

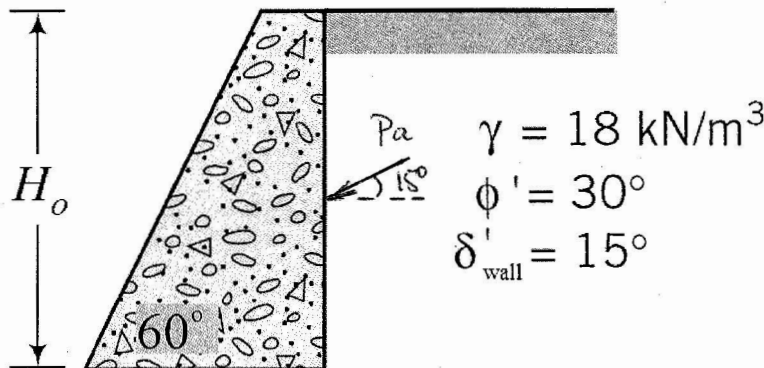


Assignment 5

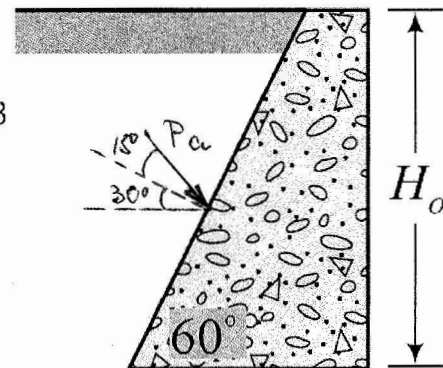
Question 1

For which of the two gravity retaining walls shown below the horizontal component of the active pressure force acting on the back face of the wall will be larger. Show calculations.

a)



b)



Solution:

As there is friction between the back face of the walls and the backfill, use Coulomb's theory.

a) For $\alpha = 0^\circ$ (horizontal backfill) $\beta = 90^\circ$ $\delta'_{wall} = 15^\circ$ $\phi' = 30^\circ$

$$K_a = \frac{\sin^2(\beta + \phi')}{\sin^2\beta \sin(\beta - \delta'_{wall}) \left[1 + \sqrt{\frac{\sin(\phi' + \delta'_{wall}) \sin(\phi' - \alpha)}{\sin(\beta - \delta') \sin(\alpha + \beta)}} \right]^2}$$

$$K_a = \frac{\sin^2(90 + 30)}{\sin^2 90 \sin(90 - 15) \left[1 + \sqrt{\frac{\sin(30 + 15) \sin(30 - 0)}{\sin(90 - 15) \sin(0 + 90)}} \right]^2} = 0.301$$

The active pressure force is:

$$P_a = \frac{1}{2} K_a \gamma H_0^2 = \frac{1}{2} (0.301) (18) H_0^2 = 2.709 H_0^2$$

It is inclined at an angle $\delta'_{wall} = 15^\circ$ to the horizontal.

The horizontal component is:

$$P_{h_1} = P_a \cos \delta'_{\text{wall}} = 2.709 H_0^2 \cos(15^\circ) = 2.617 H_0^2$$

b) For $\alpha = 0^\circ$ $\beta = 0^\circ$ $\delta'_{\text{wall}} = 15^\circ$ $\phi' = 30^\circ$

$$K_a = \frac{\sin^2(60 + 30)}{\sin^2 60 \sin(60 - 15) \left[1 + \sqrt{\frac{\sin(30 + 15) \sin(30 - 0)}{\sin(60 - 15) \sin(0 + 60)}} \right]^2} = 0.609$$

$$P_a = \frac{1}{2} K_a \gamma H_0^2 = \frac{1}{2} (0.609)(18) H_0^2 = 5.481 H_0^2$$

The resultant is inclined at an angle δ'_{wall} to the normal to the back face of the wall.

$$P_{h_2} = P_a \cos(30^\circ + \delta'_{\text{wall}}) = 5.481 H_0^2 \cos(30 + 15) = 3.876 H_0^2$$

$$P_{h_1} = 2.617 H_0^2 < P_{h_2} = 3.876 H_0^2$$

Therefore, retaining wall b) will have a larger horizontal component of the active pressure force acting on the back face of the wall.



