



University of Technology
Building and Construction Eng. Dept.
Final Exam – 19/5/2016

Subject : Soil Mechanics
Branch : All Branches

Class: 3rd Year
Time : 3 hrs.



Note: Answer Four Questions only

Q1-A) - Answer three of the following. Enhance your answer with suitable sketches:

- 1- Compare between kaolinite and montmorillonite.
- 2- Compare between the unconsolidated undrained test (UU) and consolidated drained test (CD)
- 3- Compare between pore water pressure and excess pore water pressure.
- 4- Compare between standard Proctor compaction test and modified Proctor compaction test.

(9 marks)

Q1-B)-A soil sample has a bulk unit weight of 19.62 kN/m^3 and a dry unit weight of 17.66 kN/m^3 . Given that the specific gravity of the soil is 2.70. Find:

1) void ratio (e) 2) porosity (n) 3) Degree of saturation (s) 4) Relative density , if the maximum and the minimum void ratios of the soil are 0.85 and 0.45 respectively .

(16 marks)

Q2-A)-Answer with true (T) or false (F), and correct the false one.

- 1- All soils have approximately the same shear strength at their liquid limit.
- 2- A fine grained soil with $S.L.=15\%$ and $\omega_n=20\%$, then its $S=110\%$.
- 3- The void ratio decreases with decreasing in the water content below L.L.
- 4- The coefficient of permeability of coarse grained soils is always greater than that of fine grained soils.
- 5- The total settlement of a clay layer is dependent on its coefficient of permeability.

(10 marks)

Q2-B) A covered steel (unit weight = 80 kN/m^3) tank, 15 m in diameter and 10 m high and with 20 mm wall thickness, is filled with liquid (unit weight = 9 kN/m^3) up to a height of 9.9 m. The tank sits on a concrete (unit weight = 24 kN/m^3) foundation, 15 m diameter * 0.6 m thick. The foundation rests on the surface of 5-m thick soft, normally consolidated clay above thick layer of gravel. Given $C_c = 0.6$, $C_r = 0.08$, $C_v = 1.0 \frac{\text{m}^2}{\text{year}}$, $\omega_c = 48\%$, and $G_s =$

2.7. Ground water level is at the surface, calculate:

- 1) The final consolidation settlement at the center of the tank

- 2) Differential settlement between the center and edge of the tank.
- 3) Calculate the time for 50% consolidation to occur.
- 4) The settlement, if the tank is loaded to half its capacity and kept for 2 years.
- 5) If the tank is drained (height of liquid =0) , what is the heave due to emptying the tank. Given

X/R	0	0	1	1	2
Z/R	0.6	0.333	0.333	0.6	1.2
Factor	0.85	0.95	0.45	0.4	0.05

(15 marks)

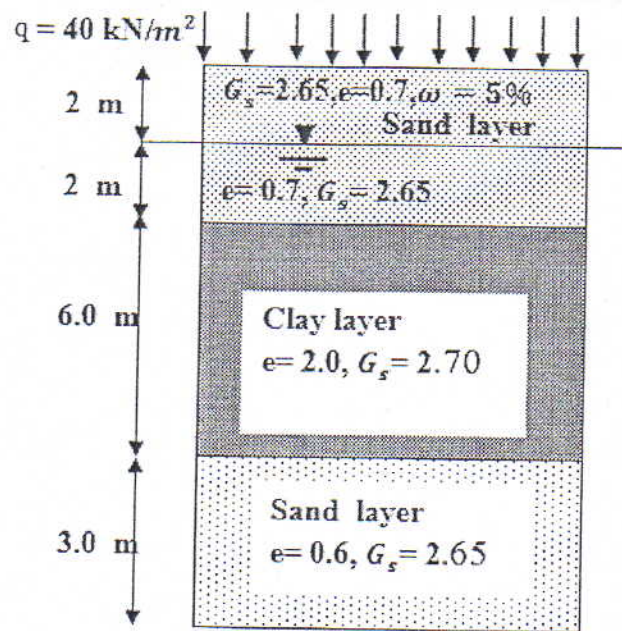
Q3-A)- The following results were obtained from a shear box test for a soil sample and the dimensions of the shear box are (60 *60) mm. Calculate the shear strength parameters (c and ϕ). (10 marks)

Normal Load (kN)	0.275	0.550	1.10
Shear Load (kN)	0.179	0.269	0.447

Q3-B)-For the soil profile shown, calculate at the middle of clay layer the:

