3.13. Design of a Spiral Column

Design a spiral column to carry a dead load of 175 kips and a live load of 300 kips. The given loads are axial loads. Use 3000 psi concrete and 40,000 psi steel.

Assume zero eccentricity:

$$P_u = 1.2P_D + 1.6P_L$$

$$P_u = 1.2 \times 175 + 1.6 \times 300 = 690 \; kips$$

$$\text{assume } \rho_g = \frac{A_s}{A_g} = 0.02$$

From ACI318, section 10.3.5.1 (Equation 10–1) we have

$$P_u = (0.85)(\phi)[A_s f_y + 0.85 f_c'(A_g - A_s)]$$

or, factor out A_g from the bracket

$$P_u = (0.85)\,(\phi)\,(A_g)\,[\rho_g f_y + 0.85 f_c'(1 - \rho_g)]$$

for spiral columns $\Phi = 0.75$, therefore, we have

$$690 \; kips = (0.85)\,(0.70)\,(A_g)\,[0.02 \times 40\,(ksi) + 0.85 \times 3\,(ksi)(1 - 0.02)]$$

Solve for A_g

$$A_g = 352 \; in^2$$

$$A_g = \frac{\pi}{4} D_g^2 = 352 \; in^2 \qquad \rightarrow \qquad D_g = 21.18 \; in \quad [round \; 21.5 \; inches]$$

The required steel area is

$$A_s = \rho A_g = (0.02)(352) = 7.04 \; in^2$$

Try 12#7 (A_s = 7.22 in^2) bars.

3.13.1. Check Spacing Requirements

Use 1.5 in cover. The core diameter is (ACI 7.7.1)

$$21.5 - (2)\,(1\tfrac{1}{2}) = 18.5 \; in$$

Using #3 spiral wire, the steel diameter is

$$21.5 - (2)\,(1\tfrac{1}{2}) - (2)(\tfrac{3}{8}) - \tfrac{7}{8} = 16.875 \; in$$

The steel circumference is

$$\pi(16.875) \;=\; 53\ in$$

The clear spacing between bars is

$$\frac{53 \;-\; (12)(0.875)}{12} \;=\; 3.54\ in$$

Since 3.54 in > (1.5) d_b = (1.5) (0.875) = 1.31 in, this acceptable (ACI 7.6.3). In addition, the minimum amount of spiral reinforcement as given in Eq. 10–6 of ACI needs to be checked.

3.13.2. Check Minimum Steel Requirements for Spiral Steel

$$(\rho_s)_{\min} \;=\; 0.45\frac{f_c'}{f_y}\left[\frac{A_g}{A_{core}} - 1\right] \;=\; (0.45)\frac{3000}{40,000}\left[\left(\frac{21.5}{18.5}\right)^2 \;-\; 1\right] \;=\; 0.0118$$

Assuming a spiral pitch, S = 2 inches,

$$(\rho_s)_{actual} \;=\; \frac{4A_{sp}}{DS} \;=\; \frac{(4)(0.11)}{(2)(18.5)} \;=\; 0.0119 \;>\; 0.0118 \;\; acceptable$$

The clear spacing between spirals is

$$2 \;-\frac{3}{8} \;=\; 1.625\ in$$

Since 1.0 in < 1.625 in < 3 in, this is acceptable