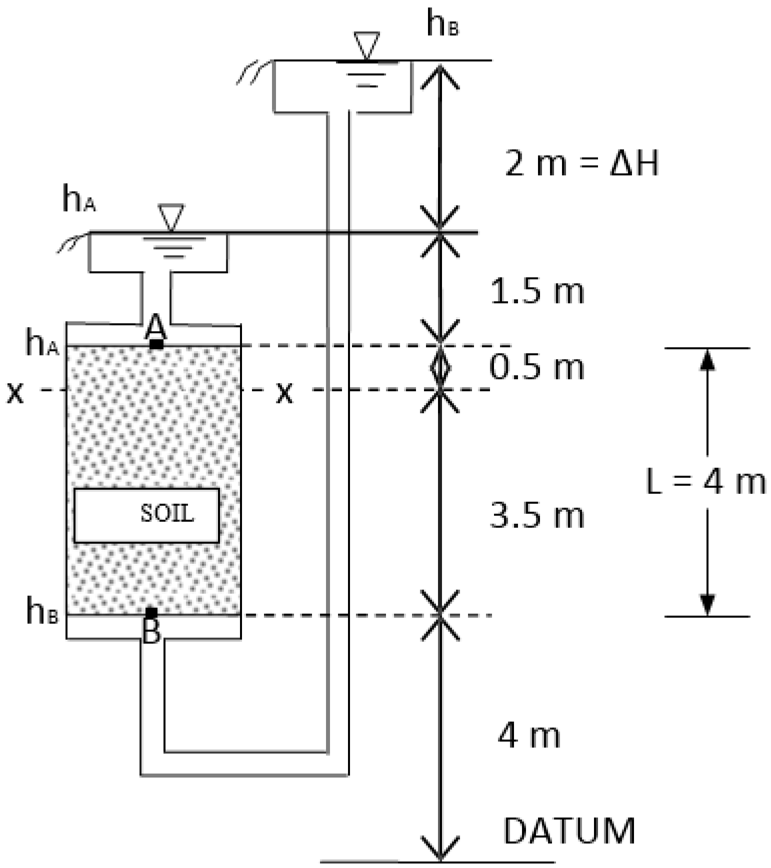
CE 363-364 Homework-3-Solution

Question 1



a) Elevation head, Pressure head, Total head at plane X-X,

$$h_A = z_A + u_A/\gamma_w$$

$$h_A = 8\ m\ (\ elev.head\ ) + 1.5\ m\ (\ pressure\ head\ ) = 9.5\ m$$

$$h_B = 4\ m\ (\ elev.head\ ) + 7.5\ m\ (\ pressure\ head\ ) = 11.5\ m$$

$$\Delta h = 2\ m$$

The flow direction is from greater head to lower head.

OR

You could also calculate the head difference between points A and B by finding the reservoir head differences which is 2 m = ΔH.

To contiune with X-X plane calculations , it is better to find hydraulic gradient in the soil :

$i = \frac{\Delta H}{L} = \frac{2\ m}{4\ m} = 0.5$ (b)

OR

$i = \frac{\Delta H}{L} = \frac{11.5\ m - 9.5\ m}{4\ m} = 0.5$

<u>At X-X Section</u>

$z = 7.5\ m\ ,\ h_{x-x} = h_B - (3.5\ m\ ) * i$

$h_{x-x} = 11.5\ m - 3.5\ m * 0.5 = 9.75\ m$

OR

$h_{x-x} = h_A + 0.5 * i = 9.5\ m + 0.5 * 0.5 = 9.75\ m$ Total Head

Since $h_{x-x} = z_{x-x} + \frac{u_{x-x}}{\gamma_w}$; $z_{x-x} = 7.5\ m\ ,\ Elev. Head$

$\frac{u_{x-x}}{\gamma_w} = 9.75\ m - 7.5\ m = 2.25\ m$ Pressure Head

$c)\ \ q = k * i\ \ = (\ 2 * 10^{-3}\ cm/s\ ) * (\ 0.5\ ) = 10^{-3} cm/s$

$A = \pi * \frac{(20\ cm)^2}{4} = 314\ cm^2$

$Q = A * k * i = 314\ cm^2 * 10^{-3} cm/s = 0.314\ cm^3/s$

$1\ day = 86400\ s\ \ \ \ ,Q = 0.314\ (cm^3)/s * 86400\ s\ =\ 27130 cm^3/day = 0.027\ m^3/day$

d) Eff. Stress on plane X-X,

$Total\ Stress\ on\ X - X : 1.5\ m * 10 kN/m^3\ + 0.5\ m * 20 kN/m^3\ = 25\ kN/m^2$

$Pore\ Pressure\ on\ X - X :\ \ \frac{u_{x-x}}{\gamma_w} = 2.25\ m\ \ ; u_{x-x} = 22.5\ kN/m^2$

