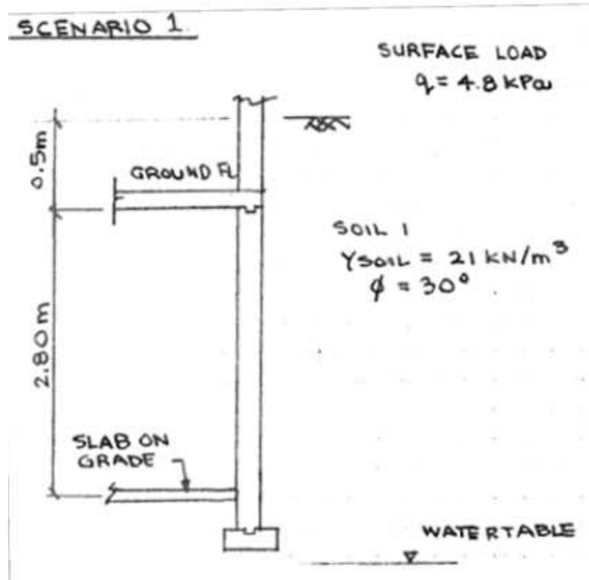
tutorial question 1

Given



$q := 4.8kPa$

$\gamma_{soil} := 21\frac{kN}{m^3}$

$\phi := 30°$

$x_1 := 0.5m$

$x_2 := x_1 + 2.8m$

$x_2 = 3.3\,m$

$k_0 := 1 - \sin(\phi)$ at rest

$k_0 = 0.5$ lateral earth pressure co-eff

at 0.5 m below grade

$\sigma_t - u = x_1 \cdot (\gamma_{soil}) + q - u_1 \qquad u_1 := 0$

$\sigma_t := x_1 \cdot (\gamma_{soil}) + q - u_1$

$\sigma_t = 15.3 \cdot kPa$

$p_0 := k_0 \cdot (\sigma_t)$

$p_0 = 7.65 \cdot kPa$

$p_0 \cdot 1.5 = 11.475 \cdot kPa$ due to live load

at 3.3 m below grade

$\sigma_t - u = x_2 \cdot (\gamma_{soil}) + q - u_2 \qquad u_2 := 0$

$\sigma_t := x_2 \cdot (\gamma_{soil}) + q - u_2$

$\sigma_t = 74.1 \cdot kPa$

$p_0 := k_0 \cdot (\sigma_t)$

$p_0 = 37.05 \cdot kPa$

$p_0 \cdot 1.5 = 55.575 \cdot kPa$ due to live load

Given

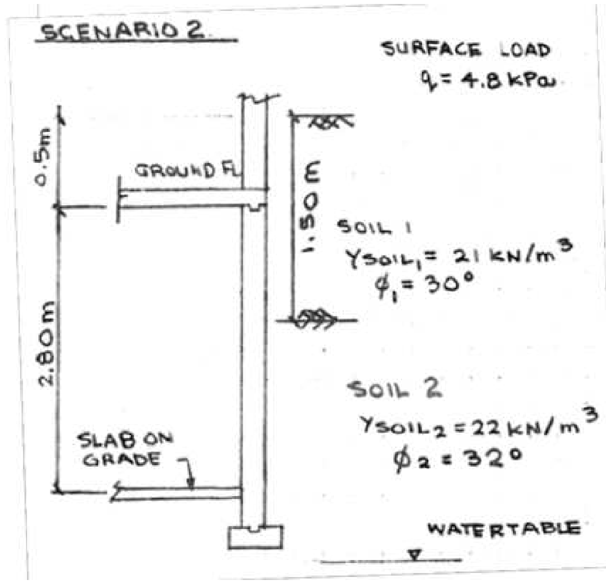
$\phi_1 := 30°$ $\qquad$ $\phi_2 := 32°$

$q := 4.8\text{kPa}$ $\qquad$ $x_1 := 0.5\text{m}$

$\gamma_{soil1} := 21 \frac{\text{kN}}{\text{m}^3}$ $\qquad$ $x_2 := 1.5\text{m}$