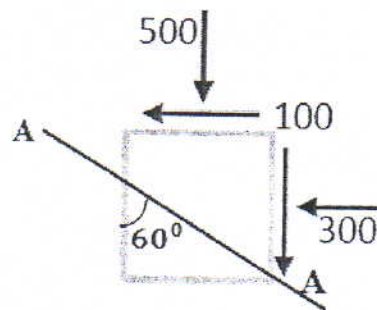
- 1- Total stress, effective stress and pore water pressure for the following conditions:
 - a-before the application of the load.
 - b-immediately after application of the load.
 - c- after very long time.
- 2- The final consolidation settlement at the middle of clay layer given the void ratio $e=2.0$ and the compression index $C_c = 2.0$.
- 3- The days needed for consolidation to reach 80%. Given $C_v = 1.5 \times 10^{-3} \text{ cm}^2/\text{sec}$. (15 marks)

U%	10	20	30	40	50	60	70	80	90
Tv	0.008	0.031	0.071	0.126	0.197	0.287	0.403	0.567	0.848



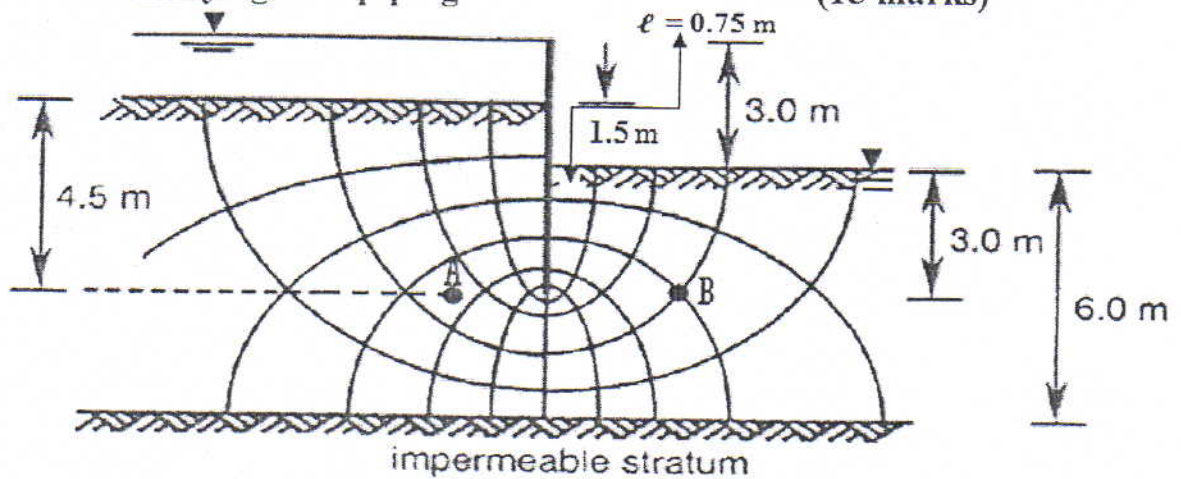
Q4-A)- Given : The stresses (in kPa) on an elements shown below: Find

- 1- The magnitude and direction of the major and minor principal stresses.
 - 2- The maximum shear stress and the orientation of plane at which it acts.
 - 3- The stresses on plan A-A shown in figure.
- (10 marks)



Q4-B) - For the sheet pile wall shown in figure below, find

- 1- Quantity of seepage ($k = 0.5 \times 10^{-3} \text{ m/sec}$)
 - 2- Pore water pressure at points A and B
 - 3- Factor of safety against piping
- (15 marks)



Q5-A)-Results of CU tests conducted on three saturated clay samples are given below. Determine:

1- The shear strength parameters c, ϕ, c' and ϕ' .

2- Plot the stress path (P-q) for the test.

(10 marks)

Test No.	1	2	3
Confining Pressure σ_3 (kPa)	40	80	120
Deviator stress (kPa)	110	190	240
Pore water pressure at failure (kPa)	15	20	35

