



CHAPTER 7: Reinforced Concrete Column and Wall Footings

7.3 Pile Cap Configurations

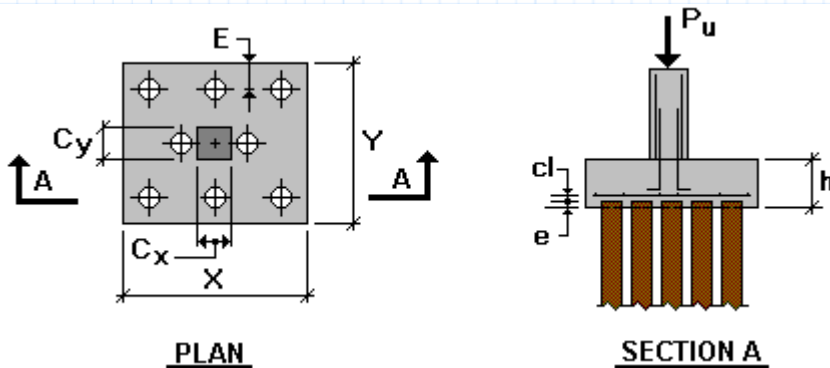
Description

This application calculates pile coordinates and pile cap plan dimensions for pile groups with 2 to 20 piles. The purpose of this application is to show the pile group layout, pile coordinates and plan dimensions used in **Section 7.2** for selecting pile cap depth and reinforcement.

The user must enter the minimum pile spacing, factors for rounding pile coordinates and pile cap plan dimensions to practical dimensions, and the minimum edge distance from center of pile to outside face of concrete.

Input

Notation



Input Variables

Minimum pile spacing:

$$s := 3 \cdot ft$$

Factor for rounding pile spacing:

$$SzP := \frac{1}{2} \cdot in$$

Factor for rounding pile cap dimensions:

$$SzD := 1 \cdot in$$

Minimum edge distance from center of pile:

$$E := 1 \cdot ft + 3 \cdot in$$

Computed Variables

X the longer plan dimension of the pile cap

Y the shorter plan dimension of pile cap

x pile coordinates in the X direction from the centroid of the pile group

y pile coordinates in the Y direction from the centroid of the pile group

Calculations

Dimensions used to compute pile coordinates:

$$s0 := 0 \cdot ft \quad s0 = 0 \text{ ft}$$

$$s1 := SzP \cdot \text{ceil} \left(\frac{2 \cdot s \cdot \sin(45 \cdot deg)}{SzP} \right) \quad s1 = 4.25 \text{ ft}$$

$$s2 := SzP \cdot \text{ceil} \left(\frac{s \cdot \sin(60 \cdot deg)}{SzP} \right) \quad s2 = 2.625 \text{ ft}$$

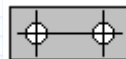
$$s3 := \frac{s}{2} + s2 \quad s3 = 4.125 \text{ ft}$$

