University of Technology

Building and Construction Eng. Dept.

Final Exam / 2013/ Set 2

Subject : Soil Mechanics Class: 3rd Year

Branch : All Branches Time: 3 hrs.

Note: Answer Five Questions only

Q1 a) A cylinder of soil weighs 653 gm wet and 500.6 gm dry. It is 37.39 cm^2 in cross – sectional area and its height is 8.32 cm. The specific gravity of the solids is 2.65. Calculate the water content , dry unit weight and void ratio. If the sample was decreased in volume by 5 cm^3, calculate the change in water content and void ratio.

(14 marks)

Q1 b) Explain briefly two of the following (with sketches and equations)

i- **Coefficient of consolidation (C_v) using Taylor method.**

ii- **Factors affecting compaction.**

iii- **Expression for the corrected area of the soil sample in the triaxial test (UU)**

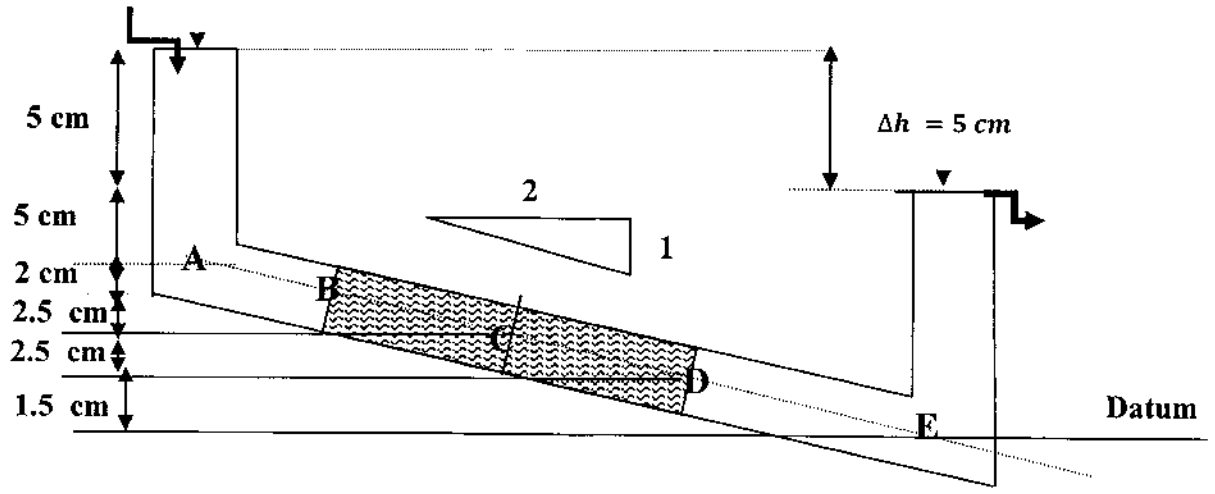
(6 marks)

Q2-a) – The particle size distribution of a soil gives the following information.

Particle size (mm)	6	4.75	2	1.3	0.6	0.2	0.075	0.002
% finer	100	84	84	60	30	10	4	2

Use the Unified Soil classification to classify the soil. **(6 marks)**

Q2-b)- For the setup shown , determine the pressure, elevation and total head at points A, B, C , D and E .



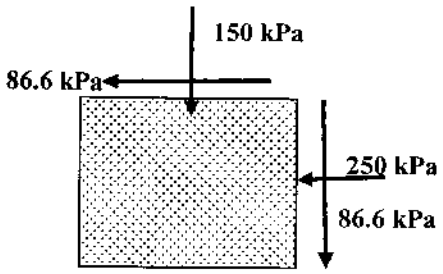
(14 marks)

Q3-a)-The stresses for a sample of sand are given in figure below, find:

i- **Major and minor principal stresses and their orientation.**

ii- **Maximum and minimum shear stresses.**

(10 marks)

