

Foundation Design | (2nd Edition)

Chapter 6, Problem 9QPP

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Step-by-step solution

Step 1 of 9

Calculate the weight of the foundation.

$$W_f = V\gamma$$

$$= LBD\gamma$$

Here, V is the volume of the foundation, L is the length of the foundation, B is the width of the foundation, D is the depth of the foundation, and γ is the unit weight of the foundation.

Substitute 8 ft for L , 5 ft for B , 3 ft for D , and 123 lb/ft^3 for γ .

$$W_f = 8 \times 5 \times 3 \times 123$$

$$= 14,760 \text{ lb}$$

$$= 14.760 \text{ k}$$

Calculate the base area of footing.

$$A = LB$$

Substitute 8 ft for L and 5 ft for B .

$$A = 8 \times 5$$

$$= 40 \text{ ft}^2$$

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Step 2 of 9

Calculate allowable bearing capacity.

$$q_a = \frac{P + W_f}{A} - u$$

Here, P is the applied normal load, A is the base area of the footing, and u is the pore water pressure.

Substitute 200 k for P , 14.760 k for W_f , 40 ft^2 for A , and 0 for u .

$$q_a = \frac{200 + 14.760}{40} - 0$$

$$= 5.369 \text{ k}$$

Calculate ultimate bearing capacity using total stress analysis.

$$q_{ult} = c'N_c s_c d_c i_c b_c g_c + \sigma'_{zd} N_q s_q d_q i_q b_q g_q + 0.5\gamma' B N_\gamma s_\gamma d_\gamma i_\gamma b_\gamma g_\gamma \dots (1)$$

Here, s_c, s_q, s_γ are shape factors, d_c, d_q, d_γ are depth factors, i_c, i_q, i_γ are load inclination factors, b_c, b_q, b_γ are base inclination factors, g_c, g_q, g_γ are ground inclination factors, c' is effective cohesion for soil beneath foundation, N_c, N_q, N_γ are Terzaghi's bearing capacity factors, σ'_{zd} is vertical effective stress at depth D below ground surface, and ϕ_r is effective friction angle for soil beneath foundation.

Ignore b and g factors, since the foundation base is not inclined and also there is no ground inclination.

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Refer to table 6.1, "Bearing capacity factors," in the textbook.

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$$N_q = 14.7$$

$$N_r = 16.7$$

Calculate shape factor s_c .

$$s_c = 1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$$

Substitute 5 ft for B , 8 ft for L , 14.7 for N_q , and 25.8 for N_c .

$$\begin{aligned} s_c &= 1 + \left(\frac{5}{8}\right)\left(\frac{14.7}{16.7}\right) \\ &= 1 + (0.625 \times 0.88) \\ &= 1.55 \end{aligned}$$

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Calculate shape factor s_q .

$$s_q = 1 + \left(\frac{B}{L}\right) \tan \phi'$$

Substitute 5 ft for B , 8 ft for L , and 28° for ϕ' .

$$\begin{aligned} s_q &= 1 + \left(\frac{5}{8}\right) \tan 28^\circ \\ &= 1 + (0.625 \times 0.53) \\ &= 1.54 \end{aligned}$$

Calculate shape factor s_r .

$$s_r = 1 - 0.4 \left(\frac{B}{L}\right)$$

Substitute 5 ft for B and 8 ft for L .

$$\begin{aligned} s_r &= 1 - 0.4 \left(\frac{5}{8}\right) \\ &= 0.75 \end{aligned}$$

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Step 5 of 9

Calculate depth factors.

$$\frac{D}{B} \leq 1$$

Substitute 5 ft for B and 3 ft for d .

$$\begin{aligned} \frac{3}{5} &\leq 1 \\ 0.6 &\leq 1 \end{aligned}$$

Consider formula k for shallow foundation.

$$k = \frac{D}{B}$$

Substitute 5 ft for B and 3 ft for d .

$$\begin{aligned} k &= \frac{3}{5} \\ &= 0.6 \end{aligned}$$

Calculate depth factor d_c .

$$d_c = 1 + 0.4k$$

Substitute 0.6 for k .

$$\begin{aligned} d_c &= 1 + (0.4 \times 0.6) \\ &= 1.24 \end{aligned}$$

Calculate depth factor d_q .