$x_3 := 3.3\text{m}$

$\gamma_{soil2} := 22 \frac{\text{kN}}{\text{m}^3}$



$k_{0.5} := 1 - \sin(\phi_1)$ at rest $\quad$ soil 1

$k_{0.5} = 0.5$ lateral earth pressure co-eff

at 0.5 m below grade

$\sigma_t - u = x_1 \cdot (\gamma_{soil1}) + q - u_1 \quad u_1 := 0$

$\sigma_t := x_1 \cdot (\gamma_{soil1}) + q - u_1$

$\sigma_t = 15.3 \cdot \text{kPa}$

$p_0 := k_{0.5} \cdot (\sigma_t)$

$p_0 = 7.65 \cdot \text{kPa}$

$p_0 \cdot 1.5 = 11.475 \cdot \text{kPa}$ $\quad$ due to live load

at 1.5 m below grade

$\sigma_t - u = x_2 \cdot (\gamma_{soil1}) + q - u_1 \quad u_1 := 0$

$\sigma_t := x_2 \cdot (\gamma_{soil1}) + q - u_1$

$\sigma_t = 36.3 \cdot \text{kPa}$

$p_0 := k_{0.5} \cdot (\sigma_t)$

$p_0 = 18.15 \cdot \text{kPa}$

$p_0 \cdot 1.5 = 27.225 \cdot \text{kPa}$ $\quad$ due to live load

$k_{01.5} := 1 - \sin(\phi_2)$ at rest   soil 2

$k_{01.5} = 0.47$ lateral earth pressure co-eff

at 1.5 m below grade

$\sigma_t - u = x_2 \cdot (\gamma_{soil1}) + q - u_2$ $u_2 := 0$ use weight of soil above the section

$\sigma_t := x_2 \cdot (\gamma_{soil1}) + q - u_2$

$\sigma_t = 36.3 \cdot kPa$

$p_0 := k_{01.5} \cdot (\sigma_t)$

$p_0 = 17.064 \cdot kPa$

$p_0 \cdot 1.5 = 25.596 \cdot kPa$ due to live load

$u_2 := 0$

at 3.3 m below grade

use weight of soil above + weight of total....follow carefully

$\sigma_t - u = x_3 \cdot (\gamma_{soil1} \cdot x_2 + \gamma_{soil2} \cdot x_2) + q - u_2$

$\sigma_t := [(\gamma_{soil1} \cdot x_2) + [\gamma_{soil2} \cdot (x_3 - x_2)]] + q - u_2$

$\sigma_t = 75.9 \cdot kPa$

$p_0 := k_{01.5} \cdot (\sigma_t)$

$p_0 = 35.679 \cdot kPa$

$p_0 \cdot 1.5 = 53.519 \cdot kPa$ due to live load

from mdsolids $mf := 31.9 kN \cdot m$

$vf := 54.9 kN$

scenario 3

Given

$\phi_1 := 30°$ $\qquad \phi_2 := 32°$

$q := 4.8\text{kPa}$ $\qquad x_1 := 0.5\text{m}$

$\gamma_{soil1} := 21\dfrac{\text{kN}}{\text{m}^3}$ $\qquad x_2 := 1.5\text{m}$

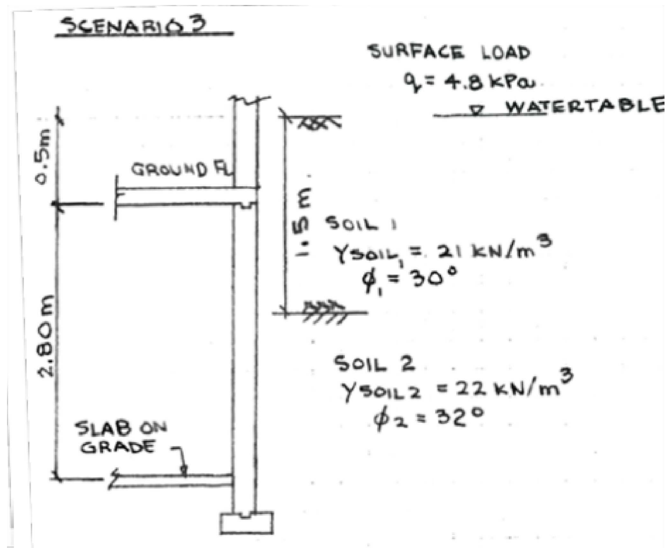
$x_3 := 3.3\text{m}$

$\gamma_{soil2} := 22\dfrac{\text{kN}}{\text{m}^3}$

$\gamma_{water} := 9.81\dfrac{\text{kN}}{\text{m}^3}$

$k_{0.5} := 1 - \sin(\phi_1)$ at rest soil 1

$k_{0.5} = 0.5$ lateral earth pressure co-eff



soil | hydrostatic

at 0.5 m below grade

$\sigma_t - u = x_1 \cdot (\gamma_{soil1}) + q - u_1$ $\qquad u_1 := \gamma_{water} \cdot x_1$

$\sigma_t := x_1 \cdot (\gamma_{soil1}) + q - u_1$ $\qquad u_1 = 4.905 \cdot \text{kPa}$

