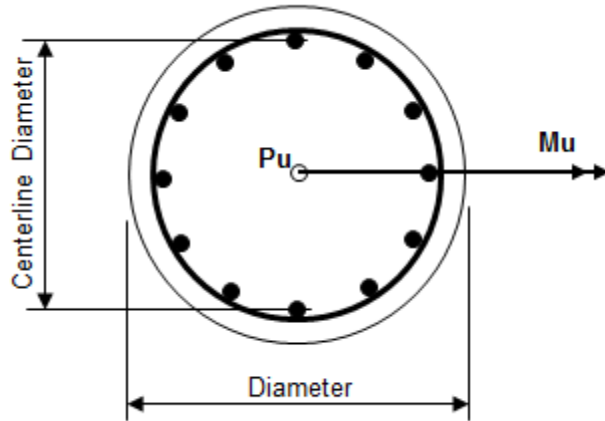




Circular Column Capacity



Input Data

$$f_c = 4\text{ksi}$$

$$f_y = 60\text{ksi}$$

$$E = 29000\text{ksi}$$

$$\text{Cover} = 3\text{in}$$

$$D_{\text{column}} = 18\text{in}$$

$$\text{Number_of_longitudinal_bars} = 6$$

$$\text{Bar} := \begin{array}{l} \#3 \\ \#4 \\ \#5 \\ \#6 \\ \#7 \end{array}$$

$$\text{Tie} := \begin{array}{l} \#3 \\ \#4 \\ \#5 \\ \#6 \\ \#7 \end{array}$$

$$D_{\text{bar}} = 0.375\text{ in}$$

$$D_{\text{tie}} = 0.375\text{ in}$$

Load Case/Combination

$$D_L = 8.1\text{kip}$$

$$W_L = 3.4\text{kip}$$

$$S_L = 1.1\text{kip}$$

$$D_{\text{PuL}} = D_L \cdot 1.4 = 11.34\text{ kip}$$

$$D_{\text{Mu}} = 0$$

$$W_{\text{PuL}} = W_L \cdot 1.6 = 5.44\text{ kip}$$

$$W_{\text{Mu}} = W_{\text{PuL}} = 5.44\text{ kip}$$

$$S_{\text{PuL}} = S_L \cdot 1.4 = 1.54\text{ kip}$$

$$S_{\text{Mu}} = 0$$

$$P_u = D_{\text{PuL}} + W_{\text{PuL}} + S_{\text{PuL}} = 18.32\text{ kip}$$

$$M_u = D_{\text{Mu}} + W_{\text{Mu}} + S_{\text{Mu}} = 5.44\text{ kip}$$

[ACI 318-11 Section 8.5.2](#)

[ACI 318-11 Section 7.7.1](#)

[Column Diameter](#)

[ACI 318-11 Section 10.9.2](#)

[ACI 318-11 Appendix E](#)

[ACI 318-11 Appendix E](#)

[ACI 318-11 Section 9.2.1](#)

$$A_{\text{bar}} := \frac{\pi}{4} \cdot D_{\text{bar}}^2 = 0.11 \text{ in}^2$$

$$A_{\text{gross}} := \frac{\pi}{4} \cdot D_{\text{column}}^2 = 254.469 \text{ in}^2$$

$$A_{\text{steel}} := A_{\text{bar}} \cdot \text{Number_of_longitudinal_bars} = 0.663 \text{ in}^2$$

$$\text{Ratio}_{\text{steel}} := \frac{A_{\text{steel}}}{A_{\text{gross}}} = 2.6042 \times 10^{-3}$$

ACI 318-11
Section 10.9.1

$$\text{Centerline_D}_{\text{bars}} := D_{\text{column}} - 2 \cdot (\text{Cover} + D_{\text{tie}}) - D_{\text{bar}} = 10.875 \text{ in}$$

$$\text{Spacing} := \frac{(\pi \cdot \text{Centerline_D}_{\text{bars}} - \text{Number_of_longitudinal_bars} \cdot D_{\text{bar}})}{\text{Number_of_longitudinal_bars}} = 5.319 \text{ in}$$

