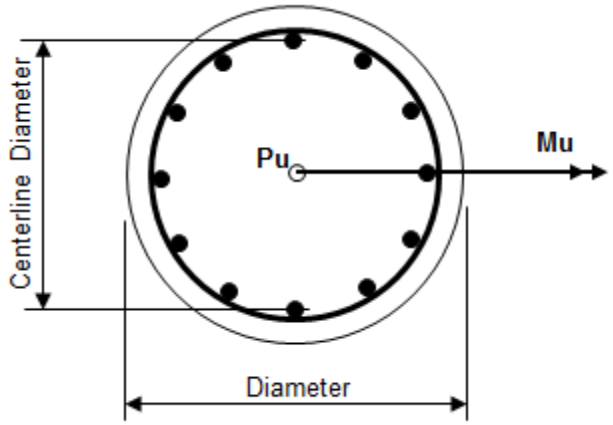
Circular Column Capacity



Input Data

$f'_c = 4\,ksi$ $f_y = 60\,ksi$

$E = 29000\,ksi$ ACI 318-11 Section 8.5.2

$Cover = 3\,in$ ACI 318-11 Section 7.7.1

$D_{column} = 18\,in$ Column Diameter

$Number\_of\_longitudinal\_bars = 6$ ACI 318-11 Section 10.9.2

Bar := #3 #4 #5 #6 #7

Tie := #3 #4 #5 #6 #7

ACI 318-11 Appendix E

$D_{bar} = 0.375\,in$ $D_{tie} = 0.375\,in$ ACI 318-11 Appendix E

Load Case/Combination

ACI 318-11 Section 9.2.1

$D_L = 8.1\,kip$ $W_L = 3.4\,kip$ $S_L = 1.1\,kip$

$D_{PuL} = D_L \cdot 1.4 = 11.34 \cdot kip$ $D_{Mu} = 0$

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

$S_{PuL} = S_L \cdot 1.4 = 1.54 \cdot kip$ $S_{Mu} = 0$

$P_u = D_{PuL} + W_{PuL} + S_{PuL} = 18.32 \cdot kip$ $M_u = D_{Mu} + W_{Mu} + S_{Mu} = 5.44 \cdot kip$

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

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

$A_{steel} := A_{bar} \cdot Number\_of\_longitudinal\_bars = 0.663\,in^2$

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

ACI 318-11
Section 10.9.1

$Centerline\_D_{bars} := D_{column} - 2 \cdot (Cover + D_{tie}) - D_{bar} = 10.875\,in$

$Spacing := \frac{(\pi \cdot Centerline\_D_{bars} - Number\_of\_longitudinal\_bars \cdot D_{bar})}{Number\_of\_longitudinal\_bars} = 5.319\,in$

ACI 318-11
Section 7.6.1

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

$w := \frac{.1 \cdot f'_c \cdot A_{gross}}{.7} = 145.411\,kip$

$c_1 := 0\,in$

Concrete

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

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

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

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

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

$P_{conc} := .85 \cdot f'_c \cdot A_{conc} = 0 \cdot kip$

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

Steel

$i := 1, 2 .. 100$

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

$$A_{st_i} := \begin{cases} A_{bar} & \text{if Number\_of\_longitudinal\_bars} \geq i \\ 0 & \text{otherwise} \end{cases}$$

$$Vol_i := X_{s_i} \cdot A_{st_i}$$

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

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

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

$$M_{st_i} := -Vol_i \cdot f_{s_i}$$

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

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

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

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

Tabulated Capacities

$j := 1, 2 .. 100$

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

Concrete

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

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

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

$$A_{conc_j} := \frac{D_{column}^2}{8} \cdot \left(2 \cdot \phi_j - \sin\left(2 \cdot \phi_j \right) \right)$$

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

$P_{conc_j} := .85 \cdot f'_c \cdot A_{conc_j}$

$M_{conc_j} := -P_{conc_j} \cdot X_{c_j}$

Steel

$$A_{st_j} := \begin{cases} A_{bar} & \text{if Number\_of\_longitudinal\_bars} \geq j \\ 0 & \text{otherwise} \end{cases}$$

$Vol_j := X_{s_j} \cdot A_{st_j}$

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

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

$P_{st_j} := A_{st_j} \cdot f_{s_j}$

$M_{st_j} := -Vol_j \cdot f_{s_j}$

$\sum_j P_{st_j} = -39.761 \cdot kip$

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

$$X_{s_j} := \begin{cases} \left[\frac{-Centerline\_D_{bars}}{2} \cdot \cos\left[\frac{2 \cdot \pi \cdot (j - 1)}{Number\_of\_longitudinal\_bars} \right] \right] & \text{if Number\_of\_longitudinal\_bars} \geq j \\ 0 & \text{otherwise} \end{cases}$$

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

$M_{n_j} := M_{conc_j} + \sum_j M_{st_j}$