Column: Part 3

Courtesy of Dr. Latifee's IMI research group, Text books (Design of concrete structures by McCormac etc.) and others

Spiral Column: Spiral columns are normally round, but they also can be made into rectangular, octagonal, or other shapes. For such columns, circular arrangements of the bars are still used. Spirals, though adding to the resilience of columns, appreciably increase costs. As a result, they are usually used only for large heavily loaded columns and for columns in seismic areas due to their considerable resistance to earthquake loadings. Spirals very effectively increase the ductility and toughness of columns, but they are much more expensive than ties.

The strength of the shell is given by the following expression, where A_c is the area of the core, which is considered to have a diameter that extends from out to out of the spiral:

$$\text{Shell strength} = 0.85 f'_c (A_g - A_c)$$

By considering the estimated hoop tension that is produced in spirals due to the lateral pressure from the core and by tests, it can be shown that spiral steel is at least twice as effective in increasing the ultimate column capacity as is longitudinal steel.[2,3] Therefore, the strength of the spiral can be computed approximately by the following expression, in which ρ_s is the percentage of spiral steel:

$$\text{Spiral strength} = 2\rho_s A_c f_{yt}$$

To make the spiral a little stronger than the spalled concrete, the code (10.9.3) specifies the minimum spiral percentage with the expression to follow, in which f_{yt} is the specified yield strength of the spiral reinforcement up to 100,000 psi.

$$\rho_s = 0.45 \left(\frac{A_g}{A_c} - 1 \right) \frac{f'_c}{f_{yt}} \qquad \text{(ACI Equation 10-5)}$$

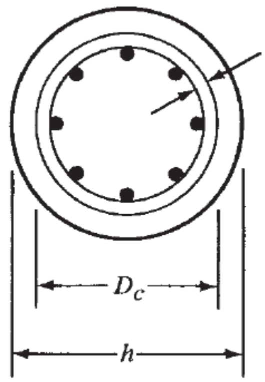
Once the required percentage of spiral steel is determined, the spiral may be selected with the expression to follow, in which ρ_s is written in terms of the volume of the steel in one loop:

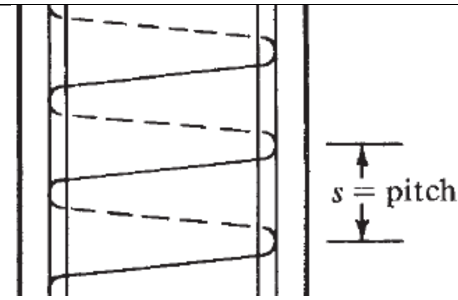
$$\rho_s = \frac{\text{volume of spiral in one loop}}{\text{volume of concrete core for a pitch } s}$$

$$= \frac{V_{\text{spiral}}}{V_{\text{core}}}$$

$$= \frac{a_s \pi (D_c - d_b)}{(\pi D_c^2/4)s} = \frac{4a_s (D_c - d_b)}{s D_c^2}$$

In this expression, ***a*s** is the cross-sectional area of the spiral bar, ***D*c** is the diameter of the core out to out of the spiral, and *d*b is the diameter of the spiral bar. The designer can assume a diameter for the spiral bar and solve for the pitch required. If the results do not seem reasonable, he or she can try another diameter. The pitch must be at least 1 inch and not more than 3 inches





Design of axially loaded Spiral Column:Example

Design a round spiral column to support an axial dead load P_D of 240 k and an axial live load P_L of 300 k. Initially assume that approximately 2% longitudinal steel is desired, $f'_c = 4000$ psi, and $f_y = 60{,}000$ psi.

SOLUTION

$$P_u = (1.2)(240\text{ k}) + (1.6)(300\text{ k}) = 768\text{ k}$$

Selecting Column Dimensions and Bar Sizes

$$\phi P_n = \phi 0.85[0.85 f'_c(A_g - A_{st}) + f_y A_{st}] \qquad \text{(ACI Equation 10-1)}$$

$$768\text{ k} = (0.75)(0.85)[(0.85)(4\text{ ksi})(A_g - 0.02A_g) + (60\text{ ksi})(0.02A_g)]$$

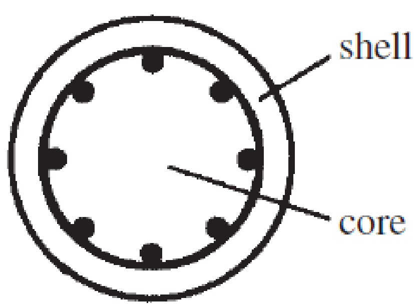
$$A_g = 266\text{ in.}^2 \qquad \underline{\underline{\text{Use 18-in. diameter column (255 in.}^2)}}$$

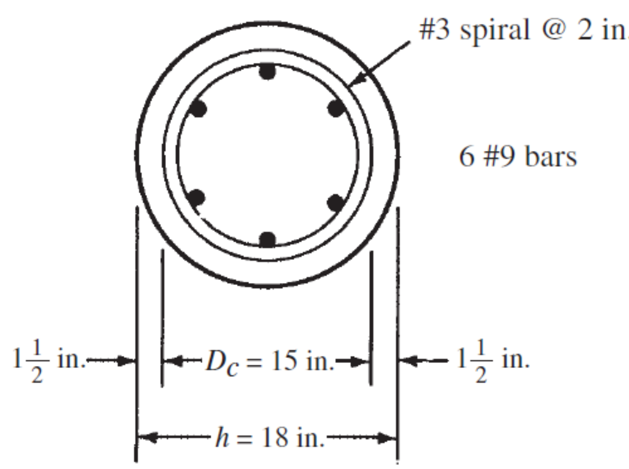
Using a column diameter with a gross area less than the calculated gross area (255 in.^{2} < 266 in.^{2}) results in a higher percentage of steel than originally assumed.