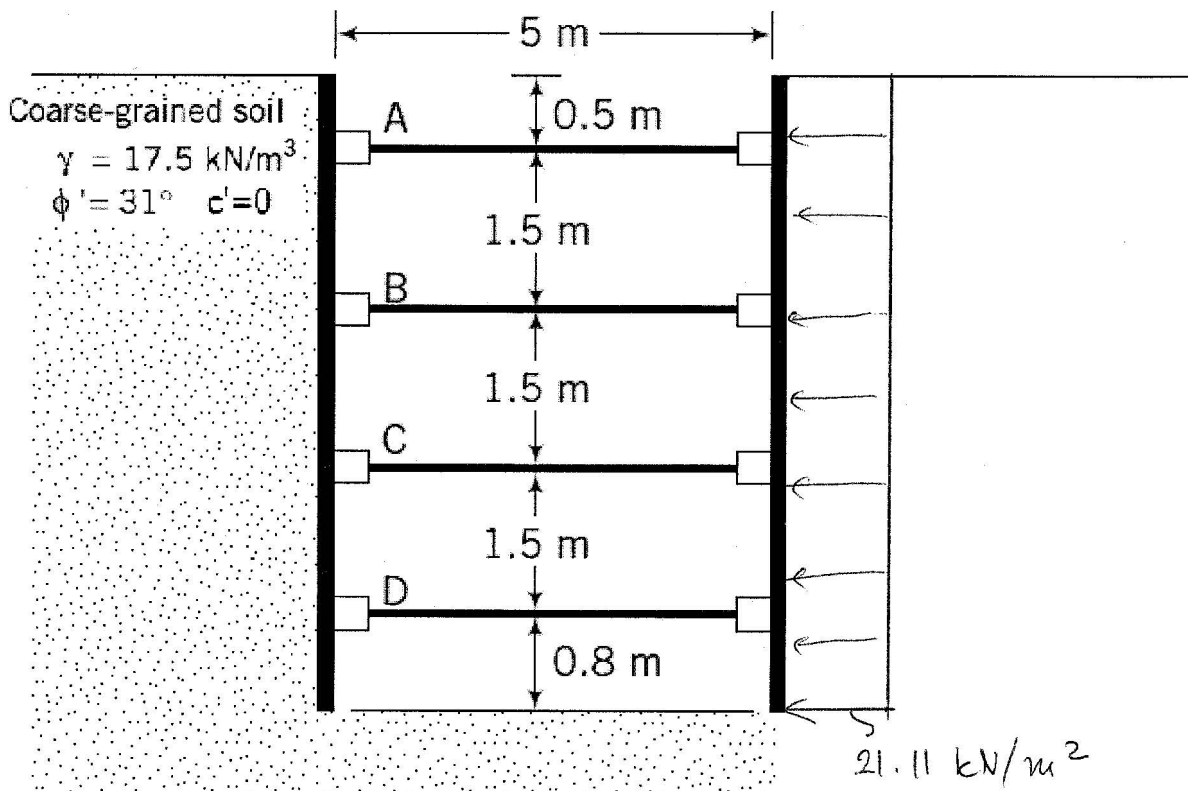
Question 2

For the braced cut shown:

- Draw the earth-pressure envelope.
- Determine the strut loads at levels A, B, C and D.
- Determine the section modulus of the sheet-pile section required.
- Determine a design section modulus for the wales at level B.

(Note: The struts are placed at 3 m, center to center, in the plan.)

Use $\sigma_{all} = 170 \times 10^3 \text{ kN/m}^2$.



Solution:

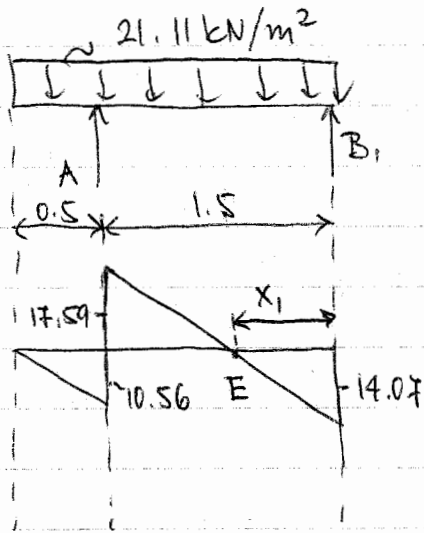
For sand:

$$\sigma_a = 0.65 \gamma H K_a$$

$$K_a = \tan^2 \left(45^\circ - \frac{\phi'}{2} \right) = \tan^2 \left(45^\circ - \frac{31}{2} \right) = 0.32$$

$$\sigma_a = 0.65 (17.5)(5.8)(0.32) = 21.11 \text{ kN/m}^2$$

Question 2 - Cont.