$$s4 := s2 + s \quad s4 = 5.625 \text{ ft}$$

Pile Group P2

$$X_2 := s + 2 \cdot E$$

$$Y_2 := 2 \cdot E$$



$$X_2 = 5.5 \text{ ft}$$

$$Y_2 = 2.5 \text{ ft}$$

P2

$$x^{(2)} := \begin{bmatrix} -\frac{s}{2} & \frac{s}{2} \end{bmatrix}^T$$

$$(x^{(2)})^T = [-1.5 \ 1.5] \text{ ft}$$

$$y^{(2)} := [s0 \ s0]^T$$

$$(y^{(2)})^T = [0 \ 0] \text{ ft}$$

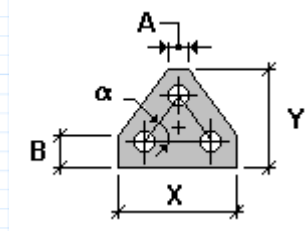
Pile Group P3

$$X_3 := s + 2 \cdot E$$

$$Y_3 := s2 + 2 \cdot E$$

$$X_3 = 5.5 \text{ ft}$$

$$Y_3 = 5.125 \text{ ft}$$



P3

$$x^{(3)} := \begin{bmatrix} s0 & -\frac{s}{2} & \frac{s}{2} \end{bmatrix}^T$$

$$\langle x^{(3)} \rangle^T = [0 \quad -1.5 \quad 1.5] \text{ ft}$$

$$y^{(3)} := \begin{bmatrix} \frac{2 \cdot s2}{3} & -\frac{s2}{3} & -\frac{s2}{3} \end{bmatrix}^T$$

$$\langle y^{(3)} \rangle^T = [1.75 \quad -0.875 \quad -0.875] \text{ ft}$$

Angle between the centerline of the two piles in the base row and a centerline drawn between either of the two piles in the base row to the pile at the apex of the 3 pile group:

$$\alpha := \text{atan} \left(\frac{2 \cdot s2}{s} \right) \quad \alpha = 60.255 \text{ deg}$$

Dimension A rounded up to a multiple of SzD:

$$A := SzD \cdot \text{ceil} \left(\frac{2 \cdot E \cdot \left(\frac{1}{\sin(\alpha)} - \frac{1}{\tan(\alpha)} \right)}{SzD} \right) \quad A = 18 \text{ in}$$

Dimension B rounded up to a multiple of SzD:

$$B := SzD \cdot \text{ceil} \left(\frac{E \cdot \left(1 + \tan(\alpha) \cdot \left(\frac{1}{\sin(\alpha)} - 1 \right) \right)}{SzD} \right) \quad B = 19 \text{ in}$$

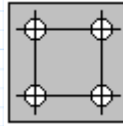
Pile Group P4

$$X_4 := s + 2 \cdot E$$

$$Y_4 := s + 2 \cdot E$$

$$X_4 = 5.5 \text{ ft}$$

$$Y_4 = 5.5 \text{ ft}$$



P4

$$x^{(4)} := \begin{bmatrix} -\frac{s}{2} & \frac{s}{2} & -\frac{s}{2} & \frac{s}{2} \end{bmatrix}^T$$

$$\langle x^{(4)} \rangle^T = [-1.5 \ 1.5 \ -1.5 \ 1.5] \text{ ft}$$

$$y^{(4)} := \begin{bmatrix} -\frac{s}{2} & \frac{s}{2} & -\frac{s}{2} & \frac{s}{2} \end{bmatrix}^T$$

$$\langle y^{(4)} \rangle^T = [-1.5 \ 1.5 \ -1.5 \ 1.5] \text{ ft}$$

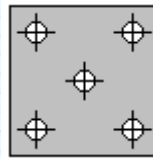
Pile Group P5

$$X_5 := s1 + 2 \cdot E$$

$$Y_5 := s1 + 2 \cdot E$$

$$X_5 = 6.75 \text{ ft}$$

$$Y_5 = 6.75 \text{ ft}$$



P5

$$x^{(5)} := \begin{bmatrix} -\frac{s1}{2} & \frac{s1}{2} & s0 & -\frac{s1}{2} & \frac{s1}{2} \end{bmatrix}^T$$

$$\langle x^{(5)} \rangle^T = [-2.125 \ 2.125 \ 0 \ -2.125 \ 2.125] \text{ ft}$$

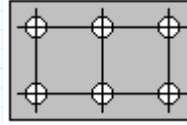
$$y^{(5)} := \begin{bmatrix} \frac{s1}{2} & \frac{s1}{2} & s0 & -\frac{s1}{2} & -\frac{s1}{2} \end{bmatrix}^T$$

