due to equivalent uniform loadings of HS 20–44.

$$\text{Bending moment at C} = \frac{WL^2}{8} + \frac{PL}{4} = \frac{9.37 \times 30^2}{8} + \frac{80.345 \times 30}{4}$$

$$= 1054.125 + 602.59 \;\; = 165.7125$$

Total live equivalent bending moment = 2 x 1656.7125 x 1.224 = 4055.63 KN.m

So the bending moment due to the Truck Loading HS 20–44 governs and it's value 4977.029 KN.m.

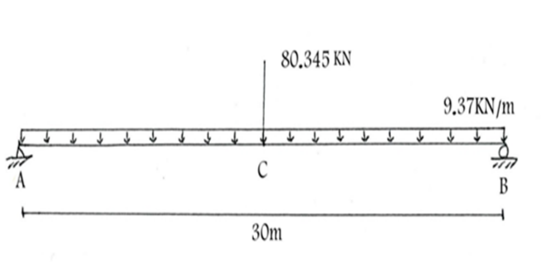

Figure 5 Equivalent uniform load for HS 20–44.

LRFD

Bending moment due to truck loading

Figure 6 shows the location of HL– 93 Truck loading to give maximum moment at point O.

$$R_A \times 30 = 35 \times 20.01 + 145 \times 15.71 + 145 \times 11.41$$

$$= 700.35 + 2277.95 + 1654.45$$

$$R_A = 154.425K$$

$$\text{Moment at O} = 154.425 \times 14.29 - 35 \times 4.3$$

$$= 2206.73 - 150.5$$

$$= 2056.23 \text{ KN.m.}$$

Citation: Qaqish S. Multiplication bending moment factor for AASHTO live Loads adopted in Jordan. *MOJ Civil Eng.* 2018;4(2):104–107.
DOI: 10.15406/mojce.2018.04.00105

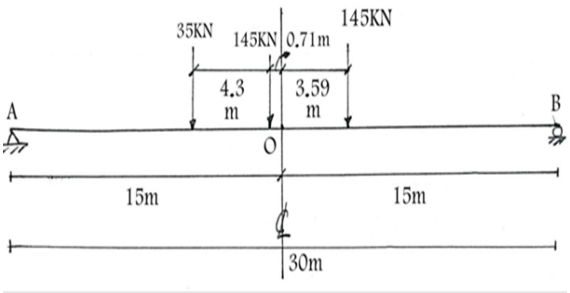

Figure 6 Truck HL–93 location for max. moment.

Bending moment due to distributed load

Figure 7 shows the maximum moment due to uniform loading of HL–93 loading.

$$\text{Bending moment at O} = 1043.67\ \text{KN. m.}$$

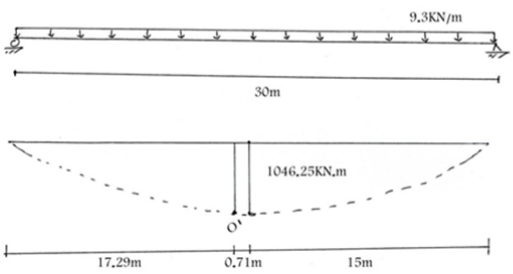

Figure 7 Moment due to additional uniform loading of HL–93.

Total live bending moment

$$(2056.23 + 1043.67) \times 2 \times 1.33 = 8245.734\ \text{KN. m.}$$

Where 33% is the impact factor, and it is calculated for two lanes.

Dead load

Bending moment due to own weight of the bridge

$$\text{Own weight of bridge} = 7.8 \times 0.2 \times 25 + 0.6 \times 0.3 \times 2 \times 25 + 2.24 \times 0.3 \times 25 \times 2 + 3.2 \times 0.2 \times 25 = 97.6\ \text{KN/m}$$

$$\text{Own weight of wearing surface} = 3.6 \times 2 \times 0.05 \times 21 = 7.56\ \text{KN. m}$$

Total Bending moment due to Dead load + Live load

LFD

B. M. due to own weight of the bridge

$$\frac{7.56 \times 30^2}{8} = 850.5\text{KN.m}$$

B.M. due to wearing surface

$$\frac{7.56 \times 30^2}{8} = 850.5\text{KN.m}$$

The truck loading is multiplied by 1.8 to encounter the unexpected traffic loading:

$$\text{Total B.M} = 1.3(\text{Moment D.L} + \text{Moment L.L.} \times 1.67)$$

$$= 1.3(11830.5 + 1.67 \times 1.8 \times 4977.029)$$

$$= 34828.89\ \text{KN. m. Total B.M} = 1.3$$

LRFD

$$\text{Total B. M.} = 1.25 \times \text{M. D. L.} + 1.5 \text{ x M W.S.} + 1.35 \times \text{ML.L}$$

$$= 1.25 \times 10980 + 1.5 \times 850.5 + 1.35 \times 8245.734$$

$$= 13725 + 1275.75 + 11131.74$$

$$= 26132.49\ \text{KN. m.}$$

So the factor to make the bending moment due to LFD equal to LRFD is:

$$\text{Factor Equal} = \frac{34828.89}{26132.49} = 1.33$$

So the live loads for LRFD should be multiplied by 1.33 to make the bending moment due to 1.8 HS 20–44 equal to the moment due to LRFD loadings.

