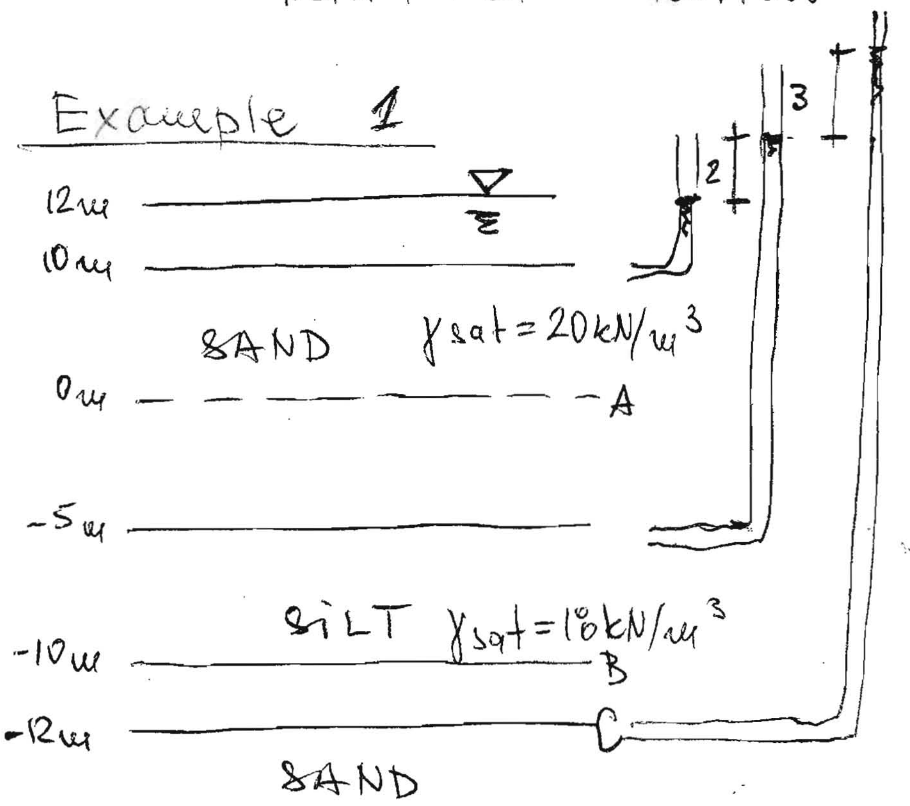
CVG 3109 - Soil Mechanics
Midterm Review

$h_1 = 3\,m$

$h_2 = 2\,m$

Example 1



Solution

@ Point C $(z = -12\,m)$

$$\sigma_C = (12-10)\gamma_w + (10-(-5))\gamma_{sat}(sand) + [(-5)-(-12)]\gamma_{sat}(silt)$$

$$\sigma_C = 2\times 9.81 + 15\times 20 + 7\times 18 = \underline{445.62\ kN/m^2}$$

$$u_C = [12-(-12)]\gamma_w + (3+2)\gamma_w = 24\times 9.81 + 5\times 9.81 = \underline{284.49\ kN/m^2}$$

$$\sigma'_C = \sigma_C - u_C = 445.62 - 284.49 = \underline{161.13\ kN/m^2}$$

@ Point B $(z = -10\,m)$

$$\sigma_B = (12-10)\gamma_w + [10-(-5)]\gamma_{sat}(sand) + [(-5)-(-10)]\gamma_{sat}(silt)$$

$$\sigma_B = 2\times 9.81 + 15\times 20 + 5\times 18 = \underline{409.62\ kN/m^2}$$

$$u_B = [12-(-10)]\gamma_w + (2)\gamma_w + \underbrace{\left\{\frac{3}{[(-5)-(-12)]}\right\}}_{i}\underbrace{[(-5)-(-10)]}_{z}\gamma_w$$

$$u_B = 22\times\gamma_w + 2\gamma_w + \left(\frac{3}{7}\right)(5)\gamma_w$$
$$u_B = 22\times 9.81 + 2\times 9.81 + 2.14\times 9.81 = \underline{256.43\ kN/m^2}$$

$$\sigma_B' = \sigma_B - u_B = 409.62 - 256.43 = \underline{153.19\ kN/m^2}$$

@ Point A ($z = 0m$)

