(1)

CIVE 353 - Geotechnical Engineering I
ASSIGNMENT 6
SOLUTIONS

University of Waterloo
Department of Civil Engineering

1. What head is required to produce quick conditions at the base of the column in Figure 2? The soil has Gs of 2.68 and water content of 14.9 percent.

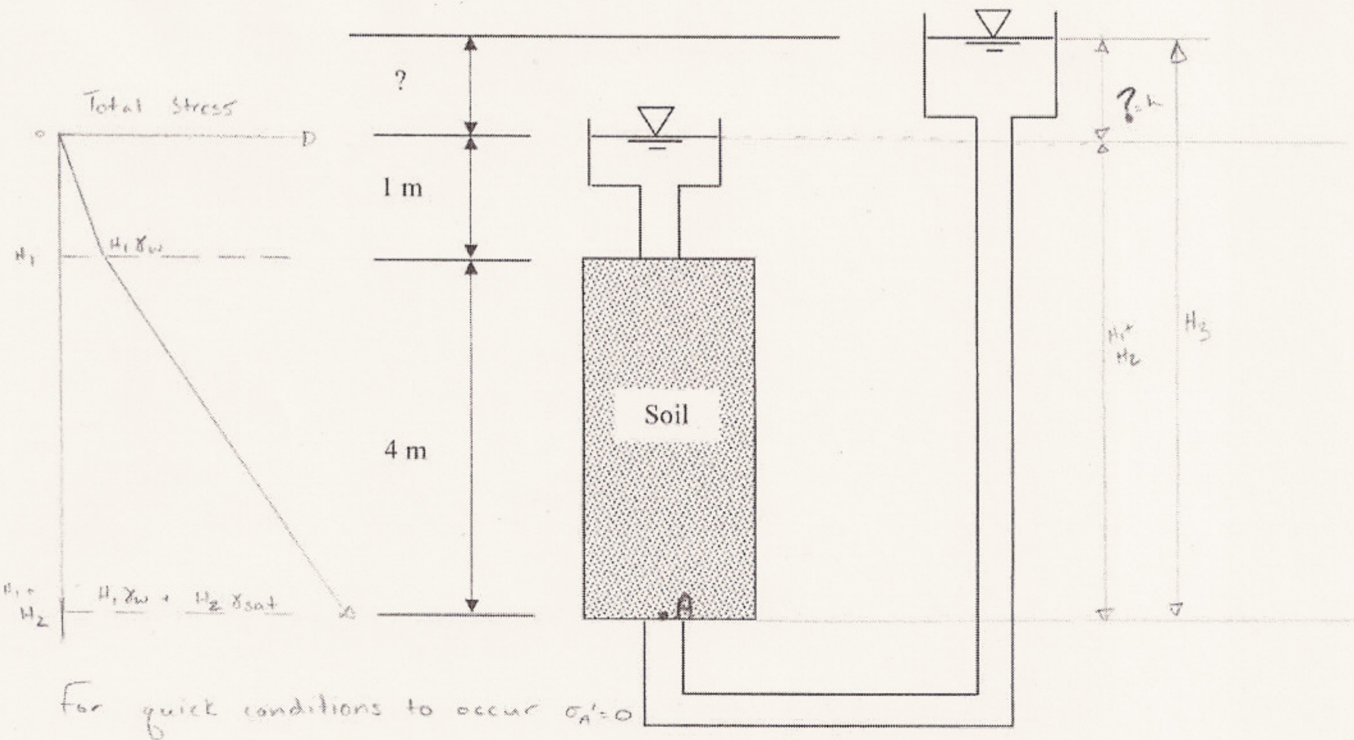


Figure 2

For quick conditions to occur $\sigma_A' = 0$

$$\sigma_A' = \sigma_A - u_A$$

also when $S_r = 1$

$$\gamma_{sat} = \frac{G_s(1+w)}{1+wG_s}\gamma_w$$

$$= \frac{2.68(1+0.149)}{1+2.68(0.149)}\, 9.81\ kN/m^3$$

$$= 21.59\ kN/m^3$$

$$\therefore\ \sigma_A = 1m\cdot\gamma_w + 4m\cdot\gamma_{sat}$$

$$u_A = H_3\cdot\gamma_w$$

$$\therefore\ \sigma_A' = 0 = (1m\cdot\gamma_w + 4m\cdot\gamma_{sat}) - (H_1 + H_2 + h)\gamma_w$$