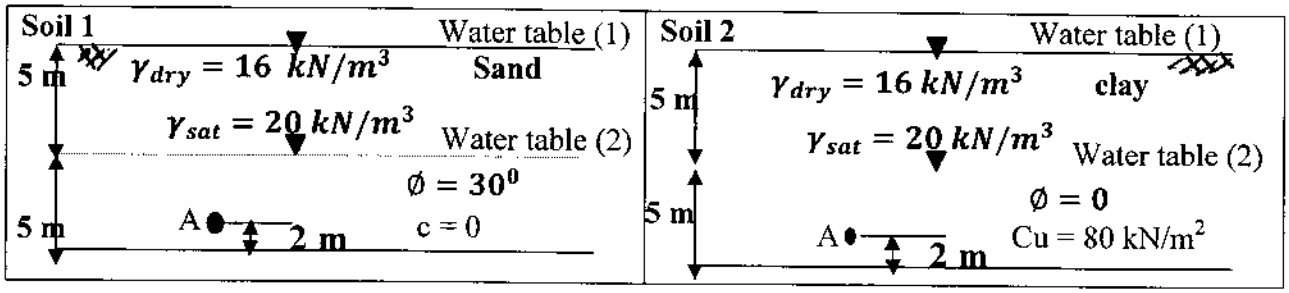


Q3-b)- The soil profile for two types of soil are given in the figures below,

if τ_b = The shear strength of soil at point A before lowering water table.

τ_a = The shear strength of soil at point A after lowering water table.

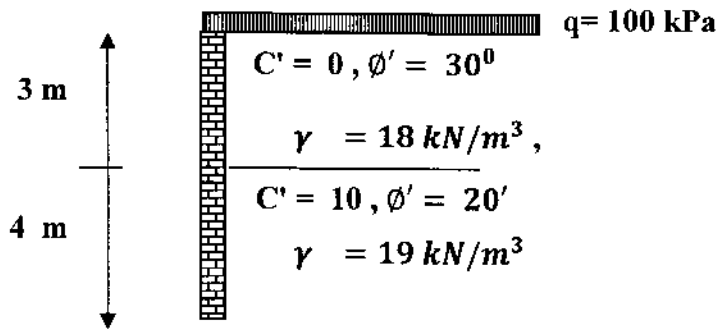
Determine: the ratio ($\frac{\tau_b}{\tau_a}$) for the two soils. **(10 marks)**



Q4-a)-A normally consolidated sample in an oedometer has a void ratio e =0.8 and an effective vertical stress of 50 kPa . If the compression index , c_c= 0.4 and recompression index, C_r= 0.1, calculate the final void ratio when the effective stress is increased to 200 kPa and then reduced back to 50 kPa.

(10 marks)

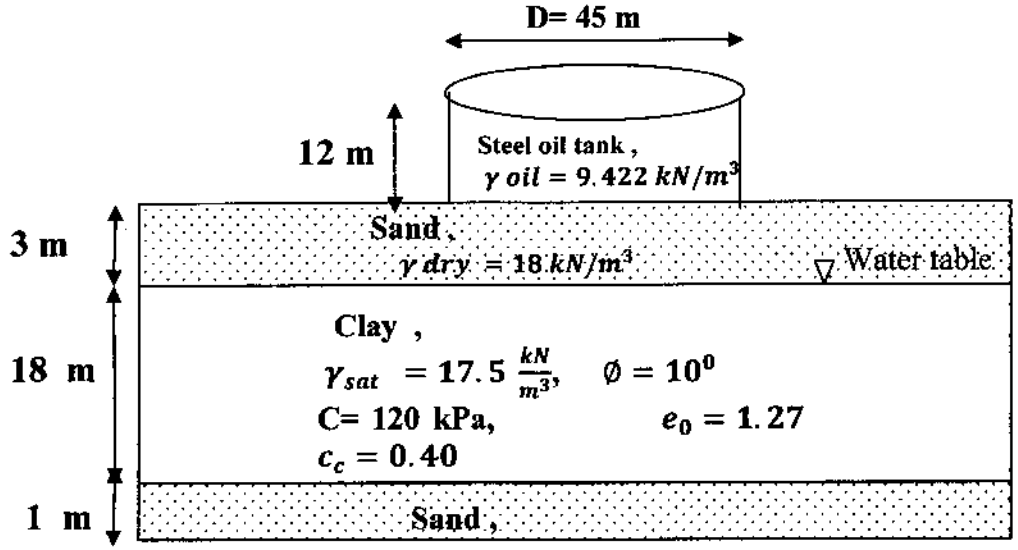
Q4-b)- For the retaining wall shown in figure, find the magnitude and position of the lateral earth thrust (active force). **(10 marks)**



Q5) An oedometer test carried out in Lab. On 20 mm thick, doubly drained sample from the clay stratum (shown below) attained 50% consolidation in 6.5 minutes, find:

i- Total differential settlement of the fully loaded tank.

ii- The time required for 75% consolidation in the field.