$$\sigma_A = (12-10)\gamma_w + (10-0)\gamma_{sat(sand)}$$

$$\sigma_A = 2\times 9.81 + 10\times 20 = \underline{219.62\ kN/m^2}$$

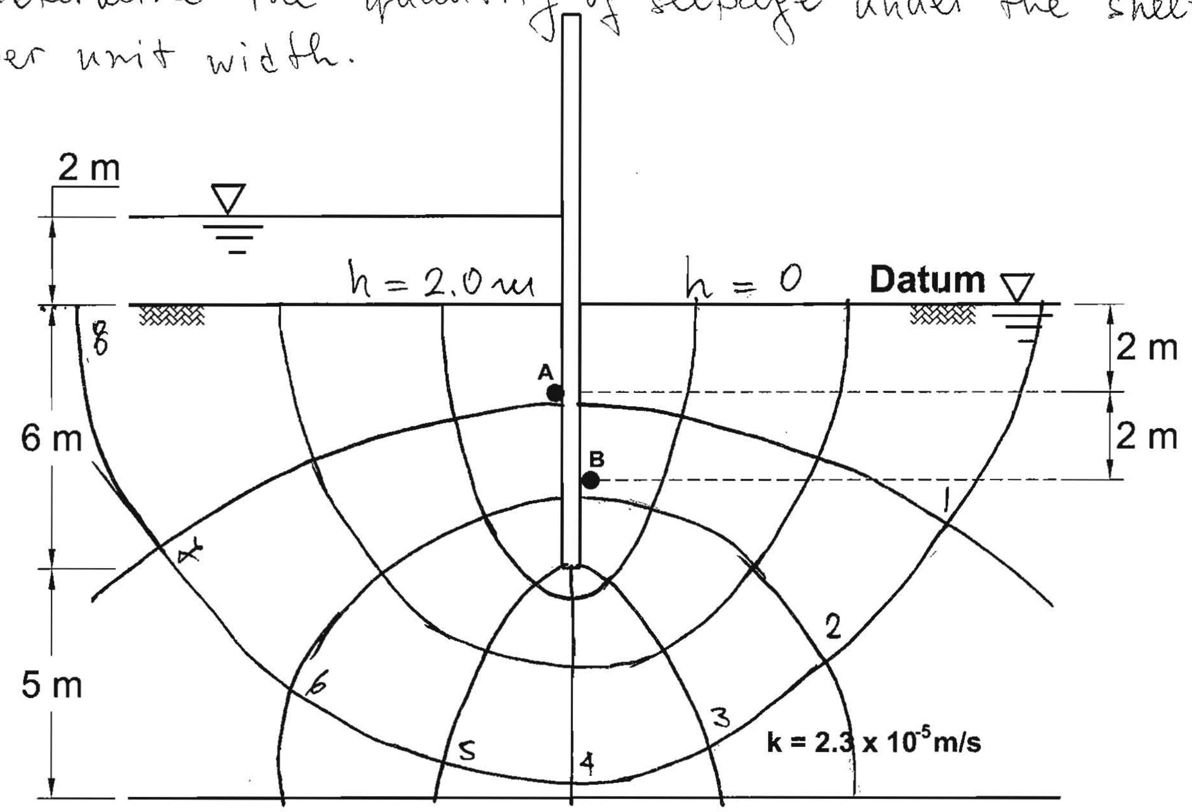
$$u_A = [12-(0)]\gamma_w + \underbrace{\left\{\frac{2}{[10-(-5)]}\right\}}_{i}\underbrace{(10-0)}_{z}\gamma_w$$

$$u_A = 12\gamma_w + \left(\frac{2}{15}\right)(10)\gamma_w = 12\times 9.81 + 1.33\times 9.81 = \underline{130.80\ kN/m^2}$$

$$\sigma_A' = \sigma_A - u_A = 219.62 - 130.80 = \underline{88.82\ kN/m^2}$$

Q2

For a sheet piling shown below calculate the effective stress at point A and B (γ_{sat} = 20 kN/m^3). Determine the quantity of seepage under the sheet piling per unit width.



