4.3 Refer to Figure 4.2. Given: $B = L = 1.75$ m, $D_f = 1$ m, $H = 1.75$ m, $\gamma = 17$ kN/m^3, $c' = 0$, and $\phi' = 30°$. Using Eq. (4.6) and FS = 4, determine the gross allowable load the foundation can carry.

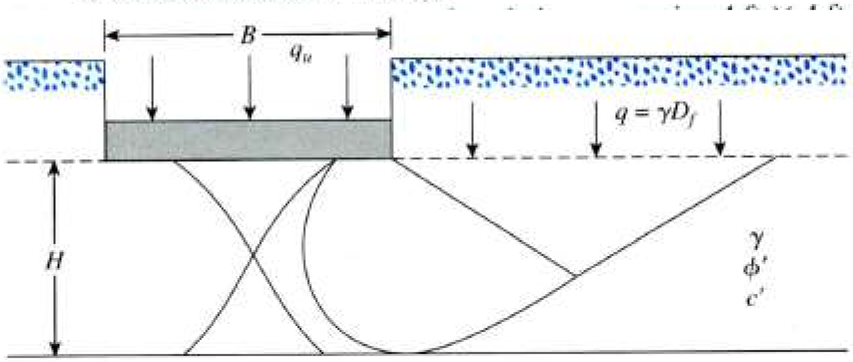


Figure 4.2 Failure surface under a rough, continuous foundation with a rigid, rough base located at a shallow depth

Given: $B := 1.75\ \text{m} \quad L := 1.75\ \text{m} \quad Df := 1\ \text{m} \quad H := 1.75\ \text{m} \quad \gamma := 17\ \frac{kN}{m^3} \quad c' := 0 \quad \phi' := 30deg \quad FS := 4$

Required: determine the gross allowable load the foundation can carry

$$\frac{H}{B} = 1 \qquad q := \gamma\cdot Df = 17$$

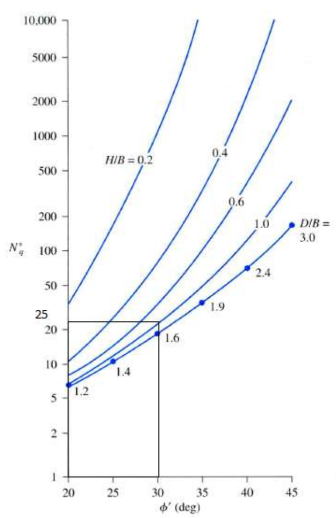


Figure 4.4 Mandel and Salencon's bearing capacity factor N_q^* [Eq. (4.2)]

From Figure 4.7, N'y:

$N'\gamma := 78$

$N'q := 22$

$qu := q\cdot N'q + .4\cdot\gamma\cdot B\cdot N'\gamma = 1.302\ \frac{kN}{m^3})^3 \qquad qa := \frac{qu}{FS} = 325.55$ Equ 4.6 p 187

$Qall := qa\cdot B\cdot L = 996.997$

4.5 Refer to Figure 4.8. For a strip foundation in two-layered clay, given:

- $\gamma_1 = 115\ \text{lb/ft}^3$, $c_1 = 1200\ \text{lb/ft}^2$, $\phi_1 = 0$
- $\gamma_2 = 110\ \text{lb/ft}^3$, $c_2 = 600\ \text{lb/ft}^2$, $\phi_2 = 0$
- $B = 3$ ft, $D_f = 2$ ft, $H = 2$ ft

Find the gross allowable bearing capacity. Use a factor of safety of 3.

$FS := 3 \quad \pi := 3.1415 \quad B := 3\ \text{ft} \quad Df := 2\ \text{ft} \quad H := 2\ \text{ft} \quad L := \infty \quad FS := 3$

$\gamma 1 := 115\ \dfrac{\text{lb}}{\text{ft}^3} \quad c1 := 1200\ \dfrac{\text{lb}}{\text{ft}^2} \quad \phi'1 := 0\text{deg}$

$\gamma 2 := 110\ \dfrac{\text{lb}}{\text{ft}^3} \quad c2 := 600\ \dfrac{\text{lb}}{\text{ft}^2} \quad \phi'2 := 0\text{deg}$

bearing capacity factors Table 3.3 p 144

$Nq1 := 1 \quad Nc1 := 5.14 \quad N\gamma 1 := 0 \qquad Nq2 := 1 \quad Nc2 := 5.14 \quad N\gamma 2 := 0$

Method

Stronger clay over soft clay gives us special case 3, thus: Eq (4.29), (4.30) and (4.31) will apply:

Determine c2/c1 to obtain the value of ca from Figure 4.10

Apply equations cited above and obtain allowable load by using equation (3.12)