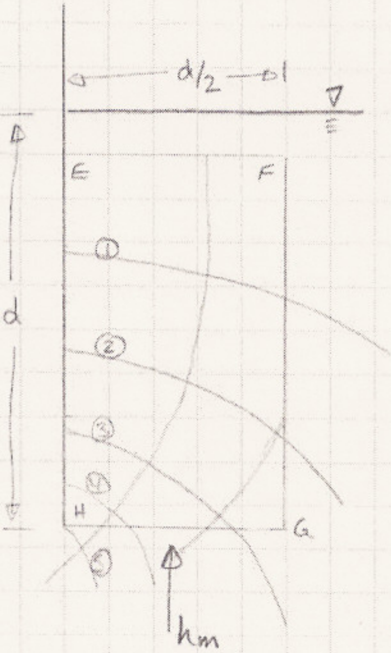
$$\therefore\ h = \frac{1m\,\gamma_w + 4m\cdot\gamma_{sat}}{\gamma_w} - (H_1 + H_2) = \frac{1m(9.81) + 4m(21.59)}{9.81} - (5m)$$

$$\therefore\ h = 4.68\ m$$

Example 3.4 (Soil Mechanics by Craig)

2. For analysis purposes consider the stability of the soil mass EFGH (6m by 3m in section)

By inspection of the flow net:



$N_d = 12$

average head on HG

$$h_m = \frac{n_d}{N_d} \cdot h$$

$$= \frac{3.5}{12} \times 8m$$

$$= 2.3 \text{ m}$$

$$i_m = \frac{h_m}{d} = \frac{2.3 \text{ m}}{6 \text{ m}}$$

$$= 0.39$$

$$i_c = \frac{\gamma'}{\gamma_w} = \frac{(19.5 - 9.81)\text{ kN/m}^3}{9.81 \text{ kN/m}^3}$$

$$= 0.988$$

$$F_{os} = \frac{i_c}{i_m}$$

$$= \frac{0.988}{0.39}$$

$$= 2.53$$

Please note; if embedded depth of pile is d, then about d/2 width on downstream side would be effected.

3.

(a) $Fos = \frac{\sigma_{Resisting}}{\sigma_{acting}}$

σ_R = total stress at clay/sand interface

$\sigma_R = 10m\ \gamma_{sat}$

$\rho = 2.0\ Mg/m^3$

$\gamma = \rho g$

$= 2.0\ Mg/m^3 \cdot 9.81\ m/s^2$

$= 19.62\ kN/m^3$ ← Assume this is saturated unit weight

$\sigma_R = 10m \cdot \gamma_{sat}$

$= 10m \cdot 19.62\ kN/m^3$

$= 196.2\ kPa$

σ_a = stress imparted by H_2O in upwards direction

$= 18m \cdot \gamma_w$

$= 18m \cdot 9.81\ m/s^2$

$= 176.6\ kPa$

$Fos = \frac{\sigma_R}{\sigma_a}$

$= \frac{196.2\ kPa}{176.6\ kPa}$

$= 1.11$

(b) Find river elevation nescessary to cause quick condition.