(20 marks)

Given

X/R	0	1	0	1	1
Z/R	0.1333	0.9333	0.5333	0.1333	0.5333
Factor	0.98	0.65	0.90	0.50	0.42

Q6-A The following results were obtained at failure in a series of consolidated undrained tests with pore water pressure measurements. Determine the values of shear strength parameters c , ø and C' , ∅′

	specimen (1)	specimen (2)
σ_3 (all round pressure)	150 kN/m^2	300 kN/m^2
σ_d (deviator stress)	192 kN/m^2	341 kN/m^2
u (pore water pressure at failure)	80 kN/m^2	154 kN/m^2

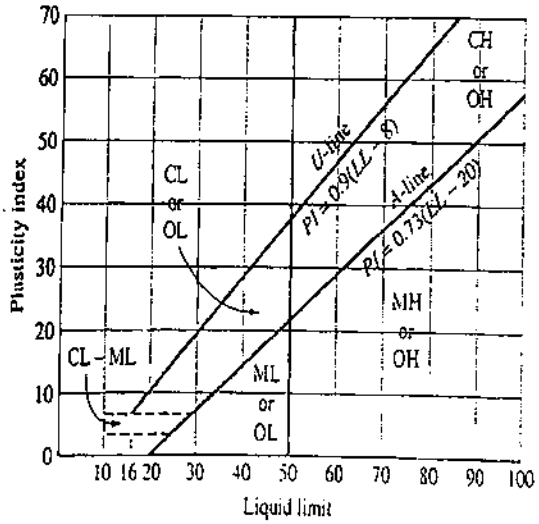
(14 marks)

Q6-B)- A soil specimen was tested in the laboratory . At the beginning both σ_v and σ_h were equal 100 kN/m^2 , then σ_v was increased to 450 kN/m^2 while σ_h was held constant. Find the slop of the stress path.

(6 marks)

Good Luck

Some useful information's:



$$Tv = \frac{Cv\,t}{d^2}$$

For N.C.C. $S_{cf} = \frac{Cc}{1+e} Hlog \frac{P_\circ + \Delta P}{P_\circ}$

For O.C.C.

$$if\ P_\circ + \Delta P \leq P_C\ then\ S_{cf} = \frac{Cr}{1+e} Hlog \frac{P_\circ + \Delta P}{P_\circ}$$

$$if\ P_\circ + \Delta P > P_C\ then \text{ use :}$$

$$S_{cf} = \frac{Cr}{1+e} Hlog \frac{P_c}{P_\circ} + \frac{Cc}{1+e} Hlog \frac{P_\circ + \Delta P}{P_c}$$

$$O.C.R = \frac{P_c}{P_\circ}$$

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

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

Soil Mechanic / Final 2013

Q.1 A) weight of water = 653 − 500.6 = 152.4 gm

$$\text{water content} = \frac{w_w}{w_s} = \frac{653-500.6}{500.6} * 100 = 30.44\ \%$$

$$\gamma_d = \frac{w_s}{V} = \frac{500.6}{311.08} = 1.609\ gm/cm^3$$

V_s = area * h
= 37.39 * 8.32
= 311.08 cm^3

$$\gamma_d = \frac{G_s}{1+e}\gamma_w \Rightarrow 1.609 = \frac{2.65}{1+e} * 1$$

$$\Rightarrow e = 0.647$$

new volume = 311.08 − 5 = 306.08 cm^3

$$\gamma_d = \frac{w_s}{V} = \frac{500.6}{306.08} = 1.635\ gm/cm^3$$

$$\gamma_d = \frac{G_s}{1+e}\gamma_w \Rightarrow 1.635 = \frac{2.65}{1+e} * 1 \Rightarrow e_2 = 0.621$$

