Circular Column Capacity

$ORIGIN := 1$

Define unit $klbf := 10^3 \cdot lbf$

Input Data

$fc := 4 \cdot ksi$

$Fy := 60 \cdot ksi$

$columndiam := 18 \cdot in$

$clearcover := 1.5 \cdot in$

$tiediam := 0.5 \cdot in$

$bardiam := 0.75 \cdot in$

$bararea := \frac{\pi \cdot bardiam^2}{4}$ $\quad bararea = 0.442 \cdot in^2$

$nbrlongbars := 6$

$grossarea := \pi \cdot \frac{columndiam^2}{4}$ $\quad grossarea = 254.469 \cdot in^2$

$steelarea := nbrlongbars \cdot bararea$ $\quad steelarea = 2.651 \cdot in^2$

$steelratio := \frac{steelarea}{grossarea}$ $\quad steelratio = 0.0104$

$centerdiambars := columndiam - 2 \cdot (clearcover + tiediam) - bardiam$ $\quad centerdiambars = 13.25 \cdot in$

$clearspacingbars := \frac{\pi \cdot centerdiambars - nbrlongbars \cdot bardiam}{nbrlongbars}$ $\quad clearspacingbars = 6.188 \cdot in$

$Pn_{max} := 0.8[0.85 \cdot fc \cdot grossarea + steelarea \cdot (Fy - 0.85 \cdot fc)]$ $\quad Pn_{max} = 8.122 \times 10^5 \cdot lbf$

$fcAg := \frac{0.1 \cdot fc \cdot grossarea}{0.7}$ $\quad fcAg = 1.454 \times 10^5 \cdot lbf$

Concrete

$$a(c) := \min(0.85\cdot c, \text{columndiam})$$

$$d(c) := 2\cdot\sqrt{a(c)\cdot \text{columndiam} - a(c)^2}$$

$$\varphi(c) := \begin{array}{|l} \text{return } \operatorname{atan}\left(\dfrac{d(c)}{2\cdot\left|\dfrac{\text{columndiam}}{2} - a(c)\right|}\right) \text{ if } a(c) \le \dfrac{\text{columndiam}}{2} \\ \pi - \operatorname{atan}\left(\dfrac{d(c)}{2\cdot\left|\dfrac{\text{columndiam}}{2} - a(c)\right|}\right) \text{ otherwise} \end{array}$$

$$\text{Aconc}(c) := \frac{\text{columndiam}^2\cdot(2\cdot\varphi(c) - \sin(2\cdot\varphi(c)))}{8}$$

$$X(c) := \begin{array}{|l} \text{return } \dfrac{-d(c)^3}{12\cdot \text{Aconc}(c)} \text{ if } c > 0 \\ \dfrac{-\text{columndiam}}{2} \end{array}$$

$$\text{Pconc}(c) := 0.85\cdot fc\cdot \text{Aconc}(c)$$

$$\text{Mconc}(c) := -\text{Pconc}(c)\cdot X(c)$$

Steel

$$Xs(n) := \begin{array}{|l} \text{return } \dfrac{-\text{centerdiambars}}{2}\cdot\cos\left[2\cdot\pi\cdot\dfrac{(n-1)}{\text{nbrlongbars}}\right] \text{ if nbrlongbars} \ge n \\ 0 \text{ otherwise} \end{array}$$

$$\text{Ast}(n) := \begin{array}{|l} \text{return bararea if nbrlongbars} \ge n \\ 0 \text{ otherwise} \end{array}$$

$$es(c,n) := \begin{cases} \text{return } 0.003\cdot\left[1 - \frac{1}{c}\cdot\left(\frac{columndiam}{2} + Xs(n)\right)\right] & \text{if } c > 0 \\ -0.003 & \text{otherwise} \end{cases}$$

$$fs(c,n) := \begin{array}{|l} k \leftarrow 29000\cdot ksi \\ \text{return } k\cdot es(c,n) \quad \text{if } \left|k\cdot es(c,n)\right| \le Fy \\ Fy\cdot sign(es(c,n)) \quad \text{otherwise} \end{array}$$

$$Pst(c,n) := Ast(n)\cdot fs(c,n)$$

$$Mst(c,n) := -Xs(n)\cdot Ast(n)\cdot fs(c,n)$$

$$Pstsum(c) := \sum_{n=1}^{30} Pst(c,n)$$

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$$Pn(c) := \begin{array}{|l} ptot \leftarrow Pstsum(c) + Pconc(c) \\ \text{return } Pn_{max} \quad \text{if } ptot \ge Pn_{max} \\ ptot \quad \text{otherwise} \end{array}$$

$$Mn(c) := Mconc(c) + Mstsum(c)$$

$$\varphi s(Pn) := \begin{array}{|l} \text{return } 0.9 \quad \text{if } Pn \le 0 \\ \text{otherwise} \\ \quad \begin{array}{|l} \varphi s \leftarrow 0.7 \quad \text{if } Pn \ge fcAg \\ \varphi s \leftarrow 0.9 - 0.2\cdot\frac{Pn}{fcAg} \quad \text{otherwise} \end{array} \\ \varphi s \end{array}$$