$$\langle y^{(5)} \rangle^T = [2.125 \ 2.125 \ 0 \ -2.125 \ -2.125] \text{ ft}$$

Pile Group P6

$$X_6 := 2 \cdot (s + E) \quad Y_6 := s + 2 \cdot E$$

$$X_6 = 8.5 \text{ ft} \quad Y_6 = 5.5 \text{ ft}$$



P6

$$x^{(6)} := [-s \ s0 \ s \ -s \ s0 \ s]^T$$

$$\langle x^{(6)} \rangle^T = [-3 \ 0 \ 3 \ -3 \ 0 \ 3] \text{ ft}$$

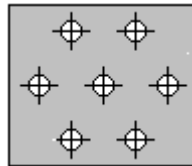
$$y^{(6)} := \left[\frac{s}{2} \ \frac{s}{2} \ \frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \right]^T$$

$$\langle y^{(6)} \rangle^T = [1.5 \ 1.5 \ 1.5 \ -1.5 \ -1.5 \ -1.5] \text{ ft}$$

Pile Group P7

$$X_7 := 2 \cdot (s + E) \quad Y_7 := 2 \cdot (s2 + E)$$

$$X_7 = 8.5 \text{ ft} \quad Y_7 = 7.75 \text{ ft}$$



P7

$$x^{(7)} := \left[-\frac{s}{2} \ \frac{s}{2} \ -s \ s0 \ s \ -\frac{s}{2} \ \frac{s}{2} \right]^T$$

$$\langle x^{(7)} \rangle^T = [-1.5 \ 1.5 \ -3 \ 0 \ 3 \ -1.5 \ 1.5] \text{ ft}$$

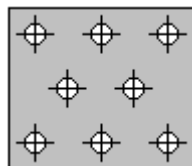
$$y^{(7)} := [s2 \ s2 \ s0 \ s0 \ s0 \ -s2 \ -s2]^T$$

$$\langle y^{(7)} \rangle^T = [2.625 \ 2.625 \ 0 \ 0 \ 0 \ -2.625 \ -2.625] \text{ ft}$$

Pile Group P8

$$X_8 := 2 \cdot (s + E) \quad Y_8 := 2 \cdot (s2 + E)$$

$$X_8 = 8.5 \text{ ft} \quad Y_8 = 7.75 \text{ ft}$$



P8

$$x^{(8)} := \begin{bmatrix} -s & s & 0 & s & -\frac{s}{2} & \frac{s}{2} & -s & s & 0 & s \end{bmatrix}^T$$

$$\langle x^{(8)} \rangle^T = [-3 \ 0 \ 3 \ -1.5 \ 1.5 \ -3 \ 0 \ 3] \text{ ft}$$

$$y^{(8)} := [s \ 2 \ s \ 2 \ s \ 2 \ s \ 0 \ s \ 0 \ -s \ 2 \ -s \ 2 \ -s \ 2]^T$$

$$\langle y^{(8)} \rangle^T = [2.625 \ 2.625 \ 2.625 \ 0 \ 0 \ -2.625 \ -2.625 \ -2.625] \text{ ft}$$

Pile Group P9

$$X_9 := 2 \cdot (s + E) \quad Y_9 := 2 \cdot (s + E)$$

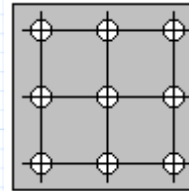
$$X_9 = 8.5 \text{ ft} \quad Y_9 = 8.5 \text{ ft}$$

$$x^{(9)} := [-s \ s \ 0 \ s \ -s \ s \ 0 \ s \ -s \ s \ 0 \ s]^T$$

$$\langle x^{(9)} \rangle^T = [-3 \ 0 \ 3 \ -3 \ 0 \ 3 \ -3 \ 0 \ 3] \text{ ft}$$

$$y^{(9)} := [s \ s \ s \ s \ 0 \ s \ 0 \ s \ 0 \ -s \ -s \ -s]^T$$

$$\langle y^{(9)} \rangle^T = [3 \ 3 \ 3 \ 0 \ 0 \ 0 \ -3 \ -3 \ -3] \text{ ft}$$