Solution:

Total Head Loss: $H = 2 - 0 = 2$ m

Number of equipotential drops; $N_d = 8$

$\Delta h = \frac{2}{8} = 0.25$ m

Number of flow channels; $N_f = 3.2$

Pore water pressure at point A ($z = -2$ m)

Total head: $2 - 0.8 \times \Delta h = 2 - 0.8 \times 0.25 = 1.8$ m

h_{pA} = Pressure head = Total − Elevation head $= 1.8 - (-2) = 3.8$ m

$u_A = h_{p(A)} \times \gamma_w = 3.8 \times 9.81 = 37.28$ kN/m^2

Mid-term Review

Example 2 - Cont

Pore water pressure at point B ($z = -4\ m$)

Total head $= 2 - 6.2 \times \Delta h = 0.45\ m$

h_{P_B} = pressure head = Total head - elevation head

$h_{P_B} = 0.45 - (-4) = 4.45\ m$

$u_B = h_{P_B} \times \gamma_w = 4.45 \times 9.81 = 43.65\ kN/m^2$

Calculating Stresses at A and B

$\sigma_A = 2 \times \gamma_w + 2 \times \gamma_{sat} = 2 \times 9.81 + 2 \times 20 = 59.62\ kN/m^2$

$u_A = 37.28\ kN/m^2$

$\sigma'_A = \sigma_A - u_A = 59.62 - 37.28 = 22.34\ kN/m^2$

$\sigma_B = (2 + 2)\ \gamma_{sat} = 4 \times 20 = 80\ kN/m^2$

$u_B = 43.65\ kN/m^2$

$\sigma'_B = \sigma_B - u_B = 80 - 43.65 = 36.35\ kN/m^2$

Quantity of seepage;

$q = kH\left(\frac{N_f}{N_d}\right)$ (/width)

$q = (2.3 \times 10^{-5})(2)\left(\frac{3.2}{8}\right) = 1.84 \times 10^{-5}\ m^3/s$ (/width)

Mid-term Review

Example 3

e_o (sand) = 0.76
w (clay) = 38%
H_o (clay) = 2.0 m
OCR = 1.5
C_c = 0.3
C_s = 0.05
G_s = 2.7

Solution

1) Calculate σ_o' and e_o in the middle of the clay layer:

Sand

$$\gamma_d = \frac{G_s}{1+e_o}\gamma_w = \frac{2.7}{(1+0.76)} \times 9.81 = 15.05 \text{ kN/m}^3$$

$$\gamma_{sat} = \left(\frac{G_s + e_o}{1+e_o}\right)\gamma_w = \left(\frac{2.7+0.76}{1+0.76}\right) \times 9.81 = 19.3 \text{ kN/m}^3$$

Clay: Below water table, assume S = 100%

$$e_o = wG_s = 0.38 \times 2.7 = 1.026 = 1.03$$

$$\gamma_{sat} = \frac{(G_s + e_o)}{(1+e_o)}\gamma_w = \left(\frac{2.7+1.03}{1+1.03}\right) \times 9.81 = 18.03 \text{ kN/m}^3$$

2) Calculate in-situ stress in the middle of clay

$$\sigma_o = 3 \times 15.05 + 7.4 \times 19.3 + 1.0 \times 18.03 = 206.0 \text{ kN/m}^2$$

$u_o = (7.4 + 1.0) \times 9.81 = 82.40 \text{ kN/m}^2$

$\sigma_0' = \sigma_0 - u_o = 206.0 - 82.40 = 123.6 \text{ kN/m}^2$

$\Delta\sigma = 140 \text{ kPA}$

3) Final effective stress in the middle of clay, σ_1'

$\sigma_1' = \sigma_0' + \Delta\sigma = 123.6 + 140 = 263.6 \text{ kN/m}^2$

4) Determine the preconsolidation pressure, σ_p'

$$OCR = \frac{\sigma_p'}{\sigma_0'}$$

$\sigma_p' = \sigma_0' \times OCR = 123.6 \times 1.5 = 185.4 \text{ kN/m}^2$

5) Compare in-situ, preconsolidation and final effective stresses!

$\sigma_0' = 123.6 < \sigma_p' = 185.4 < \sigma_1' = 263.6 \text{ kN/m}^2$.

6) Calculate Consolidation Settlement

$$S_c = \frac{C_s}{1+e_o} H_o \log\left(\frac{\sigma_p'}{\sigma_0'}\right) + \frac{C_c}{1+e_o} H_o \log\left(\frac{\sigma_1'}{\sigma_p'}\right)$$

$$S_c = \frac{0.05}{1+1.03} \times 2 \log\left(\frac{185.4}{123.6}\right) + \frac{0.3}{1+1.03} \times 2 \log\left(\frac{263.6}{185.4}\right)$$

$S_c = 0.0087 + 0.045 = 0.054 \text{ m} = \underline{54 \text{ mm}}$