let H_R = the river elevation nescessary to develop quick conditions

Note: quick condition occurs when $\sigma_A' = 0$

$$\sigma_A' = \sigma_A - u_A$$

$$\therefore \sigma_A = u_A$$

$$\sigma_A = 10m \cdot \gamma_{sat}$$
$$= 196.2 \text{ kPa}$$

$$u_A = H_R \cdot \gamma_w$$

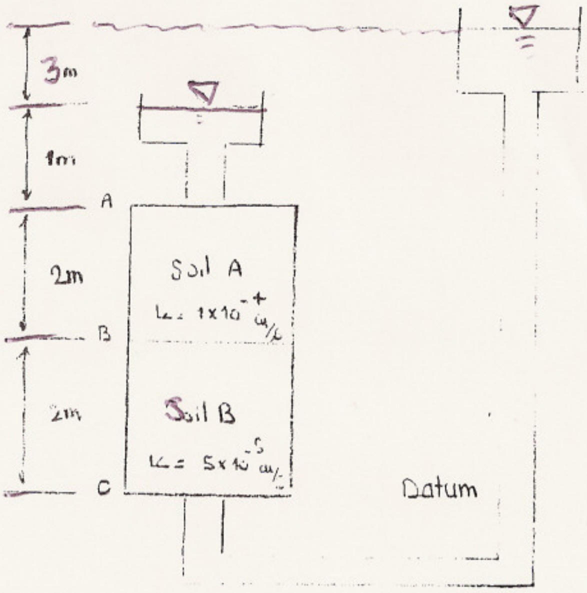
$$\sigma_A = H_R \gamma_w$$

$$\therefore H_R = \frac{\sigma_A}{\gamma_w}$$

$$= \frac{196.2 \text{ kPa}}{9.81 \text{ kN/m}^3}$$

$$= 20m$$

Q.4.



	TH	EH	PH
A	5m	4m	1m
C	8m	0	8m

Flow thru soil A is equal to flow thru soil B.

$$q_A = q_B$$

$$k_A i_A A_A = k_B i_B A_B \xrightarrow{A_A = A_B} k_A i_A = k_B i_B$$

$$\boxed{k_A \frac{\Delta h_A}{2m} = k_B \frac{\Delta h_B}{2m}}$$

Head lost between point c and Point A is 3m

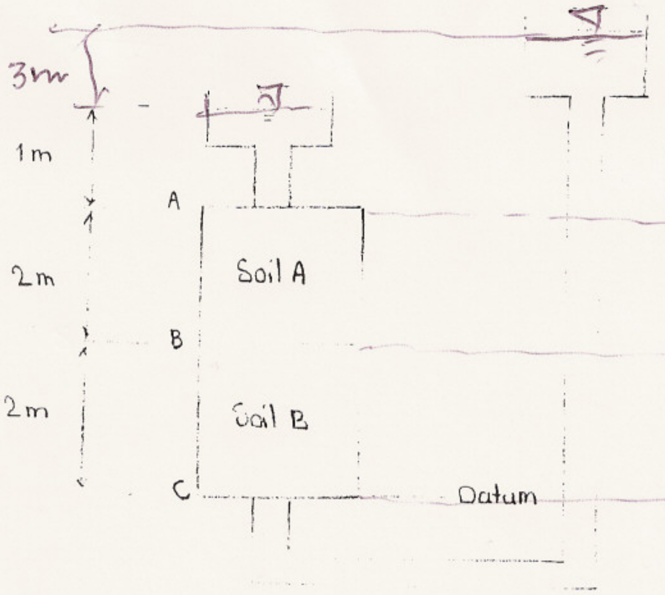
$$\Delta h = 3m$$

$$\Delta h = \Delta h_A + \Delta h_B$$

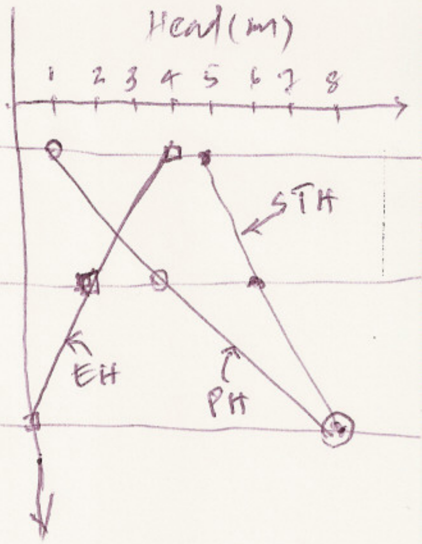
$$\longrightarrow \begin{cases} k_A \Delta h_A = k_B \Delta h_B \\ \Delta h_A + \Delta h_B = 3m \end{cases} \longrightarrow \begin{cases} 1\times10^{-4}\, \Delta h_A = 5\times10^{-5}\, \Delta h_B \\ \Delta h_A + \Delta h_B = 3m \end{cases}$$

$$\Longrightarrow \begin{cases} \Delta h_A = 0.5\, \Delta h_B \\ \Delta h_A + \Delta h_B = 3m \end{cases} \longrightarrow \begin{cases} \Delta h_B = 2m \\ \Delta h_A = 1m \end{cases}$$