P9

Pile Group P10

$$X_{10} := 3 \cdot s + 2 \cdot E \quad Y_{10} := 2 \cdot (s + E)$$

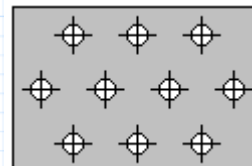
$$X_{10} = 11.5 \text{ ft} \quad Y_{10} = 7.75 \text{ ft}$$

$$x^{(10)} := \begin{bmatrix} -s & s & 0 & s & \frac{-3 \cdot s}{2} & \frac{-s}{2} & \frac{s}{2} & \frac{3 \cdot s}{2} & -s & s & 0 & s \end{bmatrix}^T$$

$$\langle x^{(10)} \rangle^T = [-3 \ 0 \ 3 \ -4.5 \ -1.5 \ 1.5 \ 4.5 \ -3 \ 0 \ 3] \text{ ft}$$

$$y^{(10)} := [s \ 2 \ s \ 2 \ s \ 2 \ s \ 0 \ s \ 0 \ -s \ 2 \ -s \ 2 \ -s \ 2]^T$$

$$\langle y^{(10)} \rangle^T = [2.625 \ 2.625 \ 2.625 \ 0 \ 0 \ 0 \ 0 \ -2.625 \ -2.625 \ -2.625] \text{ ft}$$

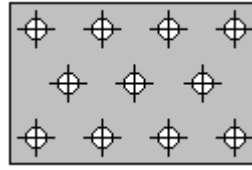


P10

Pile Group P11

$$X_{11} := 3 \cdot s + 2 \cdot E \quad Y_{11} := 2 \cdot (s + E)$$

$$X_{11} = 11.5 \text{ ft} \quad Y_{11} = 7.75 \text{ ft}$$



P11

$$x^{(11)} := \left[\begin{array}{cccccccccccc} \frac{-3 \cdot s}{2} & \frac{-s}{2} & \frac{s}{2} & \frac{3 \cdot s}{2} & -s & s & 0 & s & \frac{-3 \cdot s}{2} & \frac{-s}{2} & \frac{s}{2} & \frac{3 \cdot s}{2} \end{array} \right]^T$$

$$\langle x^{(11)} \rangle^T = [-4.5 \quad -1.5 \quad 1.5 \quad 4.5 \quad -3 \quad 0 \quad 3 \quad -4.5 \quad -1.5 \quad 1.5 \quad 4.5] \text{ ft}$$

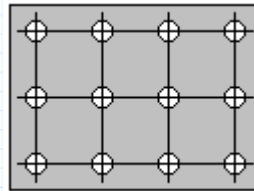
$$y^{(11)} := [s \ 2 \ s \ 2 \ s \ 2 \ s \ 2 \ s \ 0 \ s \ 0 \ s \ 0 \ -s \ 2 \ -s \ 2 \ -s \ 2 \ -s \ 2]^T$$

$$\langle y^{(11)} \rangle^T = [2.625 \ 2.625 \ 2.625 \ 2.625 \ 0 \ 0 \ 0 \ -2.625 \ -2.625 \ -2.625 \ -2.625] \text{ ft}$$

Pile Group P12

$$X_{12} := 3 \cdot s + 2 \cdot E \quad Y_{12} := 2 \cdot (s + E)$$

$$X_{12} = 11.5 \text{ ft} \quad Y_{12} = 8.5 \text{ ft}$$



P12

$$x^{(12)} := \left[\begin{array}{cccccccccccc} \frac{-3 \cdot s}{2} & \frac{-s}{2} & \frac{s}{2} & \frac{3 \cdot s}{2} & \frac{-3 \cdot s}{2} & \frac{-s}{2} & \frac{s}{2} & \frac{3 \cdot s}{2} & \frac{-3 \cdot s}{2} & \frac{-s}{2} & \frac{s}{2} & \frac{3 \cdot s}{2} \end{array} \right]^T$$

$$\langle x^{(12)} \rangle^T = [-4.5 \quad -1.5 \quad 1.5 \quad 4.5 \quad -4.5 \quad -1.5 \quad 1.5 \quad 4.5 \quad -4.5 \quad -1.5 \quad 1.5 \quad 4.5] \text{ ft}$$

