PROBLEM 4

In a three-story structure, an exterior column is to be designed for a service dead load of 222 kips, maximum live load of 297 kips, dead load moment of 136 ft-kips and live load moment of 194 ft-kips. The minimum live load compatible with the full live load moment is 166 kips, obtained when no live load is placed on the roof but a full live load is placed on the second floor. Architectural considerations require that a rectangular column be used, with dimensions $b = 20$ inch and $h = 25$ inch.

(*a*) Find the required column reinforcement for the condition that the full live load acts.
(*b*) Check to ensure that the column is adequate for the condition of no live load on the roof.
Assume material strengths are = 4 ksi and = 60 ksi.

For preliminary analysis or design of columns, special charts or tables may be used either to determine ϕP_n and ϕM_n for a given section or determine the steel requirement for a given load P_u and moment M_u. These charts and tables are published by the ACI, the Concrete Reinforcing

Steel Institute (CRSI), and the Portland Cement Association (PCA). Final design of columns must be based on statics by using manual calculations or computer programs.

SOLUTION

1. Determination of Factored Load

$P_u = 1.2 \times 222 + 1.6 \times 297 = 742$ kips.

2. Determination of Factored Moment

$M_u = 1.2 \times 136 + 1.6 \times 194 = 474$ ft-kips.

3. Selection of the Size of the Column

A column 20 inch × 25 inch is specified, and reinforcement distributed around the column perimeter will be used. Bar cover is estimated to be 2.5 inch from the column face to the steel centerline for each bar.

4. **Determination of Reinforcement Ratio,**

The column parameters (assuming bending about the strong axis) are

$$K_n = \frac{P_u}{\phi f_c' A_g} = \frac{742}{0.65 \times 4 \times 500} = 0.570$$

$$R_n = \frac{M_u}{\phi f_c' A_g h} = \frac{474 \times 12}{0.65 \times 4 \times 500 \times 25} = 0.175$$

With 2.5 inch cover, the parameter

For this column geometry and material strengths, Graph A.7 of Appendix A applies.

(*b*) With the roof live load absent, the column will carry a factored load $P_u = 1.2 \times 222 + 1.6 \times 166 = 532$ kips and factored moment $M_u = 474$ ft-kips, as before. Thus, the column parameters for this condition are

$$K_n = \frac{P_u}{\phi f'_c A_g} = \frac{532}{0.65 \times 4 \times 500} = 0.409$$

$$R_n = \frac{M_u}{\phi f'_c A_g h} = \frac{474 \times 12}{0.65 \times 4 \times 500 \times 25} = 0.175$$

and $\gamma = 0.80$ as before. From Graph A.7 it is found that a reinforcement ratio of $\rho_g = 0.017$ is sufficient for this condition, less than that required in part (a), so no modification is required.

Selecting No.3 (No.10) ties for trial, the maximum tie spacing must not exceed $48 \times 0.375 = 18$ inch, $16 \times 1.128 = 18.05$ inch, or 20 inch. Spacing is controlled by the diameter of the ties, and No. 3 (No. 10) ties will be used at 18 in. spacing, in the pattern shown in Figure below.