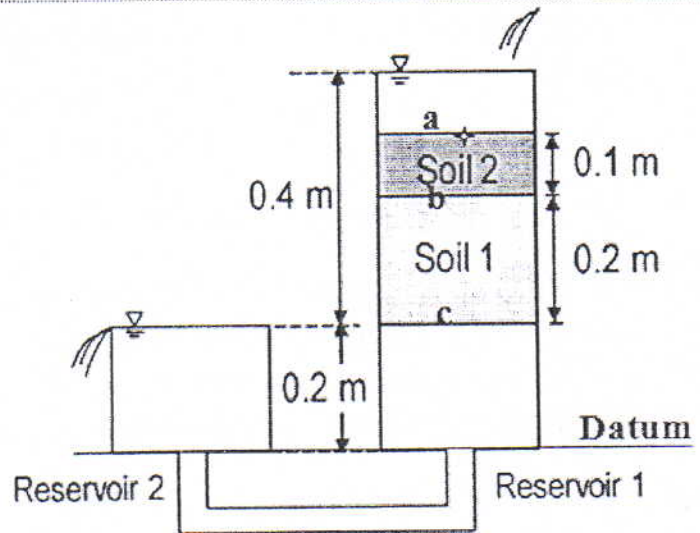
Q5-B) - For the setup shown. Given the hydraulic conductivity (k_1) of 2.4×10^{-5} m/min. and k_2 of 1.0×10^{-5} m/min, cross-sectional area of (area 1 = area 2) = $1.0 \times 10^{-2} \text{ m}^2$. Calculate:

1- The flow rate ($\frac{\text{m}^3}{\text{min}}$).

2- h_t, h_e and h_p at points a, b and c (put your results in table).

3- The $\sigma_{total}, \sigma_{effective}$ and u at points a, b and c.

Given ($\gamma_1 = 17 \text{ kPa}$ and $\gamma_2 = 20 \text{ kPa}$).



(15-marks)

Good Luck

Some useful information's:

$$T_v = \frac{C_v t}{d^2}$$

$$\text{For N.C.C.} \quad S_{cf} = \frac{C_c}{1+e} H \log \frac{\dot{p}_0 + \Delta P}{\dot{p}_0}$$

For O.C.C.

$$\text{if } \dot{p}_0 + \Delta P \leq \dot{p}_c \text{ then } S_{cf} = \frac{C_r}{1+e} H \log \frac{\dot{p}_0 + \Delta P}{\dot{p}_0}$$

if $\dot{p}_0 + \Delta P > \dot{p}_c$ then use :

$$S_{cf} = \frac{C_r}{1+e} H \log \frac{\dot{p}_c}{\dot{p}_0} + \frac{C_c}{1+e} H \log \frac{\dot{p}_0 + \Delta P}{\dot{p}_c}$$

$$\text{O.C.R} = \frac{\dot{p}_c}{\dot{p}_0}$$

$$T_v = \frac{\pi}{4} U_{av}^2 \quad \text{For } U_{av} \leq 60\%$$

$$T_v = 1.781 - 0.933 \log (100 - U_{av}) \quad \text{For } U_{av} > 60\%$$

Q.1 B)

$$\gamma_d = \frac{G_s}{1+e} \gamma_w \Rightarrow 17.66 = \frac{2.7}{1+e} * 10 \Rightarrow e = 0.53$$

$$n = \frac{0.53}{1+0.53} = 0.3464$$

$$\gamma_d = \frac{\gamma_t}{1+w} \Rightarrow 17.66 = \frac{19.62}{1+w} \Rightarrow w = 0.11$$

$$SE = G_s w \Rightarrow S = 0.53 = 2.7 * 0.11 \Rightarrow S = 56\%$$

$$R.D = \frac{0.85 - 0.53}{0.85 - 0.45} = 80\%$$

Q.2 B) weight of empty tank

$$\text{الجانب} \quad 3.14 * 15 * 10 * 0.02 * 80 = 753.6 \text{ kN}$$

$$\text{Base and roof} \quad \left(\left(\frac{15}{2} \right)^2 \pi * 80 * 0.02 \right) * 2 = 565.4 \text{ kN}$$

$$1319 \text{ kN}$$

$$\text{weight of foundation} = \left(\frac{15}{2} \right)^2 \pi * 0.6 * 24 = 2543$$

$$\text{weight of liquid} = \left(\frac{15}{2} \right)^2 \pi * 9.9 * 9 = 15737$$

$$q_{\text{for full tank}} = \frac{1319 + 2543 + 15737}{\left(\frac{15}{2} \right)^2 \pi} = 111 \text{ kN/m}^2$$

$$q_{\text{for half full}} = \frac{1319 + 2543 + \frac{15737}{2}}{\left(\frac{15}{2} \right)^2 \pi} = 66.41 \text{ kN/m}^2$$

at center

$$\frac{x}{r} = 0, \frac{z}{r} = \frac{2.5}{7.5} = 0.333$$

$$\text{factor} = 0.95$$

$$S_{cf} \text{ at center} = \frac{0.6}{1+1.296} * 5 \log \frac{18.5 + (111 * 0.95)}{18.5} = 1.079$$

