University of Technology

Building and Construction Eng. Dept.

Final Exam / 2015

Subject : Soil Mechanics — Class: 3rd Year

Branch : All Branches — Time: 3 hrs.

Note: Answer Five Questions only including question one

ملاحظة : الاجابة عن خمسة اسئلة على ان يكون السؤال الاول من ضمنها

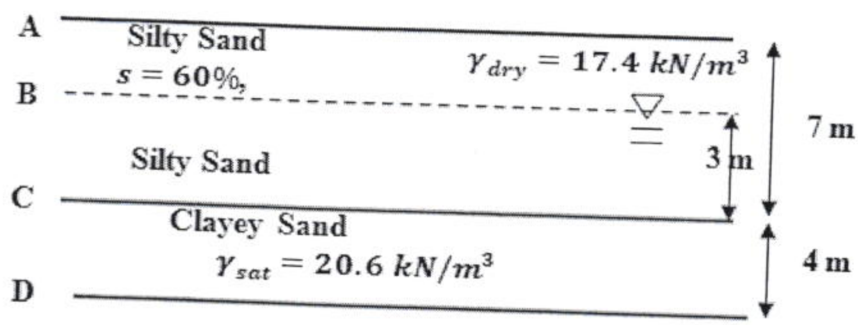
Q. No. 1:

Select the correct answer: **(20 marks)**

1. The ratio of the volume of voids to the total volume of soil is:
   a. Void ratio. b. Air content c. Degree of saturation. d. Porosity.
2. A soil sample has a specific gravity of 2.60 and a void ratio of 0.78. The water content required to fully saturate the soil at that void ratio will be:
   a. 20% b. 60 % c. 40% d. %30
3. The critical hydraulic gradient of a soil increases with :
   a. decrease in void ratio. b. increase in void ratio.
   c. decrease in specific gravity. d. none of the above.
4. Quick sand is:
   a. a type of soil.
   b. a condition in which a cohesive soil loses its strength.
   c. a condition in which a cohesionless soil loses its strength because of upward flow of water.
   d. none of the above.
5. A soil of 2000 kN is uniformly distributed over an area of 3 m x 2 m. The average vertical stress at a depth of 2 m using 2:1 method is:
   a. 100 kN/m^2 b. 160 kN/m^2 c. 48 kN/m^2 d. 37 kN/m^2
6. With an increase in the liquid limit, the compression index:
   a. decreases. b. increases. c. remains constant. d. may increase or decrease.
7. When consolidation of a saturated soil sample occurs, the degree of saturation:
   a. increases. b. decreases. c. remains constant. d. may increase or decrease.
8. For saturated normally consolidated soils, Skempton's pore pressure parameters can be represented as:
   a. $A < 1, B = 1$. b. $A > 1, B > 1$. c. $A > 1, B < 1$. d. none of the above.
9. The rise of water due to capillary action:
   a. reduces the effective stress. b. increases the effective stress. c. does not alter the stresses. d. none of the above.
10. Under a load, the void ratio of a submerged saturated clay decreses from 1.0 to 0.92. The ultimate settlement of a layer 2 m thick will be:
    a. 2.0 cm b. 4.0 cm c. 8.0 cm d. 16.0 cm.

Q. No. 2:

A) Calculate and draw diagrams of distribution of the total stress, the effective stress and pore water pressure (at points A, B, C and D) <u>if the capillary rises 1 m above the water table level</u>. (*Note*: $G_s = 2.7$ *for both soils*). (10 marks)



B) A soil sample was compacted in the standard compaction apparatus. The results of the dry unit weight and moisture content are given below. If the sample had a dry mass of 452 gm when it was compacted at W opt., Gs = 2.7, determine γ_t, e, n and the total volume of the sample (after compaction) (10 marks)

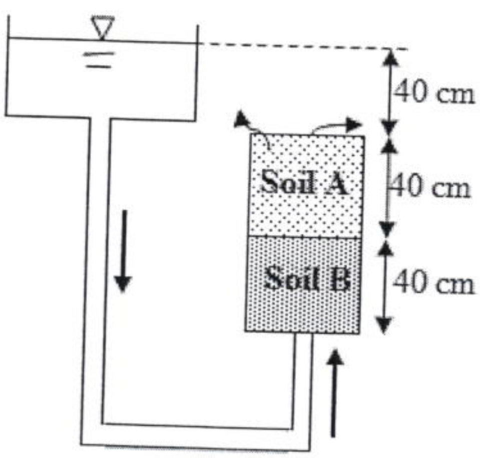
Moisture content (w%)	12.0	15.0	18.0	22.0	26.0	30.0	33.0
Dry unit weight (kN/m^3)	16.25	16.62	16.94	17.20	17.3	17.2	16.75

Q. No. 3:

A) For the setup shown, if 40% of the excess hydrostatic pressure is lost in flowing through soil B which has a coefficient of permeability of 0.05 cm/sec., determine:

a. The approach velocity and seepage velocity through each soil.

b. The hydraulic head at which instability (boiling) occurs.