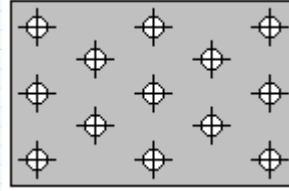
$$y^{(12)} := [s \ s \ s \ s \ s \ 0 \ s \ 0 \ s \ 0 \ s \ 0 \ -s \ -s \ -s \ -s]^T$$

$$\langle y^{(12)} \rangle^T = [3 \ 3 \ 3 \ 3 \ 0 \ 0 \ 0 \ 0 \ -3 \ -3 \ -3 \ -3] \text{ ft}$$

Pile Group P13

$$X_{13} := 2 \cdot (2 \cdot s2 + E) \quad Y_{13} := 2 \cdot (s + E)$$

$$X_{13} = 13 \text{ ft} \quad Y_{13} = 8.5 \text{ ft}$$



P13

$$x^{(13)} := [-2 \cdot s2 \ s0 \ 2 \cdot s2 \ -s2 \ s2 \ -2 \cdot s2 \ s0 \ 2 \cdot s2 \ -s2 \ s2 \ -2 \cdot s2 \ s0 \ 2 \cdot s2]^T$$

$$\langle x^{(13)} \rangle^T = [-5.25 \ 0 \ 5.25 \ -2.625 \ 2.625 \ -5.25 \ 0 \ 5.25 \ -2.625 \ 2.625 \ -5.25 \ 0 \ 5.25] \text{ ft}$$

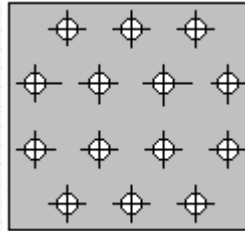
$$y^{(13)} := \left[s \ s \ s \ \frac{s}{2} \ \frac{s}{2} \ s0 \ s0 \ s0 \ -\frac{s}{2} \ -\frac{s}{2} \ -s \ -s \ -s \right]^T$$

$$\langle y^{(13)} \rangle^T = [3 \ 3 \ 3 \ 1.5 \ 1.5 \ 0 \ 0 \ 0 \ -1.5 \ -1.5 \ -3 \ -3 \ -3] \text{ ft}$$

Pile Group P14

$$X_{14} := 3 \cdot s + 2 \cdot E \quad Y_{14} := 2 \cdot (s3 + E)$$

$$X_{14} = 11.5 \text{ ft} \quad Y_{14} = 10.75 \text{ ft}$$



P14

$$x^{(14)} := \left[-s \ s0 \ s \ \frac{-3 \cdot s}{2} \ \frac{-s}{2} \ \frac{s}{2} \ \frac{3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \ \frac{-s}{2} \ \frac{s}{2} \ \frac{3 \cdot s}{2} \ -s \ s0 \ s \right]^T$$

$$\langle x^{(14)} \rangle^T = [-3 \ 0 \ 3 \ -4.5 \ -1.5 \ 1.5 \ 4.5 \ -4.5 \ -1.5 \ 1.5 \ 4.5 \ -3 \ 0 \ 3] \text{ ft}$$

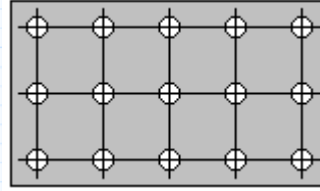
$$y^{(14)} := \left[s3 \ s3 \ s3 \ \frac{s}{2} \ \frac{s}{2} \ \frac{s}{2} \ \frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ -s3 \ -s3 \ -s3 \right]^T$$

$$\langle y^{(14)} \rangle^T = [4.125 \ 4.125 \ 4.125 \ 1.5 \ 1.5 \ 1.5 \ 1.5 \ -1.5 \ -1.5 \ -1.5 \ -1.5 \ -4.125 \ -4.125 \ -4.125] \text{ ft}$$

