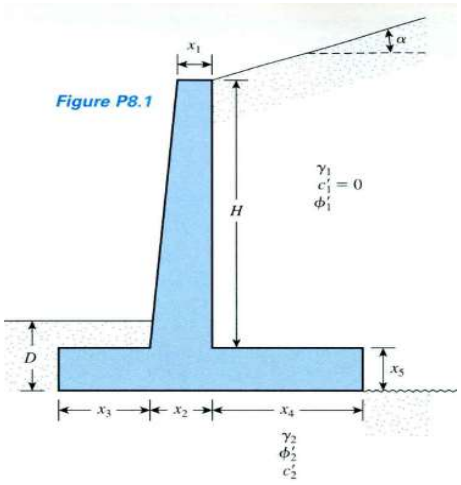
In Problems 8.1 through 8.4, use $\gamma c := 23.58\frac{kN}{m^3}$ $k1 := \frac{2}{3}$ $k2 := \frac{2}{3}$ $Pp := 0$

8.2 Repeat Problem 8.1 with the following:

Wall dimensions: $H = 6.5$ m, $x_1 = 0.3$ m, $x_2 = 0.6$ m, $x_3 = 0.8$ m, $x_4 = 2$ m, $x_5 = 0.8$ m, $D = 1.5$ m, $\alpha = 0°$

Soil properties: $\gamma_1 = 18.08$ kN/m³, $\phi_1' = 36°$, $\gamma_2 = 19.65$ kN/m³, $\phi_2' = 15°$, $c_2' = 30$ kN/m²

Calculate the factor of safety with respect to overturning, sliding, and bearing capacity



Wall dimensions $H := 6.5m$ $x1 := .3m$ $x2 := .6m$ $x3 := .8m$ $x4 := 2m$ $x5 := .8m$ $D := 1.5m$ $\alpha := 0deg$

Soil properties $\gamma1 := 18.08\frac{kN}{m^3}$ $\gamma2 := 19.65\frac{kN}{m^3}$ $\phi'1 := 36deg$ $\phi'2 := 15deg$ $c'2 := 30\frac{kN}{m^2}$ $B := x3 + x2 + x4 = 3.4\,m$

METHOD A) OVERTURNING STABILITY:

1. Determine the Rankine Active Force per unit length of Wall
1.1 Determine Ka (actie earth pressure coefficient) and H'
2. Determine the horizontal component and moment caused by that, which represent the overturning moment
3. Determine the resisting forces and its corresponding moments
4. Determine FSoverturning

B) SLIDING Sliding Factor of Safety can be calculated with EQ 8.11

C) BEARING CAPACITY FAILURE

0. Determine eccentricity and maximum and minimum pressures (pressures at the toe and heel of wall)
1. Use Table 3.3 to determine Bearing Capacity Factors
2. Use Table 3.4 to determine Shape, Depth and Inclination Factors
3. Use Meyerhoff's Equation 3.19 do determine bearing capacity qu

SOLUTION $H' := H + x5 = 7.3\,m$ With $\phi'1 := 36deg$ $\alpha := 0deg$ $Ka := 0.2596$ Table 7.1

$Pa := .5\cdot\gamma1\cdot H'^2\cdot Ka = 1.251\times10^5\frac{kg}{s^2}$ $Pa := 125\frac{kN}{m}$

Horizontal Component (Overturning Moment):

$Ph := Pa\cdot\cos(\alpha) = 1.25\times10^5\frac{kg}{s^2}$ $Ph := 125\frac{kN}{m}$ $Mo := Ph\cdot\left(\frac{H'}{3}\right) = 3.042\times10^5\,N$

Resisting Components:

$Pv := Pa\cdot\sin(\alpha) = 0\frac{kg}{s^2}$ $Pav := 0\frac{kN}{m}$

SEC	AREA (m^2)	W/unit length	M. Arm to C (m)	Moment kN-m/m
1	$A1 := x1\cdot H = 1.95\,m^2$	$w1 := \gamma c\cdot A1 = 4.598\times10^4\frac{kg}{s^2}$	$B1 := x3 + x2 - \frac{x1}{2} = 1.25\,m$	$M1 := w1\cdot B1 = 5.748\times10^4\,N$
1	$A2 := (x2 - x1)\cdot\frac{H}{2} = 0.975\,m^2$	$w2 := \gamma c\cdot A2 = 2.299\times10^4\frac{kg}{s^2}$	$B2 := x3 + \frac{2}{3}\left(x2 - \frac{x1}{2}\right) = 1.1\,m$	$M2 := w2\cdot B2 = 2.529\times10^4\,N$