ACI 318-11
Section 7.6.1

$$P_{\text{nmax}} := .8 \cdot [.85 \cdot f_c \cdot A_{\text{gross}} + A_{\text{steel}} \cdot (f_y - .85 \cdot f_c)]$$

$$w := \frac{.1 \cdot f_c \cdot A_{\text{gross}}}{.7} = 145.411 \text{ kip}$$

$$c_1 := 0 \text{ in}$$

Concrete

$$a := \begin{cases} .85 \cdot c_1 & \text{if } .85 \cdot c_1 < D_{\text{column}} \\ D_{\text{column}} & \text{otherwise} \end{cases} = 0$$

$$d := 2 \sqrt{\frac{2 \cdot a \cdot D_{\text{column}}}{2} - a^2} = 0 \text{ in}$$

$$\phi := \begin{cases} \text{atan}\left(\frac{d}{2 \cdot \left|\frac{D_{\text{column}}}{2} - a\right|}\right) & \text{if } a \leq \frac{D_{\text{column}}}{2} \\ \left(\pi - \text{atan}\left(\frac{d}{2 \cdot \left|\frac{D_{\text{column}}}{2} - a\right|}\right)\right) & \text{otherwise} \end{cases} = 0$$

$$A_{\text{conc}} := \frac{D_{\text{column}}^2}{8} \cdot (2 \cdot \phi - \sin(2 \cdot \phi)) = 0 \text{ in}^2$$

$$X_c := \begin{cases} \frac{-d^3}{12(A_{\text{conc}})} & \text{if } c_1 > 0 \\ \frac{-D_{\text{column}}}{2} & \text{otherwise} \end{cases} = -0.229$$

$$P_{\text{conc}} := .85 \cdot f_c \cdot A_{\text{conc}} = 0 \text{ kip}$$

$$M_{\text{conc}} := -P_{\text{conc}} \cdot X_c = 0 \text{ in-kip}$$

Steel

$$i := 1, 2..100$$

$$X_{s_i} := \begin{cases} \left[\frac{-\text{Centerline_D}_{\text{bars}}}{2} \cdot \cos \left[\frac{2 \cdot \pi \cdot (i - 1)}{\text{Number_of_longitudinal_bars}} \right] \right] & \text{if Number_of_longitudinal_bars} \geq i \\ 0 & \text{otherwise} \end{cases}$$

$$A_{st_i} := \begin{cases} A_{\text{bar}} & \text{if Number_of_longitudinal_bars} \geq i \\ 0 & \text{otherwise} \end{cases}$$

$$\text{Vol}_i := X_{s_i} \cdot A_{st_i}$$

$$e_{s_i} := \begin{cases} \left[.003 \cdot \left[1 - \frac{\left(\frac{D_{\text{column}}}{2} + X_{s_i} \right)}{c_1} \right] \right] & \text{if } c_1 > 0 \\ (-.003) & \text{otherwise} \end{cases}$$

$$f_{s_i} := \begin{cases} e_i \cdot E & \text{if } |e_i \cdot E| \leq f_y \\ \frac{f_y \cdot e_i}{|e_i|} & \text{otherwise} \end{cases}$$

$$P_{st_i} := A_{st_i} \cdot f_{s_i}$$

$$M_{st_i} := -\text{Vol}_i \cdot f_{s_i}$$

$$\sum_i P_{st_i} = -39.761 \cdot \text{kip}$$

$$\sum_i M_{st_i} = 2.012 \times 10^{-15} \cdot \text{in} \cdot \text{kip}$$

$$P_n := \begin{cases} P_{n\text{max}} & \text{if } \sum_i P_{st_i} + P_{\text{conc}} \geq P_{n\text{max}} \\ \left(\sum_i P_{st_i} + P_{\text{conc}} \right) & \text{otherwise} \end{cases}$$

$$M_n := \frac{M_{\text{conc}} + \sum_i M_{st_i}}{12} = 0 \cdot \text{ft} \cdot \text{kip}$$

