Introduction

AASHTO LFD 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 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

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.

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

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:

\[ \text{Impact Factor} = \text{Dynamic Load Allowance} \times \text{Static Load Factor} \]

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.

\[ \Sigma MB = 0.0 \]

\[ R_A \times 30 = 35.7 \times 19.978 + 142.7 \times 142.7 \times 11.445 \]

\[ R_A = (713.22 + 2241.817 + 1633.2) / 30 \]

\[ R_A = 152.94 \text{KN} \]

\[ R_B = 168.16 \text{KN} \]

Max. moment at C

\[ M_C = 152.94 \times 14.29 - 35.7 \times 4.268 \]

\[ = 2185.5 - 152.4 = 2033.1 \text{KN.m} \]

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

Total live load bending moment = \[ 2 \times 2033.1 \times 1.224 = 4977.029 \text{KN.m} \]

**Equivalent uniform load (HS 20–44)**

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

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

\[ = 1054.125 + 602.59 = 1657.125 \text{KN.m} \]

Total live equivalent bending moment = \[ 2 \times 1657.125 \times 1.224 = 4055.63 \text{KN.m} \]

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.

\[ R_A \times 30 = 35 \times 20.01 + 145 \times 15.71 + 145 \times 11.41 \]

\[ = 700.35 + 2277.95 + 1654.45 \]

\[ R_A = 154.425 \text{K} \]

Moment at O = \[ 154.425 \times 14.29 - 35 \times 4.3 \]

\[ = 2206.73 - 150.5 \]

\[ = 2056.23 \text{KN.m} \]
Multiplication bending moment factor for AASHTO live Loads adopted in Jordan

1. **Multiplication bending moment factor for AASHTO live Loads adopted in Jordan**

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3. **LRFD**

   Total B. M. \(= 1.25 \times \text{M. D. L.} \times 1.5 \times \text{M. W. S.} \times 1.35 \times \text{ML. L.} \)
   \[= 1.25 \times 10980 + 1.5 \times 850.5 + 1.35 \times 8245.734 \]
   \[= 13725 + 1275.75 + 11131.74 \]
   \[= 26132.49 \text{ KN. m.} \]

   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.

4. **Finite element analysis was carried out for the bridge using CSI bridge software (16), and the results are:**

   Total B. M. (LRFD) \(= 27995 \text{ KN. m.} \)
   Total B. M. (LFD) \(= 36332 \text{ KN. m.} \)
   Factor = \(\frac{34828.89}{27995} = 1.25\)

   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.

5. **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.

6. **Acknowledgements**

   None.

7. **Conflict of interest**

   The author declare there is no conflict of interest.

8. **References**

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