$\sigma'_{x-x} = \sigma_{x-x} - u_{x-x} = 25\ kN/m^2 - 22.5\ kN/m^2 = 2.5\ kN/m^2$

e) For quick condition ;

$i > i_c$

$i_c = \frac{\gamma'}{\gamma_w} = \frac{20\ kN/m^3 - 10\ kN/m^3}{10\ kN/m^3} = 1$

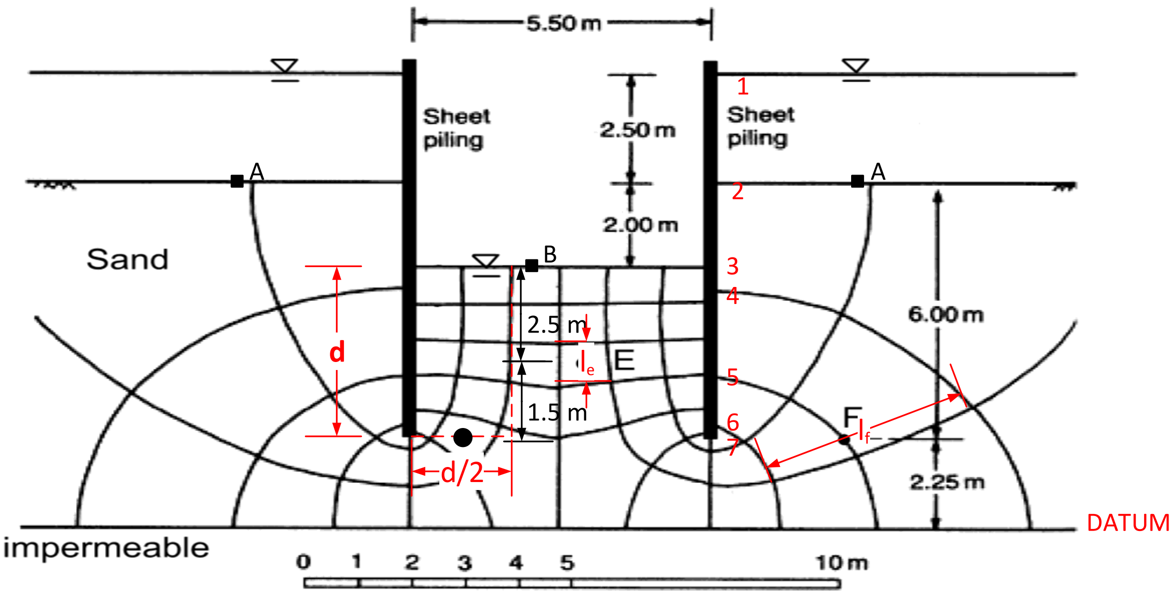
So whenever i > 1 condition is satisfied, then quick condition or boiling occurs :

$$i = \frac{\Delta H_i}{L}\ ; initially\ head\ difference\ is\ \ 2m\ ,\ \ i_{initial} = \frac{2\ m}{4\ m} = 0.5$$

$$For\ i = \frac{\Delta H_f}{L} > 1\ ;\ \ \ \Delta H_f > 4\ m\ , \Delta H_f - \Delta H_i > 4\ m - 2\ m = 2\ m$$

$$For\ boiling\ we\ should\ raise\ the\ water\ level\ on\ the\ right\ side\ for\ 2\ m.$$

<u>Question 2</u>



$$The\ bottom\ (\ where\ sand\ and\ impermeable\ layer\ intersects\ )\ was\ selected\ as\ DATUM.$$

$$\Delta H\ (\ between\ A\ and\ B\ ) = 4.5\ m$$

$$(\ h_A = 8.25\ m + 2.5\ m = 10.75\ m\ \ , h_B = 6.25\ m\ )$$

$$The\ head\ loss\ between\ two\ energy\ lines : \frac{\Delta H}{N_d} = \frac{4.5\ m}{10} = 0.45\ m$$

<u>At Point E</u>

$(\ By\ making\ the\ necessary\ scaling, the\ depth\ of$ " E " is measured as 2.5 m from the bottom of excavation)

$$\sigma_E = 2.5\ m * 19\ kN/m^3 = 47.5\ kN/m^2$$

$h_E = h_B + 2.5 * 0.45 \quad (2.5\ drops) \qquad OR \qquad h_E = h_A - 7.5 * 0.45$

$h_E = 6.25\ m + 2.5 * 0.45 = 7.375\ m$

$h_E = z_E + \frac{u_E}{\gamma_w} \quad , \qquad 7.375\ m = 3.75\ m + \frac{u_E}{\gamma_w} \ ; u_E = 36.25\ kN/m^2$

