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CODE

6.6.4.5.4 M_2 in Eq. (6.6.4.5.1) shall be at least $M_{2,min}$ calculated according to Eq. (6.6.4.5.4) about each axis separately.

$$M_{2,min} = P_u(15 + 0.03h) \qquad (6.6.4.5.4)$$

If $M_{2,min}$ exceeds M_2, C_m shall be taken equal to 1.0 or calculated based on the ratio of the calculated end moments M_1/M_2, using Eq. (6.6.4.5.3a).

COMMENTARY

R6.6.4.5.4 In the Code, slenderness is accounted for by magnifying the column end moments. If the factored column moments are small or zero, the design of slender columns should be based on the minimum eccentricity provided in Eq. (6.6.4.5.4). It is not intended that the minimum eccentricity be applied about both axes simultaneously.

The factored column end moments from the structural analysis are used in Eq. (6.6.4.5.3a) in determining the ratio M_1/M_2 for the column when the design is based on the minimum eccentricity. This eliminates what would otherwise be a discontinuity between columns with calculated eccentricities less than the minimum eccentricity and columns with calculated eccentricities equal to or greater than the minimum eccentricity.

6.6.4.6 *Moment magnification method: Sway frames*

6.6.4.6.1 Moments M_1 and M_2 at the ends of an individual column shall be calculated by (a) and (b).

(a) $M_1 = M_{1ns} + \delta_s M_{1s}$ (6.6.4.6.1a)

(b) $M_2 = M_{2ns} + \delta_s M_{2s}$ (6.6.4.6.1b)

6.6.4.6.2 The moment magnifier δ_s shall be calculated by (a), (b), or (c). If δ_s exceeds 1.5, only (b) or (c) shall be permitted:

(a) $\delta_s = \dfrac{1}{1-Q} \geq 1$ (6.6.4.6.2a)

(b) $\delta_s = \dfrac{1}{1-\dfrac{\Sigma P_u}{0.75\Sigma P_c}} \geq 1$ (6.6.4.6.2b)

(c) Second-order elastic analysis

where $\sum P_u$ is the summation of all the factored vertical loads in a story and $\sum P_c$ is the summation for all sway-resisting columns in a story. P_c is calculated using Eq. (6.6.4.4.2) with k determined for sway members from 6.6.4.4.3 and $(EI)_{eff}$ from 6.6.4.4.4 with β_{ds} substituted for β_{dns}.

R6.6.4.6 *Moment magnification method: Sway frames*

R6.6.4.6.1 The analysis described in this section deals only with plane frames subjected to loads causing deflections in that plane. If the lateral load deflections involve significant torsional displacement, the moment magnification in the columns farthest from the center of twist may be underestimated by the moment magnifier procedure. In such cases, a three-dimensional second-order analysis should be used.

R6.6.4.6.2 Three different methods are allowed for calculating the moment magnifier. These approaches include the Q method, the sum of P concept, and second-order elastic analysis.

(a) Q method:

The iterative $P\Delta$ analysis for second-order moments can be represented by an infinite series. The solution of this series is given by Eq. (6.6.4.6.2a) (MacGregor and Hage 1977). Lai and MacGregor (1983) show that Eq. (6.6.4.6.2a) closely predicts the second-order moments in a sway frame until δ_s exceeds 1.5.

The $P\Delta$ moment diagrams for deflected columns are curved, with Δ related to the deflected shape of the columns. Equation (6.6.4.6.2a) and most commercially available second-order frame analyses have been derived assuming that the $P\Delta$ moments result from equal and opposite forces of $P\Delta/\ell_c$ applied at the bottom and top of the story. These forces give a straight-line $P\Delta$ moment diagram. The curved $P\Delta$ moment diagrams lead to lateral displacements on the order of 15 percent larger than those from the straight-line $P\Delta$ moment diagrams. This effect can be included in Eq. (6.6.4.6.2a) by writing the denominator as $(1 - 1.15Q)$ rather than $(1 - Q)$. The 1.15 factor has been omitted from Eq. (6.6.4.6.2a) for simplicity.

If deflections have been calculated using service loads, Q in Eq. (6.6.4.6.2a) should be calculated in the manner explained in R6.6.4.3.

The Q factor analysis is based on deflections calculated using the I values from 6.6.3.1.1, which include the equivalent