$\sigma_t = 10.395 \cdot \text{kPa}$

with water add soil to hydrostatic

$p_0 := \left[k_{0.5} \cdot (\sigma_t)\right] + u_1$

$p_0 = 10.102 \cdot \text{kPa}$

$p_0 \cdot 1.5 = 15.154 \cdot \text{kPa}$ due to live load

at 1.5 m below grade

$\sigma_t - u = x_2 \cdot (\gamma_{soil1}) + q - u_2$ $\qquad u_2 := \gamma_{water} \cdot x_2$

$\sigma_t := x_2 \cdot (\gamma_{soil1}) + q - u_2$ $\qquad u_2 = 14.715 \cdot \text{kPa}$

$\sigma_t = 21.585 \cdot \text{kPa}$

$p_0 := \left[k_{0.5} \cdot (\sigma_t)\right] + u_2$

$p_0 = 25.508 \cdot \text{kPa}$

$p_0 \cdot 1.5 = 38.261 \cdot \text{kPa}$ due to live load

$k_{01.5} := 1 - \sin(\phi_2)$ at rest soil 2

use weight of soil above the section

$k_{01.5} = 0.47$ lateral earth pressure co-eff

soil hydrostatic

at 1.5 m below grade

$\sigma_t - u = x_2 \cdot (\gamma_{soil1}) + q - u_3$

$u_3 := \gamma_{water} \cdot x_2$

$\sigma_t := x_2 \cdot (\gamma_{soil1}) + q - u_3$

$u_3 = 14.715 \cdot kPa$

$\sigma_t = 21.585 \cdot kPa$

$p_0 := [k_{01.5} \cdot (\sigma_t)] + u_3$

$p_0 = 24.862 \cdot kPa$

$p_0 \cdot 1.5 = 37.293 \cdot kPa$ due to live load

hydrostatic

at 3.3 m below grade

$\sigma_t - u = x_3 \cdot (\gamma_{soil1} \cdot x_2 + \gamma_{soil2} \cdot x_2) + q - u_4$

$u_4 := \gamma_{water} \cdot x_3$

use weight of soil above + weight of total....follow carefully

$\sigma_t := [(\gamma_{soil1} \cdot x_2) + [\gamma_{soil2} \cdot (x_3 - x_2)]] + q - u_4$

$u_4 = 32.373 \cdot kPa$

$\sigma_t = 43.527 \cdot kPa$

$p_0 := [k_{01.5} \cdot (\sigma_t)] + u_4$

$p_0 = 52.834 \cdot kPa$

$p_0 \cdot 1.5 = 79.251 \cdot kPa$ due to live load

from mdsolids $mf := 31.9 kN \cdot m$ next week

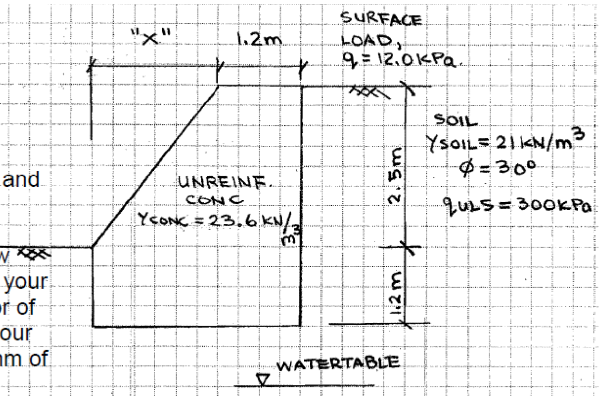
$vf := 54.9 kN$

Question 2

Determine "x" such that the gravity retaining wall shown meets the criteria for overturning, sliding, tension cracking, and soil bearing stress.

Assume that the wall has a density of 23.6 kN/m3 and is constructed of unreinforced mass concrete.

Account for passive lateral soil pressure on the low side of the wall. This will be a "beneficial force" in your design. Apply a safety factor of 2 and a load factor of 0.9 to the passive soil pressure prior to using for your checks. In your calculations, ignore the top 600 mm of soil for passive soil pressure.