Solution

$\dfrac{c2}{c1} = 0.5$

Thus

$c'a := c1 \cdot 0.94 = 1.128 \times 10^3$

4.3 Bearing Capacity of Layered Soils: Stronger Soil Underlain by Weaker Soil 19

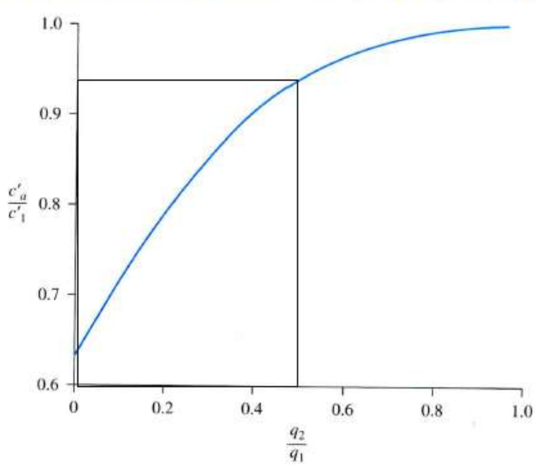


Figure 4.10 Variation of c'_a/c'_1 with q_2/q_1 based on the theory of Meyerhof and Hanna (1978)

$$qu := \left(1 + .2\frac{B}{L}\right)\cdot 5.14 \cdot c2 + \left(1 + \frac{B}{L}\right)\left(\frac{2c'a \cdot H}{B}\right) + \gamma 1 \cdot Df = 4.818 \times 10^3 \qquad \text{Eq 4.29 p195}$$

$$qt := \left(1 + .2\frac{B}{L}\right)5.14c1 + \gamma 1 \cdot Df = 6.398 \times 10^3 \qquad \text{Eq 4.30 p195}$$

solution: $qall := \dfrac{\min(qu, qt)}{FS} = 1.606 \times 10^3$

4.7 Refer to Figure 4.8. For a square foundation on layered sand, given:

- $B = 1.5$ m, $D_f = 1.5$ m, $H = 1$ m
- $\gamma_1 = 18$ kN/m^3, $\phi'_1 = 40°$, $c'_1 = 0$
- $\gamma_2 = 16.7$ kN/m^3, $\phi'_2 = 32°$, $c'_2 = 0$

Given: $B := 1.5$ $Df := 1.5$ $H := 1$ $L := 1.5$

Find: determine the gross allowable load the foundation can carry

$\gamma 1 := 18$ $c1 := 0$ $\phi'1 := 40deg$ $\gamma 2 := 16.7$ $c2 := 0$ $\phi'2 := 32deg$ $FS := 4$

Method

Case 2 Special Cases, thus use equations (4.26 and 4.27)
Determine factors for each of the layers, using table 3.3 and table 3.4

Table 3.3

$Nq1 := 64.2$ $Nq2 := 23.18$
$N\gamma 1 := 109.41$ $N\gamma 2 := 30.22$

Table 3.4

$F\gamma s1 := 1 - 0.4\cdot\left(\frac{B}{L}\right) = 0.6$ $F\gamma s2 := 1 - 0.4\cdot\left(\frac{B}{L}\right) = 0.6$

$Fqs1 := 1 + 1\cdot\tan(\phi'1) = 1.839$ $Fqs2 := (1 + 1\cdot\tan(\phi'2)) = 1.625$

Determine Ks, using angle of friction on the top layer (layer 1), Figure 4.9 and from equations (4.15) & (4.16):

Eq 4.15 p192

$q1 := c1\cdot Nc1 + 0.5\cdot\gamma 1\cdot B\cdot N\gamma 1 = 1.477\times 10^3$

Eq 4.16 p192

$q2 := c2\cdot Nc2 + 0.5\cdot\gamma 2\cdot B\cdot N\gamma 2 = 378.505$ $\frac{q2}{q1} = 0.256$

$Ks := 5$ $\frac{B}{L} = 1$

Determine Qall=qall*A

Solution

$$qu := [\gamma 1\cdot(Df + H)Nq2\cdot Fqs2 + .5\gamma 2\cdot B\cdot N\gamma 2\cdot F\gamma s2] + H^2\cdot\gamma 1\left(1 + \frac{B}{L}\right)\left(1 + \frac{2Df}{H}\right)\left(\frac{Ks\cdot\tan(\phi'1)}{B}\right) - \gamma 1\cdot H = 2.307\times 10^3$$ eqn 4.26 p 194

$$qt := \gamma 1\cdot Df\cdot Nq1\cdot Fqs1 + .5\gamma 1\cdot B\cdot N\gamma 1\cdot F\gamma s1 = 4.074\times 10^3$$

