STEEL INTERCHANGE

Steel Interchange is an open forum for *Modern Steel Construction* readers to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Opinions and suggestions are welcome on any subject covered in this magazine. If you have a question or problem that your fellow readers might help you to solve, please forward it to *Modern Steel Construction*. At the same time, feel free to respond to any of the questions that you have read here. Please send them to:

Steel Interchange
Modern Steel Construction
One East Wacker Dr., Suite 3100
Chicago, IL 60601-2001

Answers and/or questions should be typewritten and double-spaced. Submittals that have been prepared by word-processing are appreciated on computer diskette (either as a Wordperfect file or in ASCII format).

The opinions expressed in *Steel Interchange* do not necessarily represent an official position of the American Institute of Steel Construction, Inc. and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer, architect or other licensed professional for the application of principals to a particular structure.

Information on ordering AISC publications mentioned in this article can be obtained by calling AISC at 800/644-2400.

*** * * * Questions and answers can now be e-mailed to: newman@aiscmail.com * * * ***

The following responses from previous Steel Interchange columns have been received:

What is the in-plane effective length factor for each column of the frame assuming: a) the beam to be continuous but not rigidly connected to the center column? And b) the beam to be discontinuous at the center column with simple connections to it?

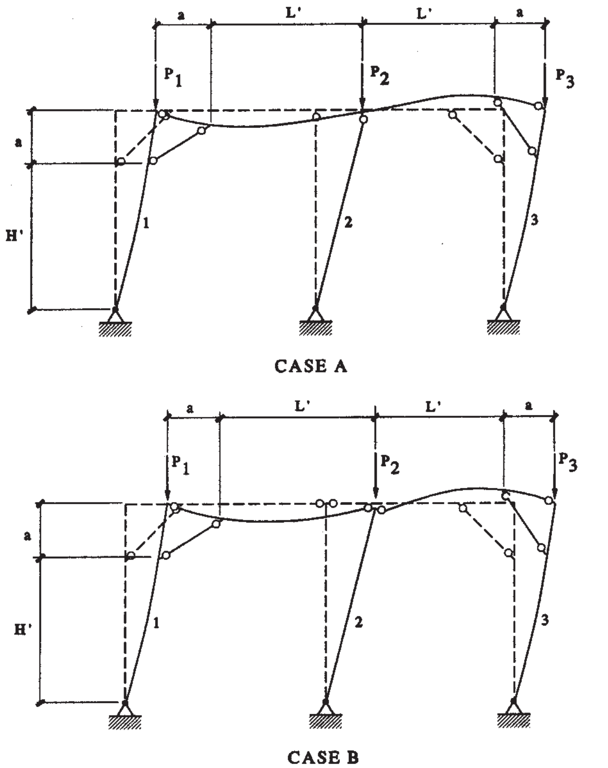

Figure 1

Complications that arise in the determination of the effective length factors for these frame configurations result from two sources; 1.) the center leaning column and 2.) the "knee braces or kickers" located at the exterior columns. Fortunately, both can be overcome using a modified alignment chart procedure proposed by LeMessurier (1977) and the assumption that the dimension *"a"* is small compared to the length of the girders and columns. The assumption of small *"a"* is adequate as kickers are used in bays where full diagonal or x-bracing is not possible. In these instances, *"a"* is usually forced to be small as a result of clearance issues.

The derivation of the alignment chart includes several assumptions violated by the configurations described. In order to elaborate on the problem further, we must look at an approximated buckled shape of the frame (in sway mode) assuming that the axial loads in all columns come from concentrated loads applied directly to the joints. The sway buckled shapes of both configurations are shown in Figure 1.

First of all, the beams in the buckled shapes do not deform in double curvature between framing columns as assumed in the derivation of the alignment chart. Secondly, the leaning column (center column) does not contribute to lateral sway stability resistence of the frame. Furthermore, it should be noted in both Case A and Case B that the buckled configuration of the beam in the frames is the same.

In order to use LeMessurier's(1977) method for computation of K-factors where leaning columns exist, we need to define modified beam and column lengths as,

$$L' = L - a \qquad H' = H - a$$

It is assumed in these definitions that the "knee-brace" region of the frame acts as rigid element and the bending lengths of the column and beam within this region can be ignored. Lastly, it is assumed that the beam is of uniform cross-section.

Having setup the problem's assumptions we can now proceed with implementation of LeMessurier's method for columns 1 and 3 in Figure 1. Column 2 will have an effective length factor of 1.0. The method incorporates the the formulas shown on the following page:

Column One:

$$K_i^2 = \frac{I_i}{P_i}\pi^2\left[\frac{\Sigma P + \Sigma(C_L P)}{\Sigma(\beta I)}\right]$$

$$C_{Li} = \frac{\beta_i K_{ni}^2}{\pi^2} - 1$$

$$\beta_i = \frac{6\left(G_{top,i} + G_{bot,i}\right) + 36}{2\left(G_{top,i} + G_{bot,i}\right) + G_{top,i}G_{bot,i} + 3}$$

Column Two:

$$\Sigma(C_L P) = C_{L1}P_1 + C_{L3}P_3$$

$$\Sigma(\beta I) = \beta_1 I_1 + \beta_3 I_3$$

$$\Sigma P = P_1 + P_2 + P_3$$

where i refers to the column under consideration (1 or 3 in this case). The G factors for the top and bottom of a column can be found in the usual manner with modification to account for the fact that the beam(s) between the columns bend in single curvature in the buckled configuration. Therefore,

$$G_{top,i} = \frac{\dfrac{I_i}{H'}}{\dfrac{I_{beam}}{2L'}}$$

$G_{bot,i} = \infty$ (theoretical for pinned base)

$G_{bot,i} = 10$ (practical value for pinned base)

It should be noted that the $2L'$ in the denominator of G_{top} accounts for single curvature bending in the beam. K_{ni} is the effective length factor obtained from the alignment chart (sidesway allowed) in the normal manner using the G-factors as computed above.

Reference

LeMessurier, W.J. (1977) "A Practical Method of Second Order Analysis, Part 2 - Rigid Frames", *Engineering Journal*, AISC, Second Quarter, 1977.

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How does one design a stepped column?

Chapter 20, "Column Design" of AISC Steel Design Guide Series #7, *Industrial Buildings: Roofs to Column Anchorage* provides design methods and procedures for stepped columns. It shows how to obtain the final forces and moments and how to use AISC equations for the final column design.

Appendix B provides an information required to calculate effective length of stepped columns.

Example 20.3.2 shows actual steps in design of stepped crane column.

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New Questions

Listed below are questions that we would like the readers to answer or discuss.

If you have an answer or suggestion please send it to the Steel Interchange Editor, Modern Steel Construction, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001. Questions can also be sent via e-mail to newman@aiscmail.com.

Questions and responses will be printed in future editions of Steel Interchange. Also, if you have a question or problem that readers might help solve, send these to the Steel Interchange Editor.

AISC Commentary Chapter F of the *Specification for Structural Steel Buildings*, section F1.3, provides equation C-F1-1 for determining an equivalent radius of gyration, r_T, for use in determining allowable strong axis bending stresses according to Eq. F1-6 and F1-7. Can this equation be used any time or are there restrictions?

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What is the design basis for seat angles in seated beam connections in the AISC *Manual of Steel Construction*? What would the capacity be for an angle length other than 6" or 8"? Are shorter angle lengths permissible? Is it permissible to lacate the top angle in the optional location, shop-weld it to the beam, and field bolt it to the column with a single bolt?

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