DISCUSSION

A Technical Note: Derivation of the LRFD Column Design Equations

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The information presented by the author on the background and development of the LRFD column design equations is much appreciated. This discussion pertains to physical justifications of the equations and an issue related to the classroom teaching of column design. A common practice in teaching the design of a particular type of structural member (tension, compression, flexural, etc), is to first describe, qualitatively, the behavior and limit states of the member, then proceed to develop analytical predictions using basic mechanics of materials principles. The predictions, together with the available experimental and/or numerical results are then used to explain the applicable design provisions, as they are approximations or simplifications to the analytical predictions. This process provides the students with a good appreciation of the provisions. This however, is not the case for column design using the LRFD equations.

The column equations were developed as a reasonable lower bound to over 300 column test results (Tide, 1985) and provide column strength predictions close to the probability-based SSRC column curve 2P (Bjorhovde, 1972; SSRC, 1976; Iwankiw, 1985). Conceptually, they do not represent the strength of any particular column. However, studies have shown that it does provide good predictions of the strength of an initially crooked, as rolled, A36 steel W8×31 column having a small end restraint and failing by flexural instability about its minor axis. A comparison of the LRFD equations with the analytically calculated curve for this column is given in Figure 1. The curve was developed using a numerical procedure presented by Shen and Lu (1983). The calculations were based on the Lehigh type linear residual stress distribution with a maximum flange tip compressive stress of 0.3 F_y. The initial crookedness was assumed to be a sine curve with a maximum value v_m = L/1500, where L is the column length. This value is close to the statistical mean of the measured crookednesses (Bjorhovde, 1972). Equal end restraint with a rotational stiffness equal to 0.1EI/L, where EI is the flexural stiffness of the column about its minor axis, was assumed. The curve was calculated directly for the initially crooked column with the assumed end restraint and no use was made of any effective length factor, K, which is valid only for initially straight columns. However, as a convenient reference, the K value of this column (if it is initially straight and buckles elastically) is 0.98. Other wide flange columns having similar yield stress, initial crookedness and end restraint have approximately the same predicted strengths. This curve also gives conservative estimates of the strengths of a variety of other columns (columns failing by instability about the major axis, high strength steel columns, box columns, etc.).

In the classrooms, this information can be presented to the students before explaining the probabilistic nature of

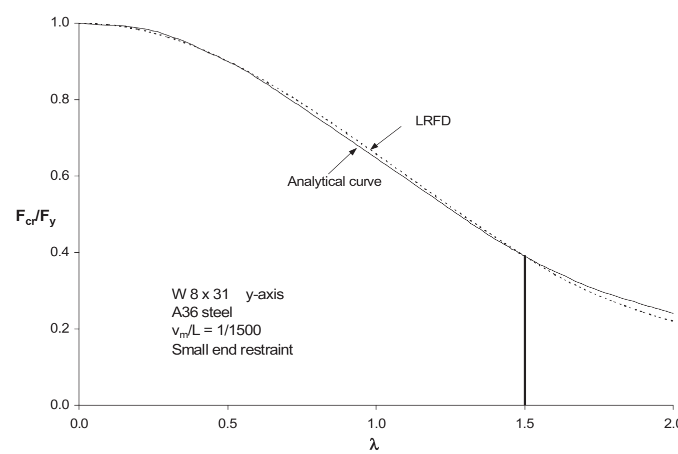

Fig. 1. Comparison of column strength curves.

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column strength and the LRFD equations. This helps the students develop a better understanding and appreciation of the design provisions.

REFERENCES

Bjorhovde, R. (1972), "Deterministic and Probabilistic Approaches to the Strength of Steel Columns," Ph.D. Dissertation, Lehigh University, May.

Iwankiw, N.R. (1985), "The AISC November 7 Column Formula," *Proceedings, Annual Technical Session*, Structural Stability Research Council, April, pp. 33-34.

Shen, Z.-Y. and Lu, L.-W. (1983), "Analysis of Initially Crooked, End Restrained Columns," *Journal of Constructional Steel Research*, Vol. 3, No. 1, pp. 10-18.

Structural Stability Research Council (SSRC) (1976), *Guide to Design Criteria for Metal Compression Members*, 3rd edition, edited by Bruce G. Johnston, John Wiley and Sons.

Tide, R.H.R. (1985), "Reasonable Column Design Equations," *Proceedings, Annual Technical Session*, Structural Stability Research Council, April, pp. 47-55.