$qall := \frac{\min(qu,qt)}{FS} = 576.693$ $q := Df\cdot\gamma = 25.5$ $qnet := qall - q$ $Qnet := qnet\cdot B\cdot L = 1.24\times 10^3$

4.9 Given: $B := 1.2$ $Df := 1$ $x := 2$ $\phi' := 35deg$ $FS := 4$ $\gamma := 16.8$ $L := \infty$ $FS = 4$

Find: Determine the net allowable bearing capacity of the foundation can carry

Method

1. Use table 3.3 to determine Nq and Ny, and Figure 4.13 p202 to determine ζq ζy
2. Apply equation 4.36 to determine ultimate bearing
3. Determine qnet=qu-q

Solution 1. $Nq := 12.75$ $N\gamma := 8.35$ $\frac{x}{B} = 1.667$ $\zeta q := 1.4$ $\zeta\gamma := 2.4$

$qu := q\cdot Nq\cdot\zeta q + .5\cdot\gamma\cdot B\cdot N\gamma\cdot\zeta\gamma = 657.178$ $q := \gamma\cdot Df = 16.8$

$qnet := qu - q = 640.378$ $\frac{kN}{m^2}$

$qall := \frac{qnet}{FS} = 160.095$

Given :

$B := 1 \quad H := 4 \quad b := 2 \quad c' := 68$

$\gamma := 16.8 \quad \phi := 0 \quad \beta := 60\text{deg}$

$FS := 3 \quad Df = 1$

4.10 A continuous foundation with a width of 1 m is located on a slope made of clay soil. Refer to Figure 4.14 and let $D_f = 1$ m, $H = 4$ m, $b = 2$ m, $\gamma = 16.8$ kN/m^3, $c = 68$ kN/m^2, $\phi = 0$, and $\beta = 60°$.

a. Determine the allowable bearing capacity of the foundation. Let FS = 3.

b. Plot a graph of the ultimate bearing capacity q_u if b is changed from 0 to 6 m.

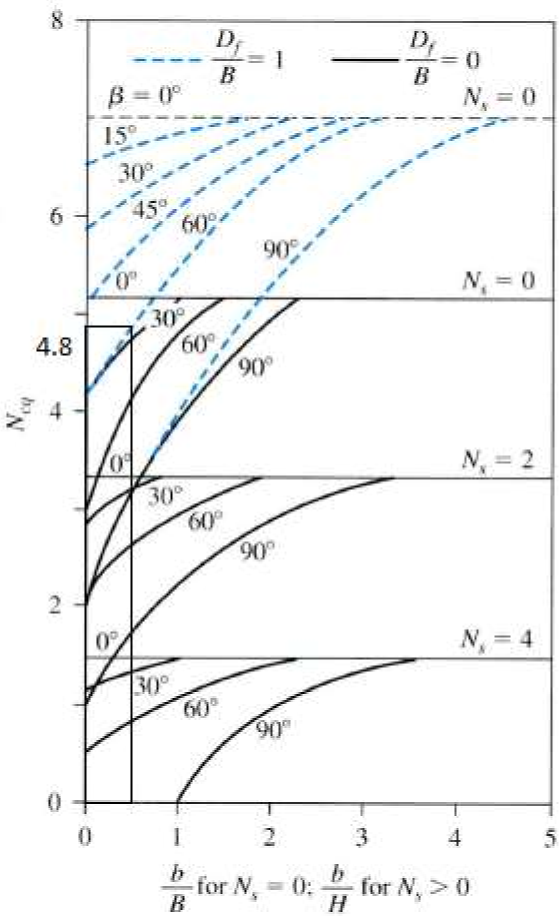


Figure 4.16 Meyerhof's bearing capacity factor N_{cq} for purely cohesive soil

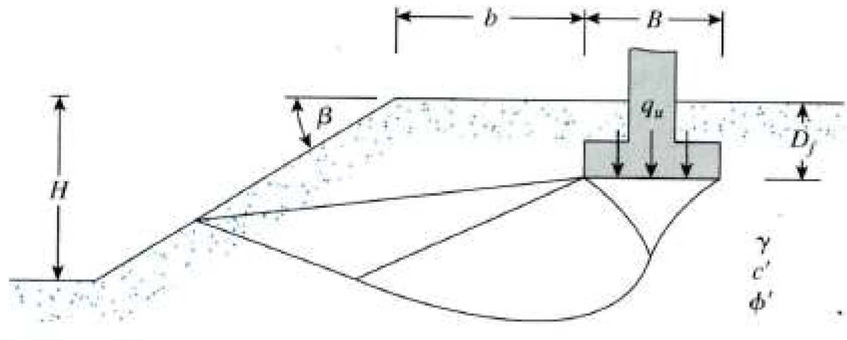


Figure 4.14 Shallow foundation on top of a slope

Method
1. Ns must be obtained using equation 4.40
   If Ns=0 use b/B and if Ns>0 use b/H on Figure 4.16
2. Determine ultimate bearing capacity with eq 4.39
3. Determine qall=qu/FS eq 3.12