1 $A3 := x5 \cdot B = 2.72\,m^2$ $w3 := \gamma c \cdot A3 = 6.414 \times 10^4 \frac{kg}{s^2}$ $B3 := \frac{B}{2} = 1.7\,m$ $M3 := w3 \cdot B3 = 1.09 \times 10^5\,N$

1 $A4 := x4 \cdot H = 13\,m^2$ $w4 := \gamma 1 \cdot A4 = 2.35 \times 10^5 \frac{kg}{s^2}$ $B4 := B - \frac{x4}{2} = 2.4\,m$ $M4 := w4 \cdot B4 = 5.641 \times 10^5\,N$

$\Sigma V := w1 + w2 + w3 + w4 = 3.681 \times 10^5 \frac{kg}{s^2}$ $\Sigma Mr := M1 + M2 + M3 + M4 = 7.559 \times 10^5\,N$

$FSoverturning := \frac{\Sigma Mr}{Mo} = 2.485$ $if(FSoverturning > 2, "OK!", "No Good") = "OK!"$

Factor of Safety against Sliding

EQ 8.11 $FSsliding := \frac{(\Sigma V \cdot \tan(k1 \cdot \phi'2) + B \cdot k2 \cdot c'2 + Pp)}{Pa \cdot \cos(\alpha)} = 1.063$ $if(FSsliding > 1.5, "okay", "not good") = "not good"$

FACTOR OF SAFETY AGAINST BEARING CAPACITY FAILURE

$e := \frac{B}{2} - \frac{(\Sigma Mr - Mo)}{\Sigma V} = 0.473\,m$ EQ 8.16, 8.17 and 8.18 $if\left(e < \frac{B}{6}, "okay", "not good"\right) = "okay"$

$qtoe := \frac{\Sigma V}{B} \cdot \left(1 + 6 \cdot \frac{e}{B}\right) = 1.987 \times 10^5\,Pa$ $qheel := \frac{\Sigma V}{B} \cdot \left(1 - 6 \cdot \frac{e}{B}\right) = 1.79 \times 10^4\,Pa$ $B' := (B - 2e) = 2.454\,m$

Using Table 3.3 we have: $\phi'2 := 15deg$ $Nc := 10.98$ $Nq := 3.94$ $N\gamma := 2.65$

$p := \frac{D}{B'} = 0.611$ $F\gamma d := 1$ $Fqd := 1 + 2 \cdot \tan(\phi'2) \cdot (1 - \sin(\phi'2))^2 \cdot \left(\frac{D}{B'}\right) = 1.18$ $Fcd := Fqd - \frac{(1 - Fqd)}{Nc \cdot \tan(\phi'2)} = 1.241$

$\psi := \operatorname{atan}\left(\frac{Pa \cdot \cos(\alpha)}{\Sigma V}\right) = 0.327$ $\psi := 18.736deg$ $Fci := \left(1 - \frac{\psi}{90 \cdot deg}\right)^2 = 0.627$ $Fqi := Fci = 0.627$ $F\gamma i := \left(1 - \frac{\psi}{\phi'2}\right)^2 = 0.062$

$q := \gamma 2 \cdot D = 2.947 \times 10^4\,Pa$

$qu := c'2 \cdot Nc \cdot Fcd \cdot Fci + q \cdot Nq \cdot Fqd \cdot Fqi + .5 \cdot \gamma 2 \cdot B' \cdot N\gamma \cdot F\gamma d \cdot F\gamma i = 3.462 \times 10^5\,Pa$

$FSbearing := \frac{qu}{qtoe} = 1.743$ $if(FSbearing > 3, "okay", "not good") = "not good"$