$\sigma'_E = 47.5\ kN/m^2 - 36.25\ kN/m^2 = 11.25\ kN/m^2$

<u>At point F</u>

$\sigma_F = 19\ kN/m^3 * 6\ m + 2.5\ m * 10\ kN/m^3 = 139\ kN/m^2$

$h_F = h_A - 2 * 0.45$

$h_F = 10.75\ m - 0.9\ m = 9.85\ m$

$9.85\ m = 2.25\ m + \frac{u_F}{\gamma_w}; \quad u_F = 76\ kN/m^2$

$\sigma'_F = 139\ kN/m^2 - 76\ kN/m^2 = 63\ kN/m^2$

b) Estimation of the hydraulic gradient at E and F ,

$i_E \approx \frac{\Delta H}{l_e} = \frac{0.45\ m}{1.17\ m} = 0.38$

(There is one drop and used length, l_e , which is measured according to scale , is shown on the figure with red).

$i_F \approx \frac{\Delta H}{l_f} = \frac{2*0.45\ m}{4.17\ m} = 0.22$

(Two drops around F is selected and an average is calculated. Length l_f , which is measured according to scale , is shown on the figure with red).

c) In the calculations below , the subscript b refers to back of the wall and the subscript f refers to front of the wall (All the calculations were done for scaled measurements)

Level	z(m)	h_b (m)	u_b / γ_w (m)	h_f (m)	u_f / γ_w (m)	$u_b - u_f$ (kN/ m^2)
1	10,75	10,75	0,00		0,00	0
2	8,25	10,75	2,50		0,00	25
3	6,25	10,39	4,14	6,25	0,00	41,4
4	5,75	10,3	4,55	6,61	0,86	36,9
5	3,58	9,85	6,27	7,6	4,02	22,5
6	2,42	9,4	6,98	8,41	5,99	9,9
7	2,25	9,31	7,06	8,73	6,48	5,85

Water pressure distribution occurs as follows :

Level	u_b (kN/m^2)	u_f (kN/m^2)	$u_b - u_f$ (kN/m^2)
1	0	0	0
2	25	0	25
3	41,4	0	41,4
4	45,5	8,6	36,9
5	62,7	40,2	22,5
6	69,8	59,9	9,9
7	70,6	64,8	5,85

For instance, calculation for point 6 :

$$h_6 = z_6 + u_6/\gamma$$

$$z_6 = 2.42\ m\ , h_{6b} = h_A - 3 * 0.45 = 10.75\ m - 1.35\ m = 9.4\ m (at\ the\ back\ of\ the\ wall)$$

$$u_{6b}/\gamma = 9.4\ m - 2.42\ m = 6.98\ m$$

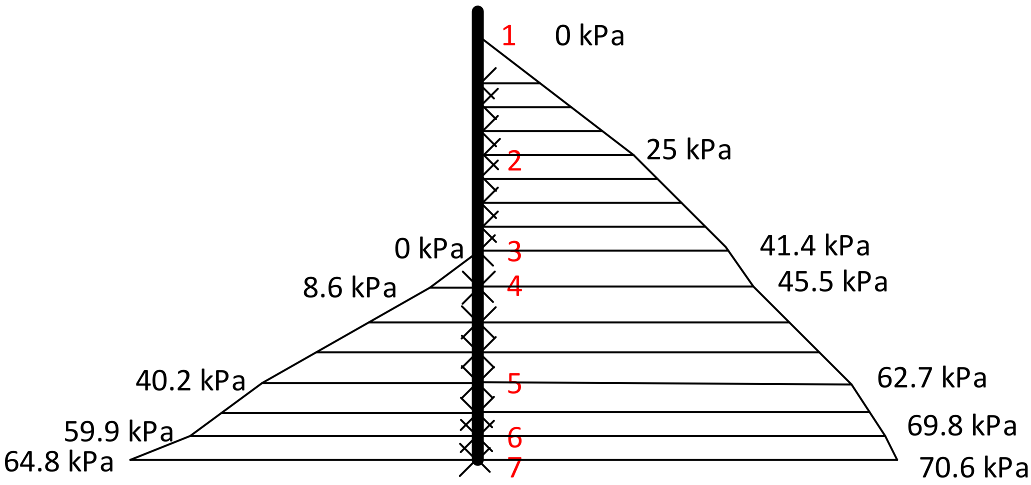
$$u_{6b} = 69.8\ kPa$$

$$h_{6f} = h_B + 4.8 * 0.45 = 6.25 + 2.16 = 8.41\ m\ (4.8\ drops\ from\ point\ B)$$

