Development of the HL-93 Notional Live Load Model

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The development of probability-based design specifications, in the form of the *AASHTO LRFD Bridge Design Specifications*, highlighted the need for an updated live load model for the design of our nation's highway bridges. The HS20-44 live load model of the *AASHTO Standard Specifications for Highway Bridges* served the bridge-design community well since its original adoption in 1944, but the calibration of the LRFD Specifications revealed its shortcomings. In calibration, the uncertainties of loads and resistances are used to develop load and resistance factors, which result in uniform reliability for the various load combinations of the LRFD Specifications. These uncertainties are quantified as a bias and coefficient of variation for each load and resistance.

For the live load, the bias is the relationship between the most likely live load a bridge will experience in terms of moment and shear and the predicted live load from the design model. The coefficient of variation reflects the spread of the distribution of the live load moments and shears that the bridge is expected to experience.

The bias must be relatively constant over all span lengths for a single live load factor to be used for all span lengths. The bias of the HS20-44 live load model is illustrated in Figure 1 taken from the commentary for Article 3.6.1.2.1 of the LRFD Specifications. In this figure, various moment ratios (simple-span positive moments and positive and negative moments along continuous spans) are plotted for span lengths from zero to 150 ft. The moment ratios are the moments due to heavy trucks on our nation's highways today divided by the moments due to the HS20-44 live load model.

To calibrate the specifications to yield uniform reliability over all span lengths, a varying load factor would need to be applied to the HS20-44 live load model as the ratios tend to grow with increasing span length. Clearly, this solution would have been less than ideal. Thus, a new live load model was developed for the LRFD Specifications.

By chance, a superposition of components of the HS20-44 live load model combining vehicles and lane load produced more uniform moment ratios, or a more constant bias, over all span lengths. Trial and error revealed this elegant solution to defining the live load. Thus, the HL-93 notional live load model of Article 3.6.1.2 of the LRFD Specifications was born.

Figure 2, taken again from the commentary for Article 3.6.1.2.1 of the LRFD Specifications, illustrates the bias of the HL-93 notional live load model of the LRFD Specifications. The model is termed a "notional" model as it is not simply a truck but a superposition of vehicular and lane loads that approximates the moments and shears of a heavier truck.

The moment ratios for the HL-93 notional live load model now cluster much more closely around a single value of one. Thus, the bias is more uniform across all span lengths and the calibration can be accomplished with a constant load factor.

Future articles will continue the discussion of the development and application of the HL-93 notional live load model.

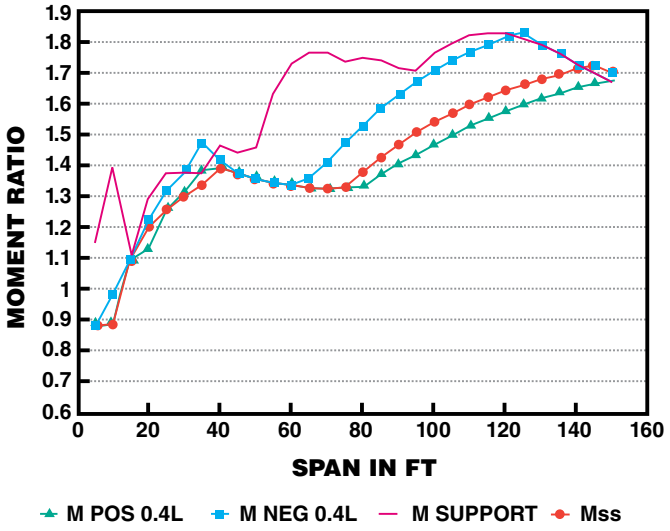

Figure 1 – Comparison of Truck Moments to HS20-44 Moments.

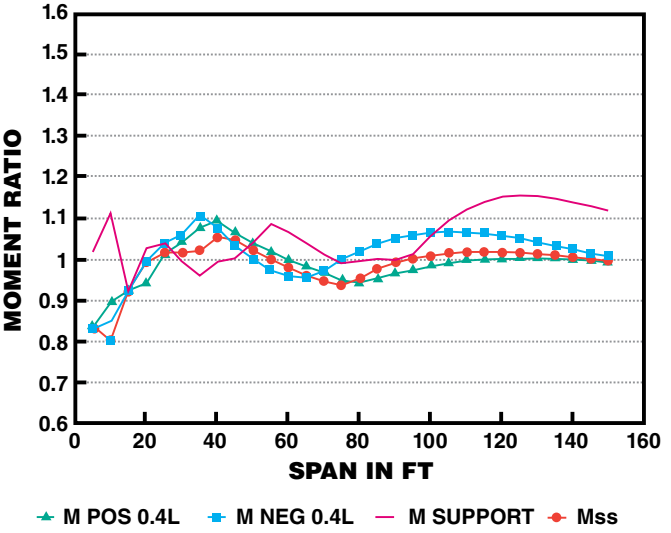

Figure 2 – Comparison of Truck Moments to HL-93 Moments.