$$768\text{ k} = (0.75)(0.85)[(0.85)(4\text{ ksi})(255\text{ in.}^2 - A_{st}) + (60\text{ ksi})A_{st}]$$

$$A_{st} = 5.97\text{ in.}^2 \qquad \underline{\underline{\text{Use 6 \#9 bars (6.00 in.}^2)}}$$

Note: Check code requirements





Design of Spiral

$$A_c = \frac{(\pi)(15\text{ in.})^2}{4} = 177\text{ in.}^2$$

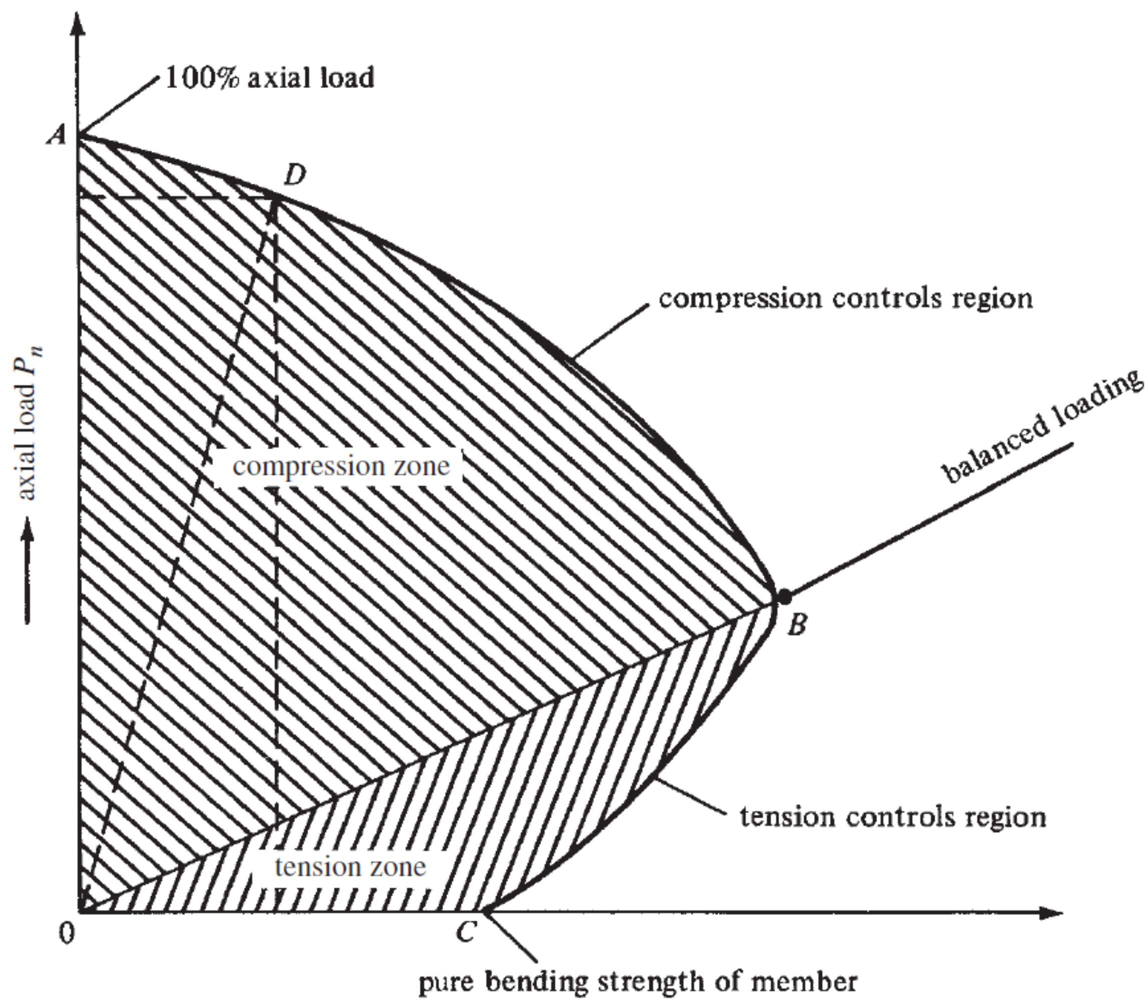
$$\text{Minimum } \rho_s = (0.45)\left(\frac{A_g}{A_c} - 1\right)\frac{f'_c}{f_y} = (0.45)\left(\frac{255\text{ in.}^2}{177\text{ in.}^2} - 1\right)\left(\frac{4\text{ ksi}}{60\text{ ksi}}\right) = 0.0132$$

Assume a #3 spiral, $d_b = 0.375$ in. and $a_s = 0.11$ in.^{2}

$$\rho_s = \frac{4a_s(D_c - d_b)}{sD_c^2}$$

$$0.0132 = \frac{(4)(0.11\text{ in.}^2)(15\text{ in.} - 0.375\text{ in.})}{(s)(15\text{ in.})^2}$$

$$s = 2.17\text{ in.}$$ Say 2 in.



Last updated on 02 August, 2016