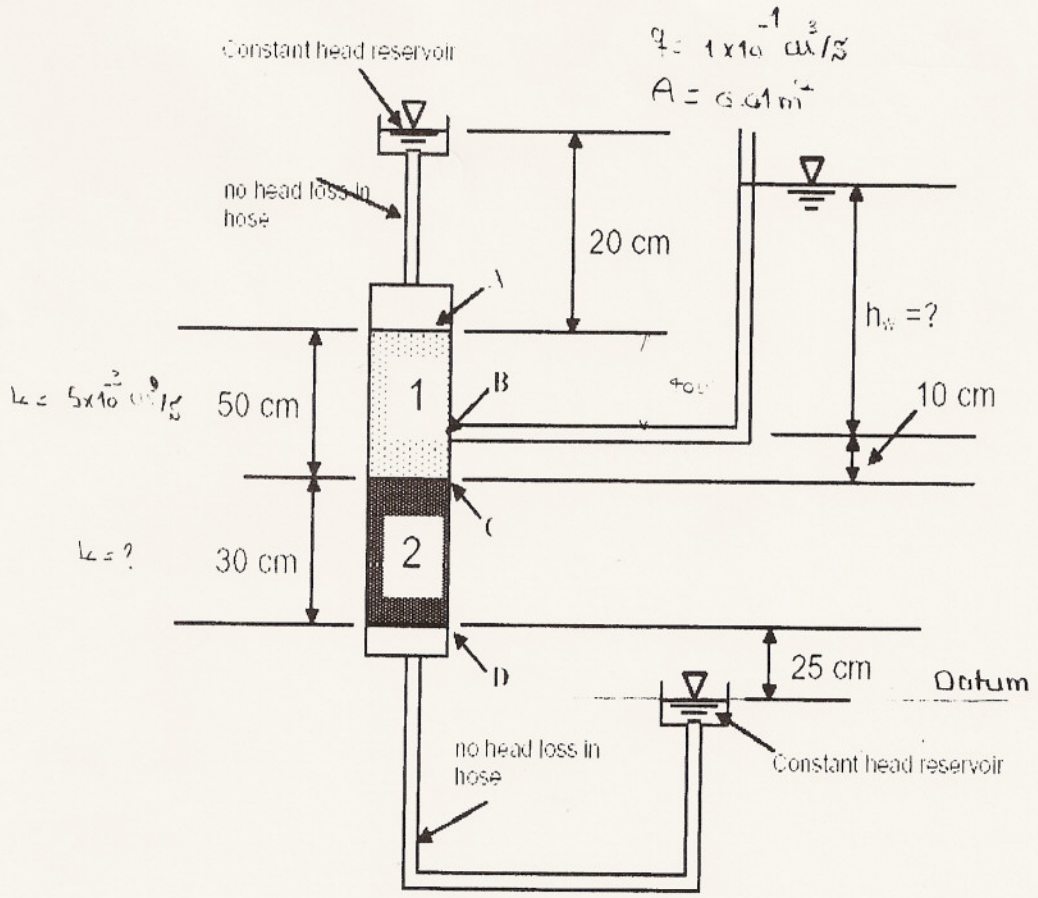
Q4 (contin'd)



TH	EH	PH
5m	4m	1m
6m	2m	4m
8m	0	8m



Q.5



TH	EH	PH
125 cm	105 cm	20 cm
0 cm	25 cm	-25 cm

- Head lost between Point A and Point D : 125 cm

$$\Delta h_1 + \Delta h_2 = 125\ cm \qquad (1)$$

- Flow through Soil $\underline{\underline{1}}$ is equal to flow through soil $\underline{\underline{2}}$

$$q_1 = q_2 \Longrightarrow k_1 i_1 A_1 = k_2 i_2 A_2 \xrightarrow{A_1 = A_2} K_1 i_1 = k_2 i_2$$