Pile Group P15

$$X_{15} := 4 \cdot s + 2 \cdot E \quad Y_{15} := 2 \cdot (s + E)$$

$$X_{15} = 14.5 \text{ ft} \quad Y_{15} = 8.5 \text{ ft}$$



P15

$$x^{(15)} := [-2 \cdot s \quad -s \quad s \quad 0 \quad s \quad 2 \cdot s \quad -2 \cdot s \quad -s \quad s \quad 0 \quad s \quad 2 \cdot s \quad -2 \cdot s \quad -s \quad s \quad 0 \quad s \quad 2 \cdot s]^T$$

$$(x^{(15)})^T = [-6 \quad -3 \quad 0 \quad 3 \quad 6 \quad -6 \quad -3 \quad 0 \quad 3 \quad 6 \quad -6 \quad -3 \quad 0 \quad 3 \quad 6] \text{ ft}$$

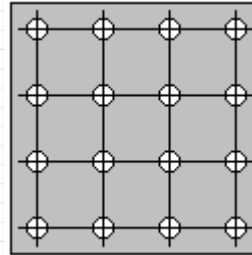
$$y^{(15)} := [s \quad s \quad s \quad s \quad s \quad s \quad 0 \quad s \quad 0 \quad s \quad 0 \quad s \quad 0 \quad s \quad 0 \quad s \quad 0 \quad s \quad 0 \quad s \quad 0 \quad s \quad 0 \quad s \quad 0 \quad -s \quad -s \quad -s \quad -s \quad -s]^T$$

$$(y^{(15)})^T = [3 \quad 3 \quad 3 \quad 3 \quad 3 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad -3 \quad -3 \quad -3 \quad -3 \quad -3] \text{ ft}$$

Pile Group P16

$$X_{16} := 3 \cdot s + 2 \cdot E \quad Y_{16} := 3 \cdot s + 2 \cdot E$$

$$X_{16} = 11.5 \text{ ft} \quad Y_{16} = 11.5 \text{ ft}$$



P16

$$x^{(16)} := \left[\begin{array}{cccccccccccccccc} -3 \cdot s & -s & s & 3 \cdot s & -3 \cdot s & -s & s & 3 \cdot s & -3 \cdot s & -s & s & 3 \cdot s & -3 \cdot s & -s & s & 3 \cdot s \\ 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 \end{array} \right]^T$$

$$(x^{(16)})^T = [-4.5 \quad -1.5 \quad 1.5 \quad 4.5 \quad -4.5 \quad -1.5 \quad 1.5 \quad 4.5 \quad -4.5 \quad -1.5 \quad 1.5 \quad 4.5 \quad -4.5 \quad -1.5 \quad 1.5 \quad 4.5] \text{ ft}$$

$$y^{(16)} := \left[\begin{array}{cccccccccccccccc} 3 \cdot s & 3 \cdot s & 3 \cdot s & 3 \cdot s & s & s & s & s & -s & -s & -s & -s & 3 \cdot s & 3 \cdot s & 3 \cdot s & 3 \cdot s \\ 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 \end{array} \right]^T$$

$$(y^{(16)})^T = [4.5 \quad 4.5 \quad 4.5 \quad 4.5 \quad 1.5 \quad 1.5 \quad 1.5 \quad 1.5 \quad -1.5 \quad -1.5 \quad -1.5 \quad -1.5 \quad -4.5 \quad -4.5 \quad -4.5 \quad -4.5] \text{ ft}$$