$$\sum M_{B_1} = 0 \quad A(1.5) - 21.11(2.0)\left(\frac{2.0}{2}\right) = 0$$

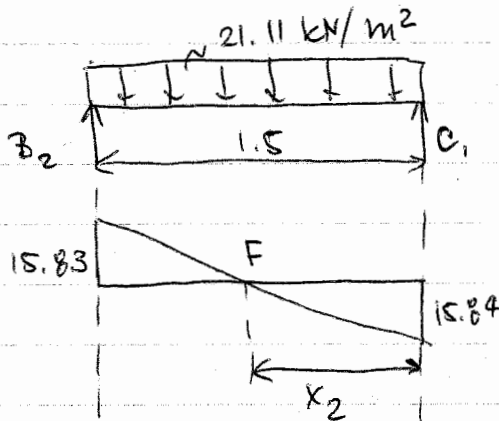
$$A = 28.15 \text{ kN/m}$$

$$\sum F_v = 0 \quad B_1 + 28.15 - (21.11)(2.0) = 0$$

$$B_1 = 14.07 \text{ kN/m}$$

$$14.07 - 21.11 x_1 = 0$$

$$x_1 = 0.67 \text{ m}$$



$$\sum M_{C_1} = 0$$

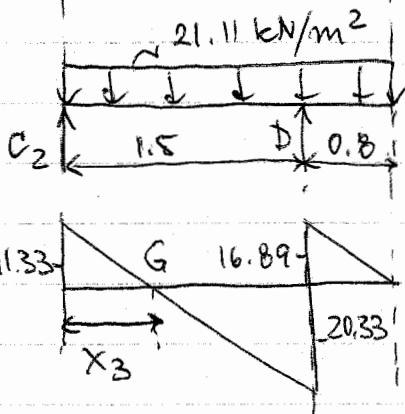
$$B_2(1.5) - 21.11(1.5)\left(\frac{1.5}{2}\right) = 0$$

$$B_2 = 15.83 \text{ kN/m}$$

$$\sum F_v = 0 \quad C_1 + 15.83 - 21.11(1.5) = 0$$

$$C_1 = 15.84 \text{ kN/m}$$

$$x_2 = \frac{1.5}{2} = 0.75 \text{ m}$$



$$\sum M_{D} = 0$$

$$D(1.5) - 21.11(2.3)\left(\frac{2.3}{2}\right) = 0$$

$$D = 37.22 \text{ kN/m}$$

$$\sum F_v = 0$$

$$37.22 + C_2 - 21.11(2.3) = 0$$

$$C_2 = 11.33 \text{ kN/m}$$

$$11.33 - 21.11(x_3) = 0 \rightarrow x_3 = 0.54 \text{ m}$$

Struts:

For $s = 3 \text{ m}$, the strut loads are as follows:

$$P_A = A(s) = 28.15(3.0) = 84.45 \text{ kN}$$

$$P_B = (B_1 + B_2)(s) = (14.07 + 15.83)(3.0) = 89.7 \text{ kN}$$

$$P_C = (C_1 + C_2)(s) = (15.84 + 11.33)(3.0) = 81.51 \text{ kN}$$

$$P_D = D(s) = 37.22(3.0) = 111.66 \text{ kN}$$

Sheet Piles:

Determine bending moment at each level:

$$M_A = \frac{1}{2}(10.56)(0.5) = 2.64 \text{ kN}\cdot\text{m}/\text{m}$$

$$M_E = \frac{1}{2}(14.07)(0.67) = 4.71 \text{ kN}\cdot\text{m}/\text{m}$$

$$M_F = \frac{1}{2}(15.84)(0.75) = 5.94 \text{ kN}\cdot\text{m}/\text{m}$$

$$M_D = \frac{1}{2}(16.89)(0.8) = 6.76 \text{ kN}\cdot\text{m}/\text{m} = M_{\text{max}}$$

$$M_G = \frac{1}{2}(11.33)(0.54) = 3.06 \text{ kN}\cdot\text{m}/\text{m}$$

$$S_{\text{sheet piles}} = \frac{M_{\text{max}}}{\sigma_{\text{all}}} = \frac{6.76}{170 \times 10^3} = 3.98 \times 10^{-5} \text{ m}^3/\text{m wall}$$

Wales at level B:

$$M_{\text{max}, B} = \frac{(B_1 + B_2)(s^2)}{8} = \frac{(14.07 + 15.83)(3.0^2)}{8} = 33.64 \text{ kN}\cdot\text{m}/\text{m}$$

$$S_{\text{wales}, B} = \frac{M_{\text{max}, B}}{\sigma_{\text{all}}} = \frac{33.64}{170 \times 10^3} = 1.98 \times 10^{-4} \text{ m}^3/\text{m wall}$$

Question 3

$$\phi' = 26^\circ$$

$$c' = 21 \text{ kN/m}^2$$

$$\rho = 1950 \text{ kg/m}^3$$

Solution:

$$a) H = 5 \text{ m} \quad \beta = 18^\circ \quad FS = ?$$

For no seepage condition:

$$FS = \frac{c' + \rho z \cos^2 \beta \tan \phi'}{\rho z \sin \beta \cos \beta}$$

$$\gamma = \rho g = 1950 \times 9.81 = 19130 \text{ N/m}^3 = 19.13 \text{ kN/m}^3$$

$$z = H = 5 \text{ m}$$

$$FS = \frac{21 + (19.13)(5.0) \cos^2 18^\circ \tan 26^\circ}{(19.13)(5.0) \sin 18^\circ \cos 18^\circ} = 2.25 > 1.3, \text{ OK}$$

$$b) 1.75 = FS \quad \beta = 27^\circ$$

$$1.75 = \frac{21 + (19.13)(H) \cos^2 27^\circ \tan 26^\circ}{(19.13)(H) \sin 27^\circ \cos 27^\circ}$$

$$H = 3.42 \text{ m}$$