Tabulated Capacities

$j := 1, 2, \dots, 100$

$$c_j := \begin{cases} \left(\frac{j-1}{10} \cdot .003 \cdot \frac{\frac{D_{\text{column}}}{2} + X_{s1}}{.003 + \frac{f_y}{E}} \right) & \text{if } 1 \leq j \leq 9 \\ \left[\left(\frac{j-10}{30} \right)^{1.5} \cdot \left(.003 \cdot \frac{\frac{D_{\text{column}}}{2} + X_{s1}}{.003 - \frac{f_y}{E}} - .003 \cdot \frac{\frac{D_{\text{column}}}{2} + X_{s1}}{.003 + \frac{f_y}{E}} \right) + .003 \cdot \frac{\frac{D_{\text{column}}}{2} + X_{s1}}{.003 + \frac{f_y}{E}} \right] & \text{if } 10 \leq j \leq 39 \\ \frac{j-40}{20} \cdot \left(.003 \cdot \frac{\frac{D_{\text{column}}}{2} + X_{s30}}{.003 + \frac{f_y}{E}} - .003 \cdot \frac{\frac{D_{\text{column}}}{2} + X_{s1}}{.003 - \frac{f_y}{E}} \right) + .003 \cdot \frac{\frac{D_{\text{column}}}{2} + X_{s1}}{.003 - \frac{f_y}{E}} & \text{if } 40 \leq j \leq 59 \\ \left[\left[\frac{j-60}{40} \right]^{\frac{j}{20}} \cdot \left(.003 \cdot \frac{\frac{D_{\text{column}}}{2} + \max(X_s)}{.003 - \frac{f_y}{E}} - .003 \cdot \frac{\frac{D_{\text{column}}}{2} + X_{s30}}{.003 + \frac{f_y}{E}} \right) + .003 \cdot \frac{\frac{D_{\text{column}}}{2} + X_{s30}}{.003 + \frac{f_y}{E}} \right] & \text{otherwise} \end{cases}$$

Concrete

$$a_j := \begin{cases} .85 \cdot c_j & \text{if } .85 \cdot c_j < D_{\text{column}} \\ D_{\text{column}} & \text{otherwise} \end{cases}$$

$$d_j := 2 \sqrt{\frac{2 \cdot a_j \cdot D_{\text{column}}}{2} - (a_j)^2}$$

$$\phi_j := \begin{cases} \text{atan} \left(\frac{d_j}{2 \cdot \left| \frac{D_{\text{column}}}{2} - a_j \right|} \right) & \text{if } a_j \leq \frac{D_{\text{column}}}{2} \\ \left(\pi - \text{atan} \left(\frac{d_j}{2 \cdot \left| \frac{D_{\text{column}}}{2} - a_j \right|} \right) \right) & \text{otherwise} \end{cases}$$

$$A_{\text{concr}j} := \frac{D_{\text{column}}^2}{8} \cdot (2 \cdot \phi_j - \sin(2 \cdot \phi_j))$$

$$X_{\text{concr}j} := \begin{cases} \frac{-(d_j)^3}{12(A_{\text{concr}j})} & \text{if } c_j > 0 \\ \frac{-D_{\text{column}}}{2} & \text{otherwise} \end{cases}$$

$$P_{\text{conc}_j} := .85 \cdot f_c \cdot A_{\text{conc}_j}$$

$$M_{\text{conc}_j} := -P_{\text{conc}_j} \cdot X_{c_j}$$

Steel

$$A_{\text{st}_j} := \begin{cases} A_{\text{bar}} & \text{if Number_of_longitudinal_bars} \geq j \\ 0 & \text{otherwise} \end{cases}$$

$$\text{Vol}_j := X_{s_j} \cdot A_{\text{st}_j}$$

$$e_j := \begin{cases} \left[\begin{array}{l} .003 \cdot \left[1 - \frac{\left(\frac{D_{\text{column}}}{2} + X_{s_j} \right)}{c_j} \right] \\ (-.003) \end{array} \right] & \text{if } c_j > 0 \\ \text{otherwise} \end{cases}$$

$$f_{s_j} := \begin{cases} e_j \cdot E & \text{if } |e_j \cdot E| \leq f_y \\ \frac{f_y \cdot e_j}{|e_j|} & \text{otherwise} \end{cases}$$

$$P_{\text{st}_j} := A_{\text{st}_j} \cdot f_{s_j}$$

$$M_{\text{st}_j} := -\text{Vol}_j \cdot f_{s_j}$$

$$\sum_j P_{\text{st}_j} = -39.761 \cdot \text{kip}$$

$$\sum_j M_{\text{st}_j} = 2.012 \times 10^{-15} \cdot \text{in} \cdot \text{kip}$$

$$X_{s_j} := \begin{cases} \left[\frac{-\text{Centerline_D_bars}}{2} \cdot \cos \left[\frac{2 \cdot \pi \cdot (j - 1)}{\text{Number_of_longitudinal_bars}} \right] \right] & \text{if Number_of_longitudinal_bars} \geq j \\ 0 & \text{otherwise} \end{cases}$$

$$P_{\text{st}_j} := \begin{cases} P_n & \text{if } \sum_j P_{\text{st}_j} + P_{\text{conc}_j} \geq P_n \\ \left(\sum_j P_{\text{st}_j} + P_{\text{conc}_j} \right) & \text{otherwise} \end{cases}$$

$$M_{\text{st}_j} := M_{\text{conc}_j} + \sum_j M_{\text{st}_j}$$