Soil Type	e	G
A	0.5	2.65
B	0.6	2.67

(10 marks)

B) The following results were taken from a direct shear test conducted on a sample of soil.

Test	Shear force (kg)	normal load (kg)
1	52.272	90
2	28.836	27

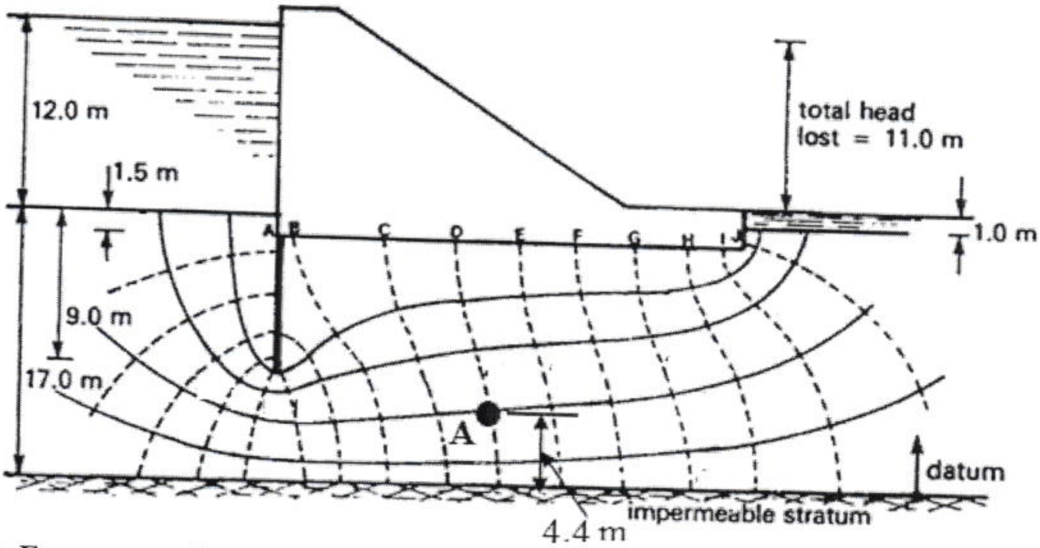
If the size of the shear box is 6 cm x 6 cm determine the shear strength parameters C and Ø for the soil.

(10 marks)

Q. No. 4:

A)The cross-section of a dam founded on a permeable stratum, which is underlain by an impermeable stratum is shown in Fig. below. The coefficient of permeability k is 5.2 x 10^{-5} m/s. A row of sheet piles has been inserted near the upstream face of the dam in order to reduce thequantity of seepage: (10 marks)

a) Determine the seepage quantity per meter.
b) Plot the distribution of uplift pressure acting on the base of the dam.
c) The piezometer reading at point (A).



B) For a normally consolidated clay, given: (10 marks)

$P_o' = 215$ kN/m^2 at $e_o = 1.22$

$P_o' + \Delta P' = 430$ kN/m^2 at $e = 0.98$

k = 0.3 x 10^{-8} m/sec. Find:

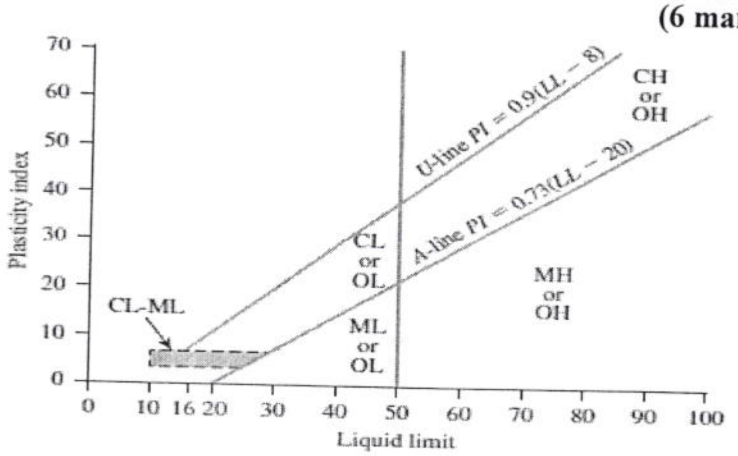
1. How long (in days) will it take for a (3 m) thick layer of the same clay (drained on both sides) in the field to reach (50%) consolidation.
2. What is the settlement at (50%) consolidation.

