Units

$$psf = 1 \cdot \frac{lbf}{ft^2}$$

$$pcf := 1 \frac{lbf}{ft^2}$$

Analysis

Loading on the Footing

$$F_{Footing} := A_{Deck} \cdot \sigma_{Deck} + A_{Footing} \cdot \rho_{Concrete} \cdot \tau$$ Total force exerted by the footing on the soil

where

A_{Deck} is the tributary area of the deck assigned to the footing
σ_{Deck} is the loading factor of the deck specified by code
$A_{Footing}$ is the area of the footing
τ is the thickness of the footing
$\rho_{Concrete}$ is the density of the concrete

Required Footing Area

$$A_{Footing} = \frac{F_{Footing}}{\sigma_{Soil}} \text{ solve}, A_{Footing} \rightarrow \frac{A_{Deck} \cdot \sigma_{Deck}}{\sigma_{Soil} - \tau \cdot \rho_{Concrete}}$$ Solving for the required footing area. Note how we need the footing thickness to determine the required area. The footing thickness must meet he following constraint.

where

σ_{Soil} is the allowed soil loading factor from the code

Concrete Volume

$$V_{Concrete}(\tau) := \frac{A_{Deck} \cdot \sigma_{Deck}}{\sigma_{Soil} - \tau \cdot \rho_{Concrete}} \cdot \tau$$ $$\tau \geq \frac{D - 5.5}{2}$$ where D is the round footing's diameter and τ is the footing thickness.

Optimization Example

$\sigma_{\textbf{Deck}} := 50$ **Standard deck loading limit**

$\rho_{\textbf{Concrete}} := 150$ **Typical concrete density**

$h\left(\tau, A_{\textbf{Deck}}, \sigma_{\textbf{Soil}}\right) := \dfrac{A_{\textbf{Deck}} \cdot \sigma_{\textbf{Deck}}}{\sigma_{\textbf{Soil}} - \tau \cdot \rho_{\textbf{Concrete}}}$ **Footing area**

$f\left(\tau, A, \sigma_{\textbf{Soil}}\right) := \dfrac{A \cdot \sigma_{\textbf{Deck}}}{\sigma_{\textbf{Soil}} - \tau \cdot \rho_{\textbf{Concrete}}} \cdot \tau$ **Footing volume**

$\tau := 1$ **Algorithm starter value**

Given

$\qquad \tau \geq \dfrac{1}{2}$

$\qquad \tau \geq \dfrac{\left[\left(\dfrac{\dfrac{A \cdot \sigma_{\textbf{Deck}}}{\sigma_{\textbf{Soil}} - \tau \cdot \rho_{\textbf{Concrete}}}}{\pi}\right)^{0.5}\right] \cdot 2 - \dfrac{5.5}{12}}{2}$

$\textbf{q}\left(A, \sigma_{\textbf{Soil}}\right) := \textbf{Minimize}(f, \tau)$ **Optimization function**

$A := \textbf{matrix}(25, 1, \textbf{f}(\textbf{i}, \textbf{j}) \leftarrow 10 \cdot \textbf{i} + 10)$ **Vector of deck tributary areas**

$\textbf{S} := \begin{pmatrix} 1500 & 2000 & 2500 & 3000 \end{pmatrix}^{\textbf{T}}$ **Allowed soil ground pressures**

$\textbf{T} := \textbf{matrix}\left(25, 4, \textbf{z}(\textbf{i}, \textbf{j}) \leftarrow \textbf{q}\left(A_{\textbf{i}}, \textbf{S}_{\textbf{j}}\right)\right)$ **Footing thicknesses**

$\beta := \dfrac{\overrightarrow{\textbf{ceil}(\textbf{T} \cdot 12)}}{12}$ **Round the thicknesses up to integer values**

$\textbf{H} := \textbf{matrix}\left[25, 4, \textbf{z}(\textbf{i}, \textbf{j}) \leftarrow 2\left(\dfrac{\textbf{h}\left(\textbf{T}_{\textbf{i}, \textbf{j}}, A_{\textbf{i}}, \textbf{S}_{\textbf{j}}\right)}{\pi}\right)^{0.5}\right]$ **Matrix of footer radii**

$\textbf{H} := \dfrac{\overrightarrow{\textbf{ceil}(\textbf{H} \cdot 12)}}{12}$ **Round the radii up to the nearest in**

$\textbf{T} := \textbf{augment}\left(\overrightarrow{\textbf{q}(A, 1500)}, \overrightarrow{\textbf{q}(A, 2000)}, \overrightarrow{\textbf{q}(A, 2500)}, \overrightarrow{\textbf{q}(A, 3000)}\right)$ **Compute data for the various soil pressures**