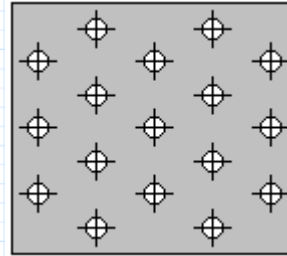
Pile Group P17

$$X_{17} := 4 \cdot s2 + 2 \cdot E$$

$$Y_{17} := 3 \cdot s + 2 \cdot E$$

$$X_{17} = 13 \text{ ft}$$

$$Y_{17} = 11.5 \text{ ft}$$



P17

$$x^{(17)} := [-s2 \ s2 \ -2 \cdot s2 \ s0 \ 2 \cdot s2 \ -s2 \ s2 \ -2 \cdot s2 \ s0 \ 2 \cdot s2 \ -s2 \ s2 \ -2 \cdot s2 \ s0 \ 2 \cdot s2 \ -s2 \ s2]^T$$

$$\langle x^{(17)} \rangle^T = [-2.625 \ 2.625 \ -5.25 \ 0 \ 5.25 \ -2.625 \ 2.625 \ -5.25 \ 0 \ 5.25 \ \dots] \text{ ft}$$

$$y^{(17)} := \left[\frac{3 \cdot s}{2} \ \frac{3 \cdot s}{2} \ s \ s \ s \ \frac{s}{2} \ \frac{s}{2} \ s0 \ s0 \ s0 \ -\frac{s}{2} \ -\frac{s}{2} \ -s \ -s \ -s \ \frac{-3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \right]^T$$

$$\langle y^{(17)} \rangle^T = [4.5 \ 4.5 \ 3 \ 3 \ 3 \ 1.5 \ 1.5 \ 0 \ 0 \ 0 \ -1.5 \ -1.5 \ -3 \ -3 \ -3 \ -4.5 \ -4.5] \text{ ft}$$

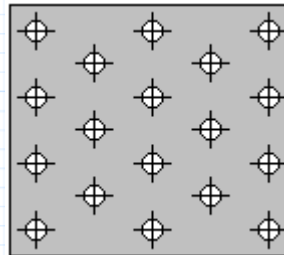
Pile Group P18

$$X_{18} := 4 \cdot s2 + 2 \cdot E$$

$$Y_{18} := 3 \cdot s + 2 \cdot E$$

$$X_{18} = 13 \text{ ft}$$

$$Y_{18} = 11.5 \text{ ft}$$



P18

$$x^{(18)} := [-2 \cdot s2 \ s0 \ 2 \cdot s2 \ -s2 \ s2 \ -2 \cdot s2 \ s0 \ 2 \cdot s2 \ -s2 \ s2 \ -2 \cdot s2 \ s0 \ 2 \cdot s2 \ -s2 \ s2 \ -2 \cdot s2 \ s0 \ 2 \cdot s2]^T$$

$$\langle x^{(18)} \rangle^T = [-5.25 \ 0 \ 5.25 \ -2.625 \ 2.625 \ -5.25 \ 0 \ 5.25 \ -2.625 \ 2.625 \ -5.25 \ 0 \ 5.25 \ -2.625 \ \dots] \text{ ft}$$

$$y^{(18)} := \left[\frac{3 \cdot s}{2} \ \frac{3 \cdot s}{2} \ \frac{3 \cdot s}{2} \ s \ s \ \frac{s}{2} \ \frac{s}{2} \ \frac{s}{2} \ s0 \ s0 \ -\frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ -s \ -s \ \frac{-3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \right]^T$$

$$\langle y^{(18)} \rangle^T = [4.5 \ 4.5 \ 4.5 \ 3 \ 3 \ 1.5 \ 1.5 \ 1.5 \ 0 \ 0 \ -1.5 \ -1.5 \ -1.5 \ -3 \ -3 \ -4.5 \ -4.5 \ -4.5] \text{ ft}$$

