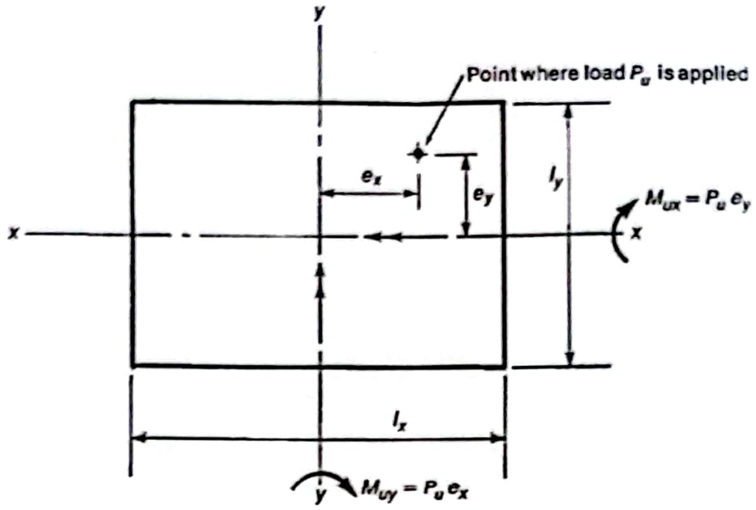
Design of Biaxially Load column

Equivalent Eccentricity Method



The equivalent eccentricity method. The biaxial eccentricities, e_x and e_y, can be replaced by an equivalent uniaxial eccentricity, e_{ox}, and the column designed for uniaxial bending and axial load. We shall define e_x as the component of the eccentricity parallel to the side l_x and the x-axis, as shown in Fig. above such that the moments, M_{uy}, and M_{ux}, are

$$M_{uy} = P_u e_x \qquad M_{ux} = P_u e_y \qquad \text{Eq. 01}$$

If

$$\frac{e_x}{\ell_x} \geq \frac{e_y}{\ell_y} \qquad \text{Eq. 02}$$

then the column can be designed for P_u and a factored moment $M_{oy} = P_u e_{ox}$, where

$$e_{ox} = e_x + \frac{\alpha e_y \ell_x}{\ell_y} \qquad \text{Eq. 03}$$

where for $P_u/f'_c A_g \leq 0.4$,

$$\alpha = \left(0.5 + \frac{P_u}{f'_c A_g}\right)\frac{f_y + 40{,}000}{100{,}000} \geq 0.6 \qquad \text{Eq. 04 (a)}$$

and for $P_u/f'_c A_g > 0.4$,

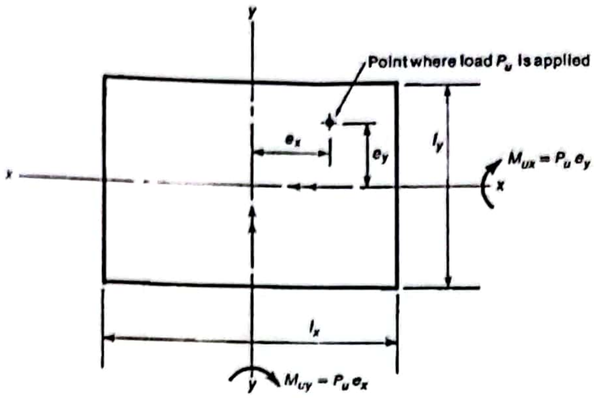
$$\alpha = \left(1.3 - \frac{P_u}{f'_c A_g}\right)\frac{f_y + 40{,}000}{100{,}000} \geq 0.5 \qquad \text{Eq. 04 (b)}$$

In Eq. 04, f_y is in psi. If the inequality in Eq. 02, is not satisfied, the definition of the x and y axes should be interchanged.

This procedure is limited in application to columns that are symmetrical about two axes with a ratio of side lengths, ℓ_x/ℓ_y, between 0.5 and 2.0. Reinforcement should be provided in all four faces of the column.

Design of Biaxially Load column

Equivalent Eccentricity Method



Select a tied column cross section to resist factored loads and moments of $P_u = 250$ kips, $M_{ux} = 55$ kip-ft, and $M_{uy} = 110$ kip-ft. Use $f_y = 60$ ksi and $f'_c = 4$ ksi.

1. Select a trial section. Assume that $\rho_g = 0.015$. Use a section with bars in the four faces, because the column is loaded biaxially. Then

$$A_{g(\text{trial})} \geq \frac{P_u}{0.40(f'_c + f_y\rho_g)}$$

$$\geq \frac{250}{0.40(4 + 60 \times 0.015)}$$

$$\geq 128 \text{ in.}^2 \text{ or } 11.3 \text{ in. square}$$

Because this column is subjected to biaxial bending, try a 16-in.-square column with eight No. 8 bars, three in each face.

2. Compute γ.

$$\gamma = \frac{(16 - 2 \times 2.5)}{16} = 0.69$$

3. Compute e_x, e_y, and e_{ox}. From the definition of the moments and eccentricities

$$e_x = \frac{M_{uy}}{P_u}$$

$$= \frac{110 \times 12}{250} = 5.28 \text{ in.}$$

$$e_y = \frac{M_{ux}}{P_u}$$

$$= \frac{55 \times 12}{250} = 2.64 \text{ in.}$$

By inspection, $e_x/\ell_x \geq e_y/\ell_y$; therefore, use Eq. 03 as given. If this were not true, you would transpose the x- and y-axes before using it. In any event, we have

$$\frac{P_u}{f'_c A_g} = \frac{250}{4 \times 256} = 0.244 < 0.4$$

Therefore, use Eq. 04 (a) to compute α:

$$\alpha = \left(0.5 + \frac{P_u}{f'_c A_g}\right)\left(\frac{f_y + 40{,}000}{100{,}000}\right)$$

$$= (0.5 + 0.244)\left(\frac{60{,}000 + 40{,}000}{100{,}000}\right)$$

$$= 0.744$$

$$e_{ox} = e_x + \frac{\alpha e_y \ell x}{\ell_y}$$

$$= \left(5.28 + 0.744 \times 2.64 \times \frac{16}{16}\right) = 7.24 \text{ in.}$$

Thus, the equivalent uniaxial moment is

$$M_{oy} = P_u e_{ox}$$

$$= 250 \times 7.24 = 1810 \text{ kip-in.}$$

The column is designed for uniaxial bending for $P_u = 250$ kips and the equivalent moment, $M_{oy} = 1810$ kip-in.

4. Use interaction diagrams to determine ρ_g. Because the column has biaxial bending, we will select a section with bars in four faces. The interaction diagrams are entered with

$$\frac{P_u}{A_g} = \frac{250}{256} = 0.977 \text{ ksi}$$

and

$$\frac{M_{oy}}{A_g h} = \frac{1810}{16^3} = 0.442 \text{ ksi}$$

From Figs. A-9a and A-9b,

$$\text{for } \gamma = 0.60,\ \rho_g = 0.025$$

$$\text{for } \gamma = 0.75,\ \rho_g = 0.018$$

By linear interpolation, $\rho_g = 0.021$ for $\gamma = 0.69$.

5. Compute A_{st} and select the reinforcement.

$$A_{st} = \rho_g A_g = 0.021 \times 256 = 5.38 \text{ in.}^2$$

Select eight No. 8 bars, three in each face, $A_{st} = 6.32$ in.^{2}. Design ties and lap splices as in earlier examples. ■