$\Delta e = 0.647 - 0.621 = 0.026$

W_w new = 152.4 − 5 = 147.4 gm

$$w_s = \frac{w_w}{w_s} = \frac{147.4}{500.6} * 100 = 29.44\ \%$$

$\Delta w\% = 30.44 - 29.44 = 1\ \%$

Q.2 A) Gravel 16 %
Sand 80 %
Silt and clay 4 %

$$C_u = \frac{D_{60}}{D_{10}} = \frac{1.3}{0.2} = 6.5$$

$$C_c = \frac{(D_{30})^2}{D_{60} * D_{10}} = \frac{(0.6)^2}{1.3 * 0.2} = 1.385$$

∴ well graded

So the Soil is well graded Sand

Q2 B)

Point	he	hp	ht
A	8.5	10	18.5
B	6.5	12	18.5
C	4	12	16
D	1.5	12	13.5
E	0	13.5	13.5

Q.3 A.) center = 200

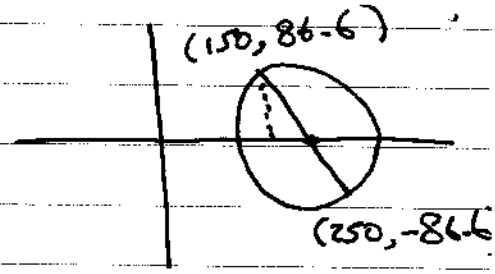
$x = 50$

$y = 86.6$

$r = \sqrt{50^2 + (86.6)^2} = 100$

$\sigma_1 = 200 + 100 = 300$ KPa

$\sigma_3 = 200 - 100 = 100$ KPa



to find θ we use stress pair $(250, -86.6)$

$$T_\theta = \frac{\sigma_1 - \sigma_3}{2} \sin 2\theta$$

$$-86.6 = \frac{300 - 100}{2} \sin 2\theta \Rightarrow \theta = -30^\circ$$

$T_{max.} = 100$ KPa , $T_{min} = -100$ KPa

Q.3B.) Before lowering $\sigma'_A = 5(20-10) + 3(20-10) = 80$

after lowering $\sigma'_A = 5 * 16 + 3(20-10) = 110$

For Soil (1) $\frac{T_b}{T_a} = \frac{80 \tan 30}{110 \tan 30} = 0.727 = 72.7\%$

For Soil (2) $\frac{T_b}{T_a} = \frac{80}{80} = 1 = 100\%$

Q.4 a) $e = 0.8$ at $P'_o = 50$ KPa $\quad C_c = 0.4$

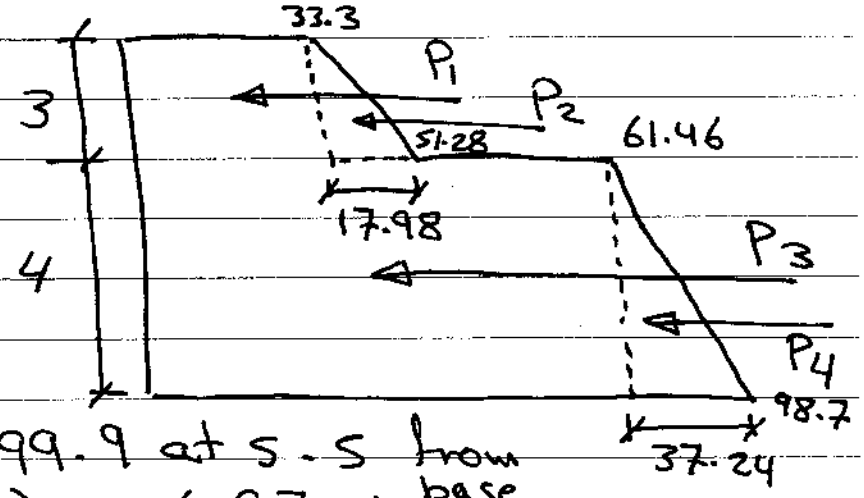
$C_r = 0.1$

$$C_c = \frac{\Delta e}{\Delta \log P} \Rightarrow 0.4 = \frac{0.8 - e}{\log \frac{200}{50}} \Rightarrow e = 0.56$$

$$C_r = \frac{\Delta e}{\Delta \log P} \Rightarrow 0.1 = \frac{e - 0.56}{\log \frac{200}{50}} \Rightarrow e = 0.62$$

(Q.4 b.) $Ka_1 = \frac{1-\sin 30}{1+\sin 30} = 0.333$, $Ka_2 = \frac{1-\sin 20}{1+\sin 20} = 0.49$