$\gamma_{soil} := 21\,\frac{kN}{m^3}$ $\gamma_{conc} := 23.6\,\frac{kN}{m^3}$ $\gamma q_{uls} := 300kPa$ $q := 12.0kPa$

$\phi := 30°$

$x := 1.7m$

$w_1 := \left[\frac{(2.5m\cdot x)}{2}\cdot 1m\right]\cdot\gamma_{conc}$ $w_2 := [(3.7m\cdot 1.2m)\cdot 1m]\cdot\gamma_{conc}$ $w_3 := [(x\cdot 1.2m)\cdot 1m]\cdot\gamma_{conc}$

$w_1 = 50.15\cdot kN$ $w_2 = 104.784\cdot kN$ $w_3 = 48.144\cdot kN$

$w_{1min} := w_1\cdot 0.9$ $w_{2min} := w_2\cdot 0.9$ $w_{3min} := w_3\cdot 0.9$

$w_{1min} = 45.135\cdot kN$ $w_{2min} = 94.306\cdot kN$ $w_{3min} = 43.33\cdot kN$

$w_{1max} := w_1\cdot 1.25$ $w_{2max} := w_2\cdot 1.25$ $w_{3max} := w_3\cdot 1.25$

$w_{1max} = 62.688\cdot kN$ $w_{2max} = 130.98\cdot kN$ $w_{3max} = 60.18\cdot kN$

$k_a := \left[\left[\tan\left[45° - \left(\frac{\phi}{2}\right)\right]\right]^2\right]$ $k_p := \left[\left(\tan\left(45° + \frac{\phi}{2}\right)\right)^2\right]$

$k_a = 0.333$ $k_p = 3$

active pressure passive pressure

failure mode 1

Given

$s_f := 2$ factor of safety

larger side

active

$u_0 := 0$

$p_{a1} := \left[\left(\gamma_{soil} \cdot 0m - u_0\right) + q\right] \cdot k_a$

$p_{a1} = 4 \cdot kPa$

$p_{a1f} := p_{a1} \cdot 1.5$

$p_{a1f} = 6 \cdot kPa$

smaller side

passive

$u_0 := 0$ calculate pour pressure here

$p_{p1} := \left(\gamma_{soil} \cdot 0.6m - u_0\right) \cdot k_p$

$p_{p1} = 37.8 \cdot kPa$

$p_{p1f} := p_{p1} \cdot \left(\frac{0.9}{s_f}\right)$

$p_{p1f} = 17.01 \cdot kPa$

$u_{3.7} := 0$

$p_{a2} := \left[\left(\gamma_{soil} \cdot 3.7m - u_{3.7}\right) + q\right] \cdot k_a$

$p_{a2} = 29.9 \cdot kPa$

$p_{a2f} := p_{a2} \cdot 1.5$

$p_{a2f} = 44.85 \cdot kPa$

$u_{3.7} := 0$ calculate pour pressure here

$p_{p2} := \left(\gamma_{soil} \cdot 1.2m - u_{3.7}\right) \cdot k_p$

$p_{p2} = 75.6 \cdot kPa$

$p_{p2f} := p_{p2} \cdot \left(\frac{0.9}{s_f}\right)$

$p_{p2f} = 34.02 \cdot kPa$

$top_{active} := \left(p_{a1f} \cdot 3.7m\right) \cdot 1m$

$top_{active} = 22.2 \cdot kN$

$bottom_{active} := \left[\frac{\left(p_{a2f} - p_{a1f}\right) \cdot 3.7m}{2}\right] \cdot 1m$

$bottom_{active} = 71.873 \cdot kN$

$top_{passive} := \left(p_{p1f} \cdot 0.6m\right) \cdot 1m$

$top_{passive} = 10.206 \cdot kN$

$bottom_{passive} := \left[\frac{\left(p_{p2f} - p_{p1f}\right) \cdot 0.6m}{2}\right] \cdot 1m$

$bottom_{passive} = 5.103 \cdot kN$

A) overturning of the wall MINIMUM

$$Min_{pivot} := top_{active} \cdot \left(\frac{3.7m}{2}\right) + bottom_{active} \cdot \left(\frac{3.7m}{3}\right)$$

$$Min_{pivot} = 129.713\, m \cdot kN$$

$$Min_{resist} := \left[top_{passive} \cdot \left(\frac{0.6m}{2}\right)\right] + \left[bottom_{passive} \cdot \left(\frac{0.6m}{3}\right)\right] + \left[w_{1min} \cdot \left(1.7m - \frac{1.7m}{3}\right)\right] \ldots$$
$$+ \left[w_{2min} \cdot \left[1.7m + \left(\frac{1.2m}{2}\right)\right]\right] + \left[w_{3min} \cdot \left(\frac{1.7m}{2}\right)\right]$$

$$Min_{resist} = 308.968\, m \cdot kN$$

$$Min_{pivot} \le Min_{resist} = 1$$

1 IS A PASS 0 IS A FAIL

MAXIMUM

$$Max_{pivot} := top_{active} \cdot \left(\frac{3.7m}{2}\right) + bottom_{active} \cdot \left(\frac{3.7m}{3}\right)$$