Multiple c-values

$$Xsmax := \begin{array}{|l} xsmax \leftarrow Xs(1) \\ \text{for } i \in 2..30 \\ \quad xsmax \leftarrow Xs(i) \quad \text{if } xsmax < Xs(i) \\ xsmax \end{array}$$

$$Xsmax = 6.625 \cdot in$$

$$cvals := \begin{bmatrix} 0.003 \cdot \dfrac{\left(\dfrac{columndiam}{2} + Xs(1)\right)}{\left(0.003 + \dfrac{60}{29000}\right)} \\ 0.003 \cdot \dfrac{\left(\dfrac{columndiam}{2} + Xs(1)\right)}{\left(0.003 - \dfrac{60}{29000}\right)} \\ 0.003 \cdot \dfrac{\left(\dfrac{columndiam}{2} + Xs(30)\right)}{\left(0.003 + \dfrac{60}{29000}\right)} \\ 0.003 \cdot \dfrac{\left(\dfrac{columndiam}{2} + Xsmax\right)}{\left(0.003 - \dfrac{60}{29000}\right)} \end{bmatrix}$$

$$c := \begin{array}{|l} \text{for } i \in 1..9 \\ \quad c_i \leftarrow \dfrac{i-1}{10} \cdot cvals_1 \\ c_{10} \leftarrow cvals_1 \\ \text{for } i \in 11..39 \\ \quad c_i \leftarrow \left(\dfrac{i-10}{30}\right)^{1.5} \cdot \left(cvals_2 - cvals_1\right) + cvals_1 \\ c_{40} \leftarrow cvals_2 \\ \text{for } i \in 41..59 \\ \quad c_i \leftarrow \dfrac{i-40}{20} \cdot \left(cvals_3 - cvals_2\right) + cvals_2 \\ c_{60} \leftarrow cvals_3 \\ \text{for } i \in 61..99 \\ \quad c_i \leftarrow \left(\dfrac{i-60}{40}\right)^{\frac{i}{20}} \cdot \left(cvals_4 - cvals_3\right) + cvals_3 \\ c_{100} \leftarrow cvals_4 \\ c \end{array}$$

$$P_n := \overrightarrow{Pn(c)}$$

$$M_n := \overrightarrow{Mn(c)}$$

$$\Phi := \overrightarrow{\varphi s(P_n)}$$

$c =$ (·in)

	1
1	0
2	0.141
3	0.281
4	0.422
5	0.562
6	0.703
7	0.843
8	0.984
9	1.124
10	1.406
11	...

$P_n =$ (·klbf)

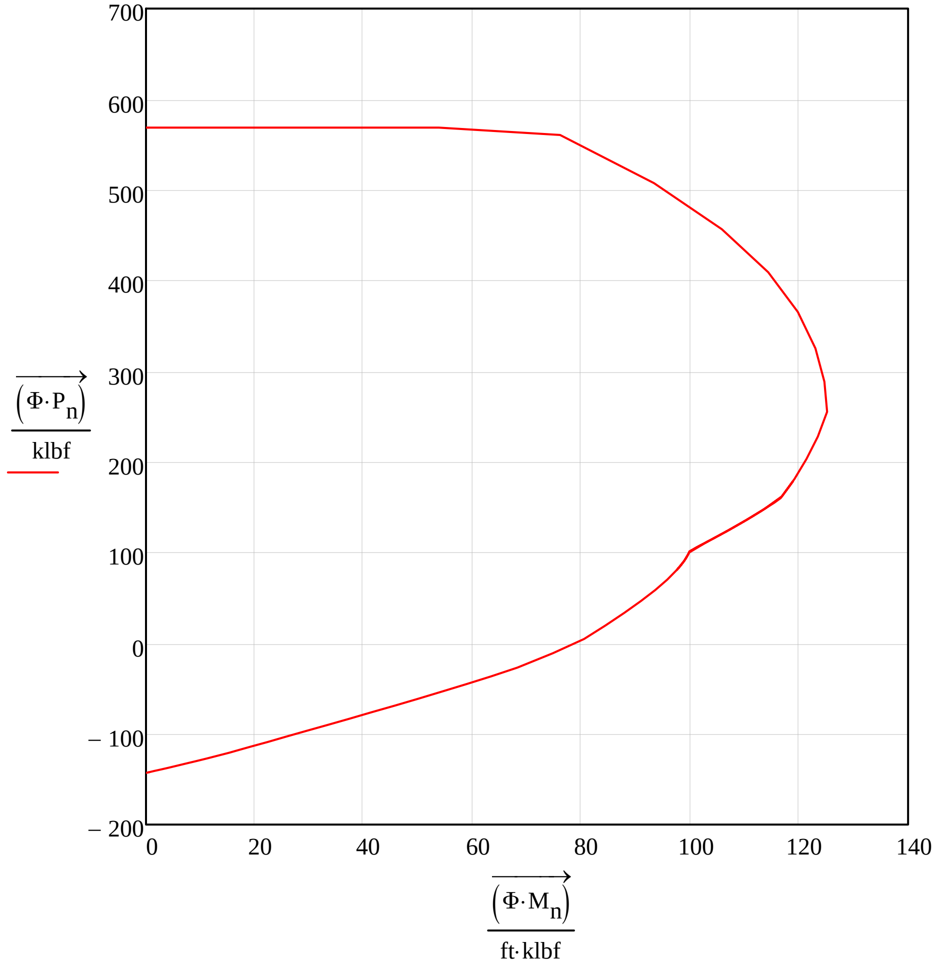
	1
1	-159.043
2	-158.25
3	-156.805
4	-154.941
5	-152.74
6	-150.252
7	-147.51
8	-144.539
9	-141.359
10	-134.432
11	...

$M_n =$ (·ft·klbf)

	1
1	$-1.342 \cdot 10^{-15}$
2	0.59
3	1.652
4	3.003
5	4.577
6	6.332
7	8.237
8	10.273
9	12.42
10	16.994
11	...

$\Phi =$

	1
1	0.9
2	0.9
3	0.9
4	0.9
5	0.9
6	0.9
7	0.9
8	0.9
9	0.9
10	0.9
11	...



700
600
500
400
300
200
100
0
– 100
– 200
(Φ·Pn)
klbf
0
20
40
60
80
100
120
140
(Φ·Mn)
ft·klbf