$\frac{Df}{B} = 1$

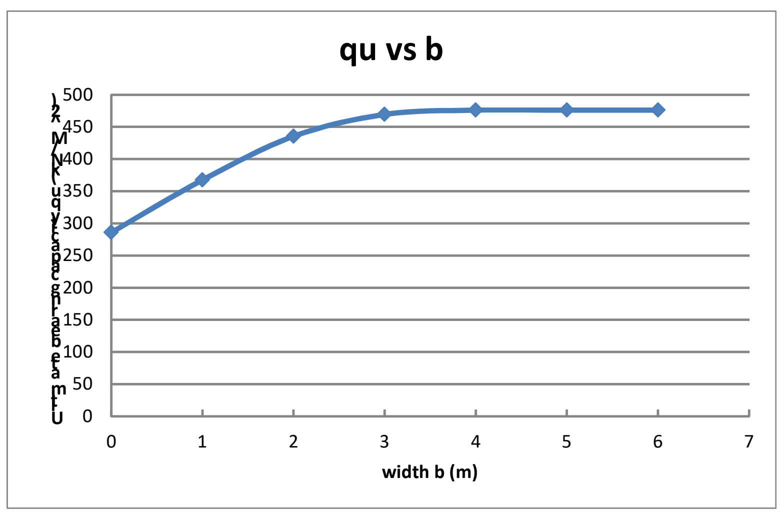
Solution

1. $Ns := \frac{\gamma \cdot H}{c} = 2.242 \times 10^{-7} \frac{s}{m} \qquad \frac{b}{B} = 2 \qquad Ncq := 6.5$

2. $qu := c' \cdot Ncq = 442$ eq 4.39 p 203

3. $qall := \frac{qu}{FS} = 147.333$

Part B)



Given $FS := 3$ $Df := 4$

$B := 4$ $H := 15$ $b := 6$ $c := 0$

$FS := 4$ $\gamma := 110$ $\phi := 40$ $\beta := 30deg$

4.11 A continuous foundation is to be constructed near a slope made of granular soil (see Figure 4.14). If $B = 4$ ft, $b = 6$ ft, $H = 15$ ft, $D_f = 4$ ft, $\beta = 30°$, $\phi' = 40°$, and $\gamma = 110\ \text{lb/ft}^3$, estimate the ultimate bearing capacity of the foundation. Use Meyerhof's solution.

Method 1. Nyq must be obtained using Figure 4.15
2. Determine ultimate bearing capacity with eq 4.38

Solution 1. $\frac{Df}{B} = 1$ $\frac{b}{B} = 1.5$ $N\gamma q := 135$ $Ncq := 4.8$

2 $qu := .5\cdot\gamma\cdot B\cdot N\gamma q = 2.97 \times 10^{4}$ eq 4.38 p 203 3 $qall := \frac{qu}{FS} = 7.425 \times 10^{3}$

4.12 A square foundation in a sand deposit measures 4 ft × 4 ft in plan. Given: $D_f = 5$ ft, soil friction angle = 35°, and unit weight of soil = 112 lb/ft³. Estimate the ultimate uplift capacity of the foundation.

Given: $B := 4$ $L := 4$ $Df1 := 5$ $\phi' := 35deg$ $\gamma := 112\ \frac{lb}{ft^{3}}$ Granular soil, c'=0 $A := B\cdot L = 16$

Find: Ultimate uplift capacity of the foundation

Method: 1. Determine the type of foundation dealt
1.1 (Calculate Df/B)
1.2. Using Table 4.3 and Eq 4.55 determine Df/B, cr
2. Determine the breakout factor Fq (using either 4.53/4.54) given the factor calculated above
3. Obtain Qu using formula 4.52

Solution: 1.1 $\frac{Df1}{B} = 1.25$ 1.2 $Ku := 0.936$ $m := 0.25$ $\frac{Dcr}{B} := 5$

Since $1.1 < 1.2$ $\frac{Df}{B} := \frac{Df1}{B}$

2 square foundation $Fq := 1 + 2\left[1 + m\cdot\left(\frac{Df1}{B}\right)\right]\left(\frac{Df1}{B}\right)\cdot Ku\cdot\tan(\phi') = 3.151$ eq 4.54 p 214

3 $Qu := Fq\cdot A\cdot\gamma\cdot Df1 = 2.823 \times 10^{4}\ lb$