Q. No. 5:

A) (6 marks)

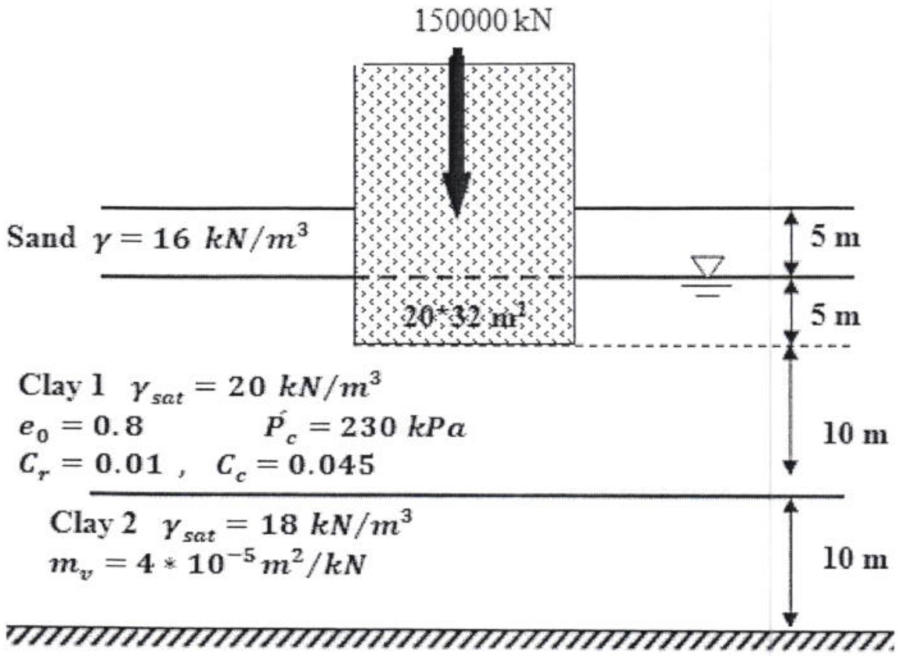
The following are the results of a sieve analysis:
Classify the soil according to unified Soil Classification System (USCS).

Sieve number	% Passing
40	100
80	97
170	92
200	90
L.L	67
P.L	35



B) A building is 20*32 m in plan. The total weight of the building is 150000 kN. It will be built on a 10 m deep raft foundation as shown in the figure: (14 marks)

1- Calculate the net foundation pressure.
2- Calculate the final consolidation settlements of this building.
3- If the allowable settlement is 1 cm for clay2: calculate the net foundation pressure that would cause this settlement.

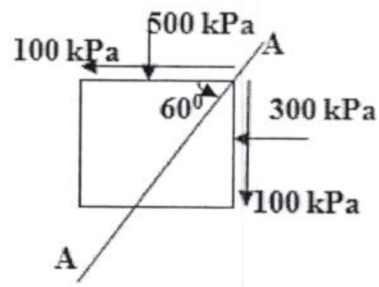


Q. No. 6:

A) A saturated specimen of cohesionless sand was tested under drained conditions in a triaxial compression test apparatus and the sample failed at a deviator stress of 482 kN/m² and the plane of failure made an angle of 60° with the horizontal. Find the magnitudes of the principal stresses. **(10 marks)**

B) For the given stress condition find:

1. **Principal stresses and their orientation.**
2. **The stresses on plane A-A.**



(10 marks)

Some useful information:

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

For O.C.C. $if\ P_\circ + \Delta P \le P_C\ then\ S_{cf} = \frac{Cr}{1+e} H \log \frac{P_\circ + \Delta P}{P_\circ}$

$if\ P_\circ + \Delta P > P_C\ then$ use: $S_{cf} = \frac{Cr}{1+e} H \log \frac{P_C}{P_\circ} + \frac{Cc}{1+e} H \log \frac{P_\circ + \Delta P}{P_C}$

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

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

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Q.1) 1) d 2) d 3) a 4) c 5) a
6) b 7) c 8) a 9) b 10) c

Q.2 A)

points	σ_{total}	u	σ'
A	0	0	0
-3 from top	3*17.4 = 52.2	-10	62.2
B	3*17.4 + 1*19.5 = 71.7	0	71.7
C	71.7 + 3*20.96 = 134.58	30	104.58
D	134.58 + 4*20.6 = 216.98	70	146.98

$\gamma_d = \frac{G_s}{1+e}\gamma_w$

$17.4 = \frac{2.7}{1+e} * 10$

$\therefore e = 0.55$

$\gamma_t = \frac{G_s + Se}{1+e}\gamma_w$

$= \frac{2.7 + 0.6 * 0.55}{1+0.55} * 10 = 19.5$

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

$= \frac{2.7 + 0.55}{1+0.55} * 10$

$= 20.96 \ kN/m^3$

Q.2 B) max. dry Density = 17.3 kN/m^3, w_{opt} = 26%

$\gamma_d = 17.3 \ kN/m^3 \Rightarrow 1.73 \ gm/cm^3$

$1.73 = \frac{W_s}{V_t} \Rightarrow 1.