$\textbf{Final} := \textbf{augment}\left(\dfrac{A}{12}, \textbf{H}^{\langle 0 \rangle}, \beta^{\langle 0 \rangle}, \textbf{H}^{\langle 1 \rangle}, \beta^{\langle 1 \rangle}, \textbf{H}^{\langle 2 \rangle}, \beta^{\langle 2 \rangle}, \textbf{H}^{\langle 3 \rangle}, \beta^{\langle 3 \rangle}\right)$ **Pull all the data together into a matrix for Excel display**

Tributary Areas (ft2)	1500 psf Round Footing Dia. (in)	Footing Thickness (in)	2000 psf Round Footing Dia. (in)	Footing Thickness (in)	2500 psf Round Footing Dia. (in)	Footing Thickness (in)	3000 psf Round Footing Dia. (in)	Footing Thickness (in)
10	9	6	7	6	7	6	6	6
20	12	6	10	6	9	6	8	6
30	14	6	12	6	11	6	10	6
40	17	6	14	6	13	6	12	6
50	18	7	16	6	14	6	13	6
60	20	8	17	6	16	6	14	6
70	22	8	19	7	17	6	15	6
80	23	9	20	8	18	6	16	6
90	25	10	21	8	19	7	17	6
100	26	11	22	9	20	7	18	7
110	28	11	24	9	21	8	19	7
120	29	12	25	10	22	8	20	7
130	30	13	26	10	23	9	21	8
140	31	13	27	11	24	9	22	8
150	33	14	28	11	25	10	22	9
160	34	14	29	12	25	10	23	9
170	35	15	29	12	26	11	24	9
180	36	15	30	13	27	11	24	10
190	37	16	31	13	28	11	25	10
200	38	17	32	14	28	12	26	10
210	39	17	33	14	29	12	26	11
220	40	18	34	14	30	12	27	11
230	41	18	35	15	30	13	28	11
240	42	19	35	15	31	13	28	12
250	43	19	36	16	32	13	29	12

Table B3. Footing Sizes[1] Based on Tributary Area for Various Soil Capacities.

Tributary Area[2] (sq. ft)	1500 psf Round Footing Diameter (in.)	Square Footing (in.)	Footing Thickness (in.)	2000 psf Round Footing Diameter (in.)	Square Footing (in.)	Footing Thickness (in.)	2500 psf Round Footing Diameter (in.)	Square Footing (in.)	Footing Thickness (in.)	3000 psf Round Footing Diameter (in.)	Square Footing (in.)	Footing Thickness (in.)
10	8	7	6	7	7	6	7	6	6	6	5	6
20	12	10	6	10	9	6	9	8	6	8	7	6
30	14	13	6	12	11	6	11	10	6	10	9	6
40	16	15	6	14	13	6	13	11	6	12	10	6
50	18	16	7	16	14	6	14	13	6	13	12	6
60	20	18	8	17	15	6	16	14	6	14	13	6
70	22	19	9	19	17	7	17	15	6	15	14	6
80	23	21	9	20	18	8	18	16	7	16	15	6
90	25	22	10	21	19	8	19	17	7	17	15	6
100	26	23	11	23	20	9	20	18	8	18	16	7
110	28	25	12	24	21	10	21	19	8	19	17	7
120	29	26	12	25	22	10	22	19	9	20	18	8
130	30	27	13	26	23	11	23	20	9	21	18	8
140	31	28	13	27	24	11	24	21	10	22	19	9
150	33	29	14	28	25	12	25	22	10	22	20	9
160	34	30	15	29	25	12	25	23	10	23	20	9
170	35	31	15	30	26	13	26	23	11	24	21	10
180	36	32	16	30	27	13	27	24	11	24	22	10
190	37	33	16	31	28	13	28	25	12	25	22	10
200	38	34	17	32	29	14	28	25	12	26	23	11
210	39	35	17	33	29	14	29	26	12	26	23	11
220	40	35	18	34	30	15	30	26	13	27	24	11
230	41	36	18	35	31	15	31	27	13	28	25	12
240	42	37	19	35	31	15	31	28	13	28	25	12
250	43	38	19	36	32	16	32	28	14	29	26	12

1. Assumes 40 psf live load, 10 psf dead load, 150 pcf concrete and 2,500 psi compressive strength of concrete. Coordinate footing thickness with post base and anchor requirements.
2. Tributary area shall be multiplied by 1.25 at center posts with beams not spliced (continuous).