Finite element analysis was carried out for the bridge using CSi bridge software (16), and the results are:

Total B. M. (LFD) 36332 KN. m.

Total B. M. (LRFD) 27995 KN. m.

$$\text{Factor} = \frac{36332}{27995} = 1.3$$

So it can be noticed that the factor from the structural calculations and the Csibridge is almost identical, and it is recommended to use 1.35 as a factor.

Conclusion

The live loads for LRFD designated as HL–93 which consist of design truck or design tandem and design lane load should be multiplied by 1.35 to encounter the unexpected traffic loading in Jordan and to be equivalent to 1.8 HS 20–44 LFD which is adopted in design bridges in Jordan to get the same bending moment for LFD and LRFD. This result will be used in Jordan for designing bridges after will be adopted in the Ministry of Public works and Housing.

Acknowledgements

None.

Conflict of interest

The author declare there is no conflict of interest.

References

1. American Association of State Highway and Transpiration Officials, AASHTO. Standard Specification for Highway Bridges. 17th ed. Washington, USA; 2002.
2. American Association of State Highway and Transportation Officials, AASHTO LRFD, Washington, USA; 2007.
3. Ministry of Public Works and Housing, Axle–Wight Records. Jordan; 1998.
4. Ministry of Transportation, A Report on Gross – Vehicle Weights on The Jordanian Road Network for the Year 1993. Jordan; 1993.

Citation: Qaqish S. Multiplication bending moment factor for AASHTO live Loads adopted in Jordan. *MOJ Civil Eng.* 2018;4(2):104–107.
DOI: 10.15406/mojce.2018.04.00105

5. Al–Foqaha'a A. Study of Recent Loading Adopted for Bridge Design in Jordan. M. Sc, Thesis, University of Jordan, Amman, Jordan; 1994 .
6. Qaqish S. Load Capacity Evaluation of T–Beam Bridges. Kerensky conference on Global trends in Structural Engineering 20–22, India; 1994.
7. Qaqish S. Stress Distribution at the Corners of Skew Bridges. 13th America Society of Civil Engineering, Engineering Mechanics Division, Baltimore, USA, 1999:13–16.
8. Qaqish S. Comparison between One Dimensional and Three Dimensional Models of Box Girder Bridge. 1st International Structural Specialty Conference, Canadian society for Civil Engineering, Calgary, Alberta, Canada; 2005.
9. Qaqish S. Comparison between One Dimensional and Three Dimensional Models of Two Continuous Spans of Box Girder Bridges. International conference on construction and building technology, Malaysia; 2008.
10. Qaqish S. Finite Element Analysis of Two Continuous Skew Spans of Box Girder Bridge and the Reaction Distribution at the Edges with 49 Degrees Skew Angle. Orlando International Engineering Education Conference, USA; 2012.
11. Campisi P. Review of Load Rating Highway Bridges. In Accordance with Load and Resistance Factor Rating Method by Lubin Gao. *J. Bridge Eng. ASCE*. 2015;20(2).
12. Deng L, He W, Shao Y. Dynamic Impact Factors for Shear and Bending Moment of Simply Supported and Continuous Concrete Girder Bridges. *J Bridge Eng, ASCE*. 2015;20(11).
13. Deng L, Wang F. Impact Factors of Simply Supported Prestressed Concrete Girder Bridges due to Vehicle Breaking. J. Bridge Eng., ASCE. 2015;20(11).
14. Leahy C, Brien O, Enright B, et al. Review of HL–93 Bridge Traffic Load Model Using an Extensive WIM Database. *J. Bridge Eng ASCE*. 2015;20(10).
15. Li G, Zhang Y, Li H. Nonlinear Seismic Analysis of Reinforced Concrete Bridges Using the Force Analogy Method. *J. Bridge Eng ASCE*. 2015;20(10).
16. Computers and Structures. SAP 2000, Version 7.0, Integrated Finite Element Analysis and Design of Structures, Berkeley, California, USA; 1998.

Citation: Qaqish S. Multiplication bending moment factor for AASHTO live Loads adopted in Jordan. *MOJ Civil Eng.* 2018;4(2):104–107.
DOI: 10.15406/mojce.2018.04.00105