Depth	σ_v	$\sigma_h = \gamma h Ka - 2c\sqrt{Ka}$
0	100	$100 * 0.333 = 33.3$
3	$100 + 3*18 = 154$	$154 * 0.333 = 51.28$
3	154	$154 * 0.49 - 2*10\sqrt{0.49} = 61.46$
7	$154 + 4*19 = 230$	$230 * 0.49 - 2*10\sqrt{0.49} = 98.7$



$P_1 = 33.3 * 3 = 99.9$ at 5.5 from base

$P_2 = \frac{1}{2}(17.98 * 3) = 26.97$ at 5 m

$P_3 = 61.46 * 4 = 245.84$ at 2 m

$P_4 = \frac{1}{2}(37.24 * 4) = 74.48$ at 1.333

$P_{total} = 447.19$

$P_{total} * X = 99.9 * 5.5 + 26.97 * 5 + 245.84 * 2 + 74.48 * 1.333$

$\Rightarrow X = 2.852$ m

(Q.5 i) Pressure $= 9.422 * 12 = 113.064$ kN/m²

at center $\frac{x}{R} = 0$, $\frac{z}{R} = \frac{12}{22.5} = 0.533$ factor = 0.9

$\Delta p = 101.76$

at outer $\frac{x}{R} = 1$, $\frac{z}{R} = \frac{12}{22.5} = 0.533$, factor = 0.42

$\Delta p = 47.49$

$P_o' = 3*18 + 9(17.5 - 10) = 121.5$

S_{ct} at center $= \frac{0.1}{1+1.27} * 18 \log \frac{121.5 + 101.76}{121.5} = 0.$ m

S_{ct} at outer $= \frac{0.1}{1+1.27} * 18 \log \frac{121.5 + 47.49}{121.5} = 0.$ m

Differentiable Sett. $= 0.$ m

Q.5 ii) for 75 %.

$T_v = 1.781 - 0.933 \log(100 - 75)$

$= 1.781 - 1.304 = 0.477$

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

$0.477 = \frac{3.019 * t}{(9000)^2} \Rightarrow t = 12797946 \text{ min}$

$t = 24.35 \text{ year}$

$T_v = \frac{\pi}{4}(0.5)^2 = 0.19625$

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

$\Rightarrow 0.19625 = \frac{C_v * 6.5}{10^2}$

$C_v = 3.019 \text{ mm}^2/\text{min}$

Q.6 A.)

Sample	σ_3	σ_d	u_f	σ_1	σ_1'	σ_3'
1	150	192	80	342	262	70
2	300	341	154	641	487	146

to find c, ϕ

$342 = 150 \tan^2(45 + \frac{\phi}{2}) + 2c \tan(45 + \frac{\phi}{2})$

$641 = 300 \tan^2(45 + \frac{\phi}{2}) + 2c \tan(45 + \frac{\phi}{2})$

$299 = 150 \tan^2(45 + \frac{\phi}{2}) \Rightarrow \phi = 19.38$

$c = 15.246$

to find c', ϕ'

$262 = 70 \tan^2(45 + \frac{\phi'}{2}) + 2c' \tan(45 + \frac{\phi'}{2})$

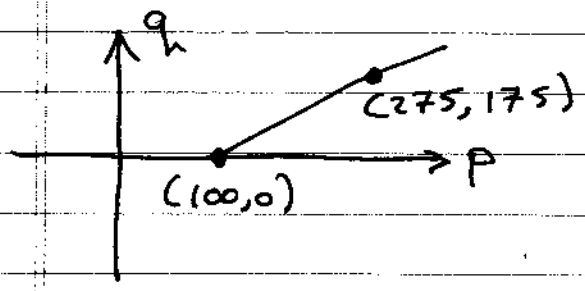
$487 = 146 \tan^2(45 + \frac{\phi'}{2}) + 2c' \tan(45 + \frac{\phi'}{2})$

$225 = 76 \tan^2(45 + \frac{\phi'}{2}) \Rightarrow \phi' = 29.67$

$c' = 15.917$

Q.6 B.)

initial				Final			
σ_v	σ_h	p	q_h	σ_v	σ_h	p	q_h
100	100	100	0	450	100	275	175



$\text{Slope} = \frac{175}{175} = 1$