8.4 Repeat Problem 8.3 using Coulomb's active earth pressure in your calculation and letting $\delta' = 2/3\,\phi_1'$.

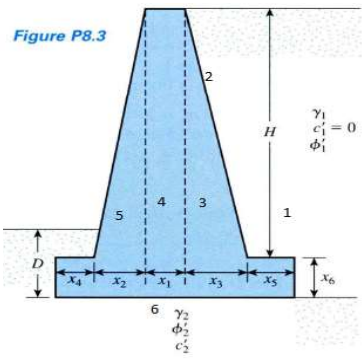
8.3 A gravity retaining wall is shown in Figure P8.3. Calculate the factor of safety with respect to overturning and sliding, given the following data:

Wall dimensions: $H = 6$ m, $x_1 = 0.6$ m, $x_2 = 2$ m, $x_3 = 2$ m, $x_4 = 0.5$ m, $x_5 = 0.75$ m, $x_6 = 0.8$ m, $D = 1.5$ m

Soil properties: $\gamma_1 = 16.5$ kN/m³, $\phi_1' = 32°$, $\gamma_2 = 18$ kN/m³, $\phi_2' = 22°$, $c_2' = 40$ kN/m²

Use the Rankine active earth pressure in your calculation.

Figure P8.3



wall dimensions $H := 6m$ $x1 := .6m$ $x2 := 2m$ $x3 := 2m$ $x4 := .5m$ $x5 := .75m$ $x6 := .8m$ $D := 1.5m$

Soil properties $\gamma 1 := 16.5\frac{kN}{m^3}$ $\gamma 2 := 18\frac{kN}{m^3}$ $\phi'1 := 32deg$ $\phi'2 := 22deg$ $c'2 := 40\frac{kN}{m^2}$ $B := x4 + x2 + x1 + x3 + x5 = 5.85\,m$

METHOD A) OVERTURNING STABILITY:

$\delta' := \frac{2}{3}\cdot\phi'1 = 0.372$

1. Determine the Rankine Active Force per unit length of Wall
1.1 Determine Ka (actie earth pressure coefficient) and H'
2. Determine the horizontal component and moment caused by that, which represent the overturning moment
3. Determine the resisting forces and its corresponding moments
4. Determine FSoverturning

B) SLIDING Sliding Factor of Safety can be calculated with EQ 8.11

C) BEARING CAPACITY FAILURE

0. Determine eccentricity and maximum and minimum pressures (pressures at the toe and heel of wall)
1. Use Table 3.3 to determine Bearing Capacity Factors
2. Use Table 3.4 to determine Shape, Depth and Inclination Factors
3. Use Meyerhoff's Equation 3.19 do determine bearing capacity qu

SOLUTION $H' := H + x5 = 6.75\,m$ $\beta := atan\left(\frac{H}{x3}\right)\cdot\left(\frac{180}{\pi}\right) = 71.565$ $\beta := 71.566deg$ $Ka := .439$ Ka table 7.4

With $\phi'1 := 36deg$ $\alpha := 90 - \frac{\beta}{deg} + 21.333 = 39.767$ $\alpha := \alpha\cdot deg = 0.694$

$Pa := .5\cdot\gamma 1\cdot H'^2\cdot Ka = 1.65\times 10^5\frac{kg}{s^2}$ $Pa := 165\frac{kN}{m}$

Horizontal Component (Overturning Moment):

$Ph := Pa\cdot\cos(\alpha) = 1.268\times 10^5\frac{kg}{s^2}$ $Ph := 126\frac{kN}{m}$ $Mo := Ph\cdot\left(\frac{H'}{3}\right) = 2.835\times 10^5\,N$

Resisting Components:

$Pv := Pa\cdot\sin(\alpha) = 1.055\times 10^5\frac{kg}{s^2}$ $Pv := 105\frac{kN}{m}$