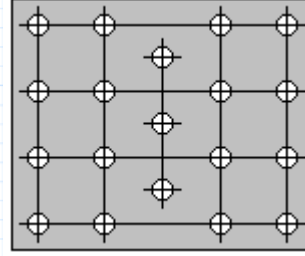
Pile Group P19

$$X_{19} := 2 \cdot (s + s2 + E)$$

$$Y_{19} := 3 \cdot s + 2 \cdot E$$

$$X_{19} = 13.75 \text{ ft}$$

$$Y_{19} = 11.5 \text{ ft}$$



P19

$$x^{(19)} := [-s4 \ -s2 \ s2 \ s4 \ s0 \ -s4 \ -s2 \ s2 \ s4 \ s0 \ -s4 \ -s2 \ s2 \ s4 \ s0 \ -s4 \ -s2 \ s2 \ s4]^T$$

$$(x^{(19)})^T = [-5.625 \ -2.625 \ 2.625 \ 5.625 \ 0 \ -5.625 \ -2.625 \ 2.625 \ 5.625 \ 0 \ -5.625 \ \dots] \text{ ft}$$

$$y^{(19)} := \left[\frac{3 \cdot s}{2} \ \frac{3 \cdot s}{2} \ \frac{3 \cdot s}{2} \ \frac{3 \cdot s}{2} \ s \ \frac{s}{2} \ \frac{s}{2} \ \frac{s}{2} \ \frac{s}{2} \ s0 \ -\frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ -s \ \frac{-3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \right]^T$$

$$(y^{(19)})^T = [4.5 \ 4.5 \ 4.5 \ 4.5 \ 3 \ 1.5 \ 1.5 \ 1.5 \ 1.5 \ 0 \ -1.5 \ -1.5 \ -1.5 \ -1.5 \ -3 \ -4.5 \ -4.5 \ -4.5 \ -4.5] \text{ ft}$$

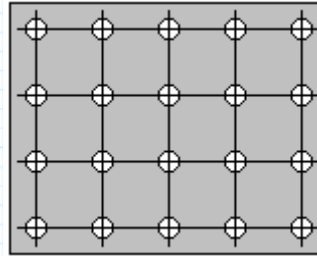
Pile Group P20

$$X_{20} := 4 \cdot s + 2 \cdot E$$

$$Y_{20} := 3 \cdot s + 2 \cdot E$$

$$X_{20} = 14.5 \text{ ft}$$

$$Y_{20} = 11.5 \text{ ft}$$



P20

$$x^{(20)} := [-2 \cdot s \ -s \ s0 \ s \ 2 \cdot s \ -2 \cdot s \ -s \ s0 \ s \ 2 \cdot s \ -2 \cdot s \ -s \ s0 \ s \ 2 \cdot s \ -2 \cdot s \ -s \ s0 \ s \ 2 \cdot s]^T$$

$$(x^{(20)})^T = [-6 \ -3 \ 0 \ 3 \ 6 \ -6 \ -3 \ 0 \ 3 \ 6 \ -6 \ -3 \ 0 \ 3 \ 6 \ -6 \ -3 \ 0 \ 3 \ 6] \text{ ft}$$

$$y^{(20)} := \left[\frac{3 \cdot s}{2} \ \frac{3 \cdot s}{2} \ \frac{3 \cdot s}{2} \ \frac{3 \cdot s}{2} \ \frac{3 \cdot s}{2} \ \frac{s}{2} \ \frac{s}{2} \ \frac{s}{2} \ \frac{s}{2} \ \frac{s}{2} \ \frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ -\frac{s}{2} \ \frac{-3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \ \frac{-3 \cdot s}{2} \right]^T$$

$$(y^{(20)})^T = [4.5 \ 4.5 \ 4.5 \ 4.5 \ 4.5 \ 1.5 \ 1.5 \ 1.5 \ 1.5 \ 1.5 \ -1.5 \ -1.5 \ -1.5 \ -1.5 \ -1.5 \ -4.5 \ -4.5 \ -4.5 \ -4.5 \ \dots] \text{ ft}$$