Discussion

The Effective Length of Columns in Unbraced Frames

Paper presented by JOSEPH A. YURA (April 1971 issue)

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IN PREVIOUS discussion to this April 1971 paper, questions were raised dealing with the applicability of the inelastic effective length factor in the interaction equation for beam-columns, Formula (1.6-1a) of the AISC Specification. It was recommended that the inelastic effective length be used in evaluating F_a, but that the elastic effective length be used in calculating F_e'. No mathematical data were provided to support this recommendation, so the purpose of this discussion is to present such data.

Formula (1.6-1a) is based on the following interaction equation:

$$\frac{P}{P_{cr}} + \frac{C_m M}{\left(1 - \dfrac{P}{P_e}\right) M_p} = 1.0 \qquad (1)$$

for beam columns with lateral bracing (no out-of-plane buckling). Equation (1) cannot be derived directly from material strength and stress conditions; rather, its applicability has been verified by comparisons with reasonably exact theoretical solutions and test results. Based on a theoretical study of unbraced single-story frames,[1] it was established that Eq. (1) produced safe, reasonable results if the effective length factor for the sidesway permitted case was used in calculating P_{cr} and P_e, and C_m was chosen as 0.85. The comparisons are reproduced in Figs. 1a and 1b, which show that the interaction equation generally underestimates the actual strength of the frame. In Fig. 1, $P_y = AF_y$ and Q_p is the lateral load producing simple plastic failure neglecting axial loads.

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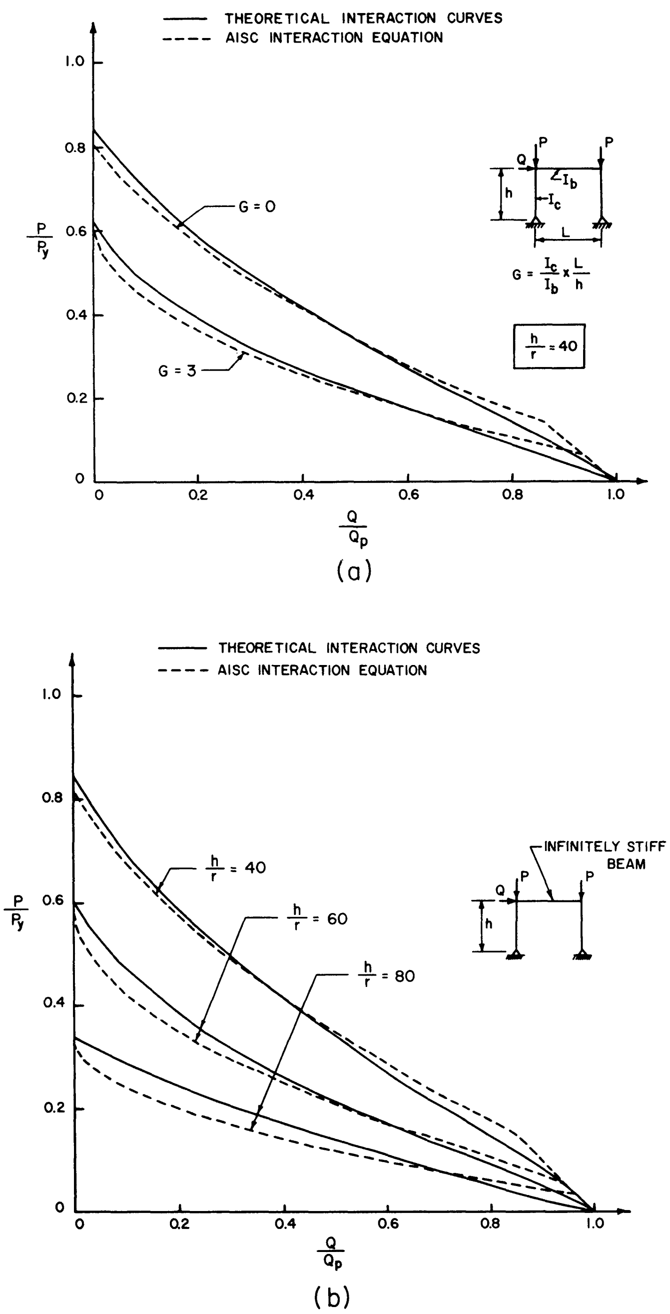

Fig. 1. Frame behavior in the elastic range

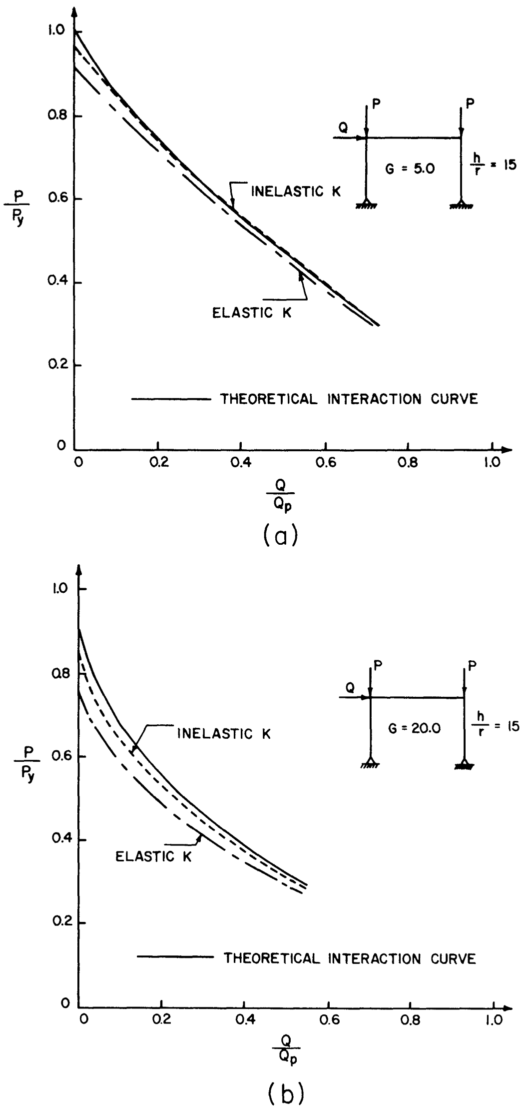

Fig. 2. Frame behavior with columns in the inelastic range

Unfortunately, the cases shown in Fig. 1 use either elastic effective length factors or a value of 2.0 corresponding to the infinitely stiff beam case. Neither of these situations provide any data related to the use of inelastic effective length factors. Consequently the frames shown in Fig. 2 have been solved in which the columns are in the inelastic range. The two cases shown in Fig. 2 were chosen to provide a wide range of G values and a significant difference between the elastic and inelastic effective length factors. For $G = 5.0$, $K_{elastic} = 3.4$ and $K_{inelastic} = 2.3$; for $G = 20.0$, $K_{elastic} = 6.0$ and $K_{inelastic} = 4.5$. The comparisons of Eq. (1) using both elastic and inelastic effective length factors in the first term with the theoretical solution based on the Lehigh Subassemblage Design Charts[2] show that the solution with $K_{inelastic}$ produces conservative results which are in better agreement with the theory.

REFERENCES

1. *Yura, J. A. and Galambos, T. V.* Strength of Single-Story Steel Frames *Journal of the Structural Division, ASCE, Vol. 91, ST5, October 1965.*
2. *Daniels, J. H. and Lu, L. W.* Design Charts for the Sway Subassemblage Method of Designing Unbraced Multi-Story Frames *Report No. 273.54, Fritz Engineering Laboratory, Lehigh University, December 1966.*