SEC	AREA (m^2)	W/unit length	M. Arm to C (m)	Moment kN-m/m
3	$A1 := x3\cdot\frac{H}{2} = 6\,m^2$	$w1 := \gamma c\cdot A1 = 1.415\times 10^5\frac{kg}{s^2}$	$B1 := B - (x5 + x3) + \frac{1x3}{3} = 3.767\,m$	$M1 := w1\cdot B1 = 5.329\times 10^5\,N$
4	$A2 := (x1)\cdot H = 3.6\,m^2$	$w2 := \gamma c\cdot A2 = 8.489\times 10^4\frac{kg}{s^2}$	$B2 := B - \left(x5 + x3 + \frac{x1}{2}\right) = 2.8\,m$	$M2 := w2\cdot B2 = 2.377\times 10^5\,N$
5	$A3 := x2\cdot H = 12\,m^2$	$w3 := \gamma c\cdot A3 = 2.83\times 10^5\frac{kg}{s^2}$	$B3 := x4 + \frac{2x2}{3} = 1.833\,m$	$M3 := w3\cdot B3 = 5.188\times 10^5\,N$
2	$A4 := x6\cdot B = 4.68\,m^2$	$w4 := \gamma c\cdot A4 = 1.104\times 10^5\frac{kg}{s^2}$	$B4 := \frac{B}{2} = 2.925\,m$	$M4 := w4\cdot B4 = 3.228\times 10^5\,N$

$\Sigma V := w1 + w2 + w3 + w4 = 6.197\times 10^5\frac{kg}{s^2}$ $\Sigma Mr := M1 + M2 + M3 + M4 = 1.612\times 10^6\,N$

$FSoverturning := \frac{\Sigma Mr}{Mo} = 5.687$

$if(FSoverturning > 2, "OK!", "No Good") = "OK!"$

Factor of Safety against Sliding

EQ 8.11 $FSsliding := \frac{(\Sigma V \cdot \tan(k1 \cdot \phi'2) + B \cdot k2 \cdot c'2 + Pp)}{Pa \cdot \cos(\alpha)} = 2.509$ $\text{if}(FSsliding > 1.5, \text{"okay"}, \text{"not good"}) = \text{"okay"}$

FACTOR OF SAFETY AGAINST BEARING CAPACITY FAILURE

$e := \frac{B}{2} - \frac{(\Sigma Mr - Mo)}{\Sigma V} = 0.781\,m$ EQ 8.16, 8.17 and 8.18 $\text{if}\left(e < \frac{B}{6}, \text{"okay"}, \text{"not good"}\right) = \text{"okay"}$

$qtoe := \frac{\Sigma V}{B} \cdot \left(1 + 6 \cdot \frac{e}{B}\right) = 1.908 \times 10^5\,Pa$ $qheel := \frac{\Sigma V}{B} \cdot \left(1 - 6 \cdot \frac{e}{B}\right) = 2.108 \times 10^4\,Pa$ $B' := (B - 2e) = 4.288\,m$

Using Table 3.3 we have: $Nq := 23.18$ $Nc := 35.49$ $N\gamma := 30.22$

$p := \frac{D}{B'} = 0.35$ $F\gamma d := 1$ $Fqd := 1 + 2 \cdot \tan(\phi'2) \cdot (1 - \sin(\phi'2))^2 \cdot \left(\frac{D}{B'}\right) = 1.111$ $Fcd := Fqd - \frac{(1 - Fqd)}{Nc \cdot \tan(\phi'2)} = 1.118$

$\psi := \text{atan}\left(\frac{Pa \cdot \cos(\alpha)}{\Sigma V}\right) = 0.202$ $\psi := 18.736\,deg$ $Fci := \left(1 - \frac{\psi}{90 \cdot deg}\right)^2 = 0.627$ $Fqi := Fci = 0.627$ $F\gamma i := \left(1 - \frac{\psi}{\phi'2}\right)^2 = 0.022$

$q := \gamma 2 \cdot D = 2.7 \times 10^4\,Pa$

$qu := c'2 \cdot Nc \cdot Fcd \cdot Fci + q \cdot Nq \cdot Fqd \cdot Fqi + .5 \cdot \gamma 2 \cdot B' \cdot N\gamma \cdot F\gamma d \cdot F\gamma i = 1.457 \times 10^6\,Pa$

$FSbearing := \frac{qu}{qtoe} = 7.636$ $\text{if}(FSbearing > 3, \text{"okay"}, \text{"not good"}) = \text{"okay"}$