$$S_{cf} \text{ at edge} = \frac{0.6}{1+1.296} * 5 \log \frac{18.5 + (111 * 0.45)}{18.5} = 0.742$$

$$\text{Differential sett} = 1.079 - 0.742 = 0.337$$

at corner (edge)

$$\frac{x}{r} = 1, \frac{z}{r} = 0.333$$

$$\text{factor} = 0.45$$

$$SE = G_s w$$

$$e = 2.7 * 0.48 = 1.296$$

$$\gamma_{sat} = \frac{G_s + e}{1+e} \gamma_w$$

$$\gamma_{sat} = \frac{2.7 + 1.296}{1+1.296} * 10$$

$$= 17.4 \text{ kN/m}^3$$

$$\sigma' = 2.5 (17.4 - 10) = 18.5$$

Q.2 B air

3) for 50% cons. $T_v = 0.196$

$$0.196 = \frac{1 + t}{(2.5)^2} \Rightarrow t = 1.225 \text{ year}$$

4) for 2 years $T_v = \frac{1 + 2}{(2.5)^2} = 0.32 \Rightarrow u = 63.2\%$ ^{من موائيل} ^{الكليل} ^{log}

$$S_{ct} \text{ for half loaded} = \frac{0.6}{1 + 1.296} * 5 \log \frac{18.5 + (66.41 * 0.95)}{18.5} = 0.842$$

$$S_{et} = 0.632 * 0.842 = 0.532 \text{ m}$$

$$5) 66.41 * 0.95 = 63.1$$

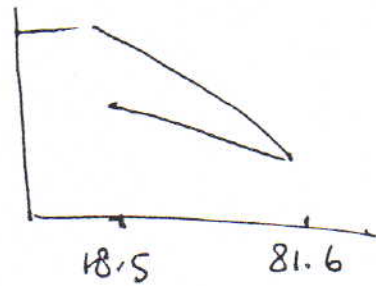
$$18.5 + 63.1 = 81.6$$

$$C_c = \frac{\Delta e}{\Delta \log P}$$
$$0.6 = \frac{\Delta e}{\Delta \log P}$$

$$0.6 = \frac{\Delta e}{\log \frac{81.6}{18.5}}$$

$$C_v = \frac{\Delta e}{\Delta \log P}$$

1.296



(23A)

Normal Stress

$$\frac{0.275}{0.0036} = 76.388$$

$$\frac{0.550}{0.0036} = 152.778$$

$$\frac{1.10}{0.0036} = 305.596$$

Shear Stress

$$\frac{0.179}{0.0036} = 49.72$$

$$\frac{0.269}{0.0036} = 74.722$$

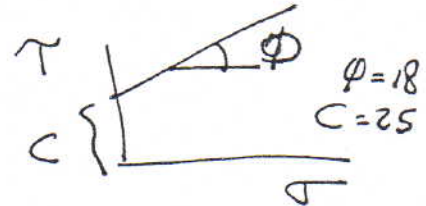
$$\frac{0.447}{0.0036} = 124.167$$

$$74.722 = C + 152.778 \tan \phi$$

$$49.72 = C + 76.388 \tan \phi$$

$$25 = 76.39 \tan \phi$$

$$\phi = 18.12^\circ \Rightarrow C = 24.16$$



Q.3 B) ① ④ $\sigma = 2 \times 16.37 + 2 \times 19.7 + 3 \times 15.66$
 $= 119 \text{ kN/m}^2$

$$u = 5 \times 10 = 50 \Rightarrow \sigma' = 119 - 50 = 69$$

⑥ $\sigma = 119 + 40 = 159$

$$u = 50 + 40 = 90$$

$$\sigma' = 69$$

⑦ $\sigma = 159$

$$u = 50$$

$$\sigma' = 109 \text{ kN/m}^2$$

② $S_{cf} = \frac{2}{1+2} \times 6 \log \frac{69+40}{69} = 0.794 \text{ m}$

③ $T_v = 0.567$ for 80% cons.

$$0.567 = \frac{1.5 \times 10^{-3} \times t}{(300)^2} \Rightarrow t = 34020000 \text{ Sec}$$

$$= 393.75 \text{ day}$$

$$\gamma_s \frac{G_s(1+w)}{1+e} \gamma_w$$

$$= \frac{2.65(1+0.05)}{1+0.7} \times 10$$

$$= 16.37$$

$$\gamma_{sat} \frac{G_s + e}{1+e} \gamma_w$$

$$\frac{2.65 + 0.7}{1.7} \times 10$$

$$= 19.7$$

$$\frac{2.7 \times 2}{3} \times 10$$

$$= 15.66$$

Q.4 A)