$$Max_{pivot} = 129.713\, m \cdot kN$$

$$Max_{resist} := \left[top_{passive} \cdot \left(\frac{0.6m}{2}\right)\right] + \left[bottom_{passive} \cdot \left(\frac{0.6m}{3}\right)\right] + \left[w_{1max} \cdot \left(1.7m - \frac{1.7m}{3}\right)\right] \ldots$$
$$+ \left[w_{2max} \cdot \left[1.7m + \left(\frac{1.2m}{2}\right)\right]\right] + \left[w_{3max} \cdot \left(\frac{1.7m}{2}\right)\right]$$

$$Max_{resist} = 427.535\, m \cdot kN$$

$$Max_{pivot} \le Max_{resist} = 1$$

B) sliding of the wall

$$V_{sliding} := top_{active} + bottom_{active}$$

$$V_{sliding} = 94.073 \cdot kN$$

$$V_{resist} := top_{passive} + bottom_{passive} + \left(w_{1min} + w_{2min} + w_{3min}\right) \cdot \tan(30°)$$

$$V_{resist} = 120.831 \cdot kN$$

$$V_{sliding} \le V_{resist} = 1$$

C) bearing failure in soil beneath base

check min first

$$min_{total} := w_{1min} + w_{2min} + w_{3min}$$

$$min_{total} = 182.77 \cdot kN$$

check max second

$$max_{total} := w_{1max} + w_{2max} + w_{3max}$$

$$max_{total} = 253.847 \cdot kN$$

Minimum / Maximum XR and moment

$$M_{min} := \left(Min_{pivot} - Min_{resist}\right) \qquad M_{min} = -179.256\, m \cdot kN$$

$$Xr_{min} := \frac{M_{min}}{-\left(w_{1min} + w_{2min} + w_{3min}\right)} \qquad Xr_{min} = 0.981\, m$$

$$M_{max} := \left(Max_{pivot} - Max_{resist}\right) \qquad M_{max} = -297.822\, m \cdot kN$$

$$Xr_{max} := \frac{M_{max}}{-\left(w_{1max} + w_{2max} + w_{3max}\right)} \qquad Xr_{max} = 1.173\, m$$

$$third_{bottom} := \frac{x + 1.2m}{3} \qquad third_{bottom} = 0.967\, m$$

case 2 MIDDLE THIRD BEARING

$P_{min} := w_{1min} + w_{2min} + w_{3min}$ $P_{max} := w_{1max} + w_{2max} + w_{3max}$

$P_{min} = 182.77 \cdot kN$ $P_{max} = 253.847 \cdot kN$

$L := 300mm$

$W := 300mm$

$A := L \cdot W$ $A = 90000 \cdot mm^2$

$Base := third_{bottom} \cdot 3$

left

right

$$Mid_{min1} := \left(\frac{P_{min}}{Base}\right) + \frac{P_{min} \cdot \left(\left|\frac{Base}{2} - Xr_{min}\right|\right)}{\left(\frac{Base^2}{6}\right)}$$

$$Mid_{min2} := \left(\frac{P_{min}}{Base}\right) - \frac{P_{min} \cdot \left(\left|\frac{Base}{2} - Xr_{min}\right|\right)}{\left(\frac{Base^2}{6}\right)}$$

$Mid_{min1} = 124.209\, m \cdot kPa$ $Mid_{min2} = 1.839\, m \cdot kPa$

left

right

$$Mid_{max1} := \left(\frac{P_{max}}{Base}\right) + \frac{P_{max} \cdot \left(\left|\frac{Base}{2} - Xr_{max}\right|\right)}{\left(\frac{Base^2}{6}\right)}$$

$$Mid_{max2} := \left(\frac{P_{max}}{Base}\right) - \frac{P_{max} \cdot \left(\left|\frac{Base}{2} - Xr_{max}\right|\right)}{\left(\frac{Base^2}{6}\right)}$$

$Mid_{max1} = 137.657\, m \cdot kPa$ $Mid_{max2} = 37.41\, m \cdot kPa$

case 3 outside middle third TENSION CRACKS

$$\sigma_{max} := \frac{P_{max}}{\left[\frac{1}{2}\cdot\left(3\cdot Xr_{max}\right)\right]} \qquad \sigma_{min} := \frac{P_{min}}{\left[\frac{1}{2}\cdot\left(3\cdot Xr_{min}\right)\right]}$$

$$\sigma_{max} = 144.244\ m\cdot kPa \qquad \sigma_{min} = 124.236\ m\cdot kPa$$

basement use at rest

multiply all p value by 1.5 due to live load

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