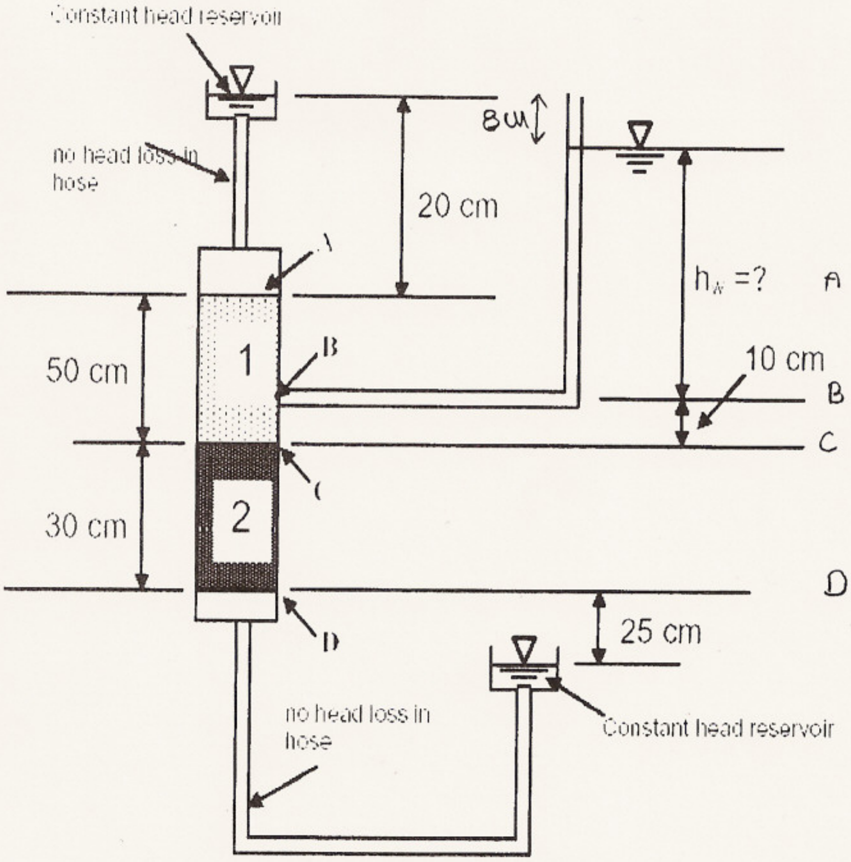
$$k_1 \frac{\Delta h_1}{50} = k_2 \frac{\Delta h_2}{30}$$

- $q_1 = k_1 \dfrac{\Delta h_1}{50} \times (0.01 \times 10^4\ cm^2)$

$$1\times10^{-1}\ cm^3/s = 5\times10^{-3} \times \frac{\Delta h_1}{50} \times (0.01\times10^4) \Longrightarrow \Delta h_1 = 10\ cm$$

$$\left|\begin{array}{l} \Delta h_1 = 10\ cm \\ \Delta h_1 + \Delta h_2 = 125\ cm \end{array}\right. \Longrightarrow \Delta h_2 = 115\ cm$$

Q.5 (cont'd)



	TH	EH	PH
A	125 cm	105 cm	20 cm
B	117 cm	65 cm	52 cm
C	115 cm	55 cm	60
D	0 cm	25 cm	-25 cm

$\Delta h_{A-B} = \frac{4}{5} \times 10\,cm = 8\,cm$

a) $\Longrightarrow \boxed{h_w = 52\,cm}$

b) Hydraulic conductivity of sand layer No. 2

$q_2 = 1 \times 10^{-1}\ cm^3/s$

$\Delta h_2 = 115\,cm$

$q_2 = k_2\, i_2\, A_2$

$10^{-1}\ cm^3/s = k_2 \times \frac{115}{30} \times (0.01 \times 10^4\ cm^2) \Longrightarrow k_2 = 0.26 \times 10^{-3}\ cm/s$

c) Seepage velocity in sand layer No. 1.

$v_s = \frac{v}{n} = \frac{k_1 i_1}{n} = \frac{5 \times 10^{-3} \times 10/50}{0.35} = 2.9 \times 10^{-3}\ cm/s$