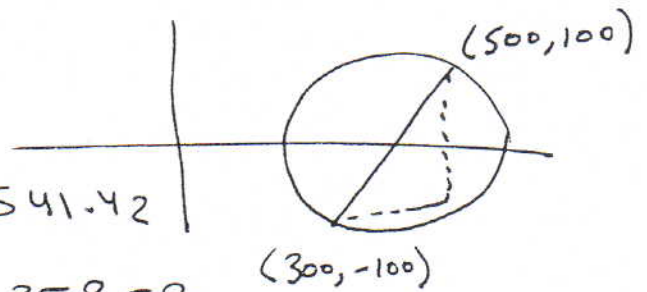
$$D = \sqrt{200^2 + 200^2} = 282.8$$

$$r = 141.42 \text{ kPa}$$

$$\sigma_1 = \frac{500 + 300}{2} + 141.42 = 541.42$$

$$\sigma_3 = \frac{500 + 300}{2} - 141.42 = 258.58$$

$$\text{max. Shear} = \frac{\sigma_1 - \sigma_3}{2} = \frac{541 - 258}{2} = 141.27$$



Q.4 B) ① $q = KH \frac{M}{Nd} = 0.5 \times 10^{-3} \times 3 \times \frac{5}{11} = 0.0006818 \text{ m}^3/\text{s}$
 $= 58.9 \text{ m}^3/\text{day}$

② $h_A = 9 - 3.5 \times 0.272 = 8.045 \text{ m}$

$h_A = 3 \text{ m} \Rightarrow h_{pA} = 8.045 - 3 = 5.045$
 $u_A = 50.45 \text{ kN/m}^2$

$h_B = 9 - 9 \times 0.272 = 6.552$

$h_{pB} = 3$

$h_{pB} = 6.552 - 3 = 3.552 \Rightarrow u_B = 35.52 \text{ kPa}$

③ $F.S = \frac{c}{\tau_c} = \frac{\frac{20 - 10}{10}}{\frac{0.272}{0.75}} = 2.76$

Q.5A)

σ_3	σ_1	u	σ_3'	σ_1'	p	q
40	150	15	25	135	$\frac{150+40}{2} = 95$	55
80	270	20	60	250	$\frac{270+80}{2} = 175$	95
120	360	35	85	325	$\frac{360+120}{2} = 240$	120

$$\sigma_1 = \sigma_3 \tan^2\left(45 + \frac{\phi}{2}\right) + 2c \tan\left(45 + \frac{\phi}{2}\right) \quad p$$

$$270 = 80 \tan^2\left(45 + \frac{\phi}{2}\right) + 2c \tan\left(45 + \frac{\phi}{2}\right) \quad q$$

$$150 = 40 \tan^2\left(45 + \frac{\phi}{2}\right) + 2c \tan\left(45 + \frac{\phi}{2}\right)$$

$$120 = 40 \tan^2\left(45 + \frac{\phi}{2}\right) \Rightarrow \phi = 30$$

$\phi = 22$ *المعطيات غير كافية* $\phi = 26$ *المعطيات غير كافية*

$c = 18.6$ $\phi = 26$ *المعطيات غير كافية*

$\phi = 32$ *المعطيات غير كافية*

Q.5B) $2.4 \times 10^{-5} \times \frac{\Delta h_{t1}}{0.2}$
 $= 1 \times 10^{-5} \times \frac{\Delta h_{t2}}{0.1} \quad \text{--- (1)}$

$\Delta h_{t1} + \Delta h_{t2} = 0.4$

Solving we get $\Delta h_{t1} = 0.182 = 0.18$

$\Delta h_{t2} = 0.218 = 0.22$ $\frac{\Delta h_{t2}}{0.1} = 12 \Delta h_{t1}$

$\Delta h_{t2} = 1.2 \Delta h_{t1}$

$q = KiA = 2.4 \times 10^{-5} \times \frac{0.182}{0.2} \times 1 \times 10^2 = 2.184 \times 10^{-7} \text{ m}^3/\text{sec}$

Points	σ_{total}	u	σ'
a	$0.1 \times 10 = 1$	1	0
b	$0.1 \times 10 + 0.1 \times 20 = 3$	-0.2	3.2
c	$3 + 0.2 \times 17 = 6.4$	0	6.4