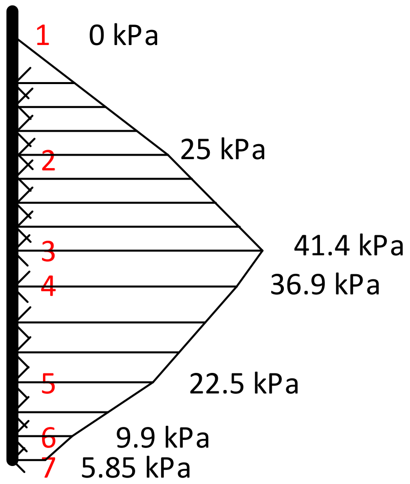
$$u_{6f}/\gamma = 8.41\ m - 2.42\ m = 5.99\ m$$

$$u_{6f} = 59.9\ kPa$$

$$u_{6b} - u_{6f} = 69.8 - 59.9 = 9.9\ kPa$$



Water Pressure Distribution



Net Water Pressure Distribution

$$R = (10.75 - 8.25) * \frac{25\ kPa}{2} + (8.25 - 6.25) * \frac{41.4\ kPa + 25\ kPa}{2} + (6.25 - 5.75) * \frac{41.4\ kPa + 36.9\ kPa}{2}$$

$$+(5.75 - 3.58) * \frac{36.9\ kPa + 22.5\ kPa}{2} + (3.58 - 2.42) * \frac{22.5\ kPa + 9.9\ kPa}{2} + (2.42 - 2.25) * \frac{9.9\ kPa + 5.85\ kPa}{2}$$

$$R = 31.25\, kN/m + 66.4\, kN/m + 19.58\, kN/m + 64.45\, kN/m + 18.79\, kN/m + \ 1.34\, kN/m$$

$$R = 201.81\, kN/m \quad (\,per\ meter\ thickness\ of\ wall\ into\ the\ page\,)$$

d) F.S against boiling at the excavated surface :

$$i_c = \frac{\gamma'}{\gamma_w} = \frac{19\ kN/m^3 - 10\ kN/m^3}{10\ kN/m^3} = 0.9$$

We could check the boiling tendency approximately in d * d/2 area shown with red line in the figure.

Average head at the bottom of this line (at a point shown with black dot)

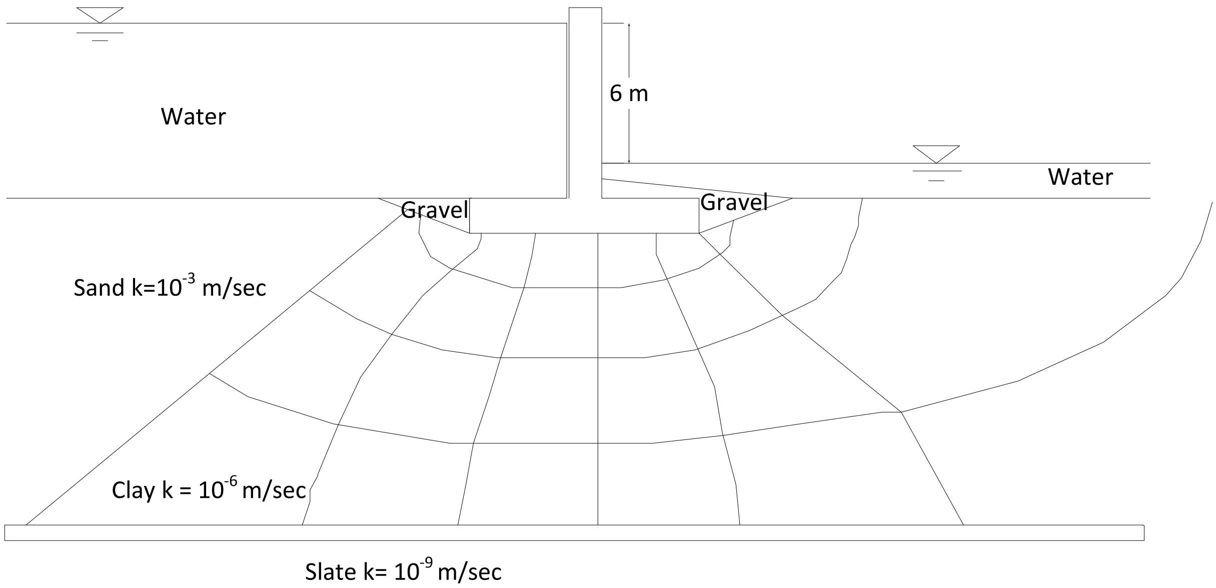
For 4.5 head drops ,

$$\Delta H = 4.5 * 0.45\ m = 1.8\ m\,, L = 4.33\ m\,, i = \frac{\Delta H}{L} = \frac{1.8\ m}{4.33} = 0.42$$

$$F.S = \frac{0.9}{0.42} = 2.14$$

Question 3

a)



b) $q = k * h * \frac{N_f}{N_d} = 10^{-6}\ m/sec * 6\ m * \frac{4}{6} = 4 * 10^{-6}\ m^3/sec$

(per meter thickness of levee wall)