$$d_q = 1 + 2k \tan \phi' (1 - \sin \phi')^2$$



$$= 1 + (0.636 \times 0.29)$$

$$= 1.185$$

Calculate depth factor d_f .

$$d_f = 1$$

Calculate m , for loads inclined in L direction.

$$m = \frac{2 + \frac{L}{B}}{1 + \frac{L}{B}}$$

Substitute 5 ft for B and 8 ft for L .

$$m = \frac{2 + \frac{8}{5}}{1 + \frac{8}{5}}$$

$$= \frac{2 + 1.6}{1 + 1.6}$$

$$= \frac{3.6}{2.6}$$

$$= 1.38$$

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Calculate load inclination factor i_e .

$$i_e = 1 - \frac{mV}{Ac'N_c}$$

Substitute 1.38 for m , 40 ft² for A , 500 for c' , and 25.8 for N_c .

$$i_e = 1 - \frac{1.38 \times 25000}{40 \times 500 \times 25.8}$$

$$= 1 - \frac{34615.38}{516000}$$

$$= 1 - 0.067$$

$$= 0.93 \geq 0$$

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Step 7 of 9

Calculate load inclination factor i_q .

$$i_q = \left[1 - \frac{V}{P + \frac{Ac'}{\tan \phi'}} \right]^m$$

Substitute 200,000 lb for P , 28° for ϕ' , 1.38 for m , 40 ft² for A , and 500 for c' .

$$i_q = \left[1 - \frac{25000}{200000 + \frac{40 \times 500}{\tan 28^\circ}} \right]^{1.38}$$

$$= \left[1 - \frac{25000}{200000 + \frac{200000}{0.53}} \right]^{1.38}$$

$$= [1 - 0.105]^{1.38}$$

$$= 0.85 \geq 0$$

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Calculate load inclination factor i_γ .

$$\left[\frac{P + \frac{P}{\tan \phi'}}{\tan \phi'} \right]$$

Substitute 200,000 lb for P , 28° for ϕ' , 1.38 for m , 40 ft^2 for A , and 500 for c' .

$$\begin{aligned} i_r &= \left[1 - \frac{25000}{200000 + \frac{40 \times 500}{\tan 28^\circ}} \right]^{1.38+1} \\ &= \left[1 - \frac{25000}{200000 + 37735.84} \right]^{2.38} \\ &= [1 - 0.105]^{2.38} \\ &= 0.75 \geq 0 \end{aligned}$$

Calculate the vertical effective stress at depth D .

$$\sigma'_{zD} = \gamma D - u$$

Substitute 123 lb/ft^3 for γ , 3 ft for D , and 0 for u .

$$\begin{aligned} \sigma'_{zD} &= 123 \times 3 - 0 \\ &= 369 \text{ lb/ft}^2 \end{aligned}$$

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Substitute 500 for c' , 369 lb/ft^2 for σ'_{zD} , 123 lb/ft^3 for γ' , 25.8 for N_c , 14.7 for N_q , 16.7 for N_γ , 1.55 for s_c , 1.54 for s_q , 0.75 for s_γ , 1.24 for d_c , 1.185 for d_q , 1 for d_γ , 0.93 for i_c , 0.85 for i_q , and 0.75 for i_γ in equation (1).

$$\begin{aligned} q_{ult} &= c'N_c s_c d_c i_c b_c g_c + \sigma'_{zD} N_q s_q d_q i_q b_q g_q + 0.5\gamma' B N_\gamma s_\gamma d_\gamma i_\gamma b_\gamma g_\gamma \\ &= \left[(500 \times 25.8 \times 1.55 \times 1.124 \times 0.93) + (369 \times 14.7 \times 1.54 \times 1.185 \times 0.85) \right] \\ &\quad + (0.5 \times 123 \times 5 \times 16.7 \times 0.75 \times 1 \times 0.75) \\ &= 32,203.74 \text{ lb} \\ &= 32.20374 \text{ k} \end{aligned}$$

Calculate factor of safety.

$$q_a = \frac{q_{ult}}{F}$$

$$F = \frac{q_{ult}}{q_a}$$

Substitute 5.369 k for q_a and 32.20374 k for q_{ult} .

$$\begin{aligned} F &= \frac{q_{ult}}{q_a} \\ &= \frac{32.20374}{5.369} \\ &= 6 \end{aligned}$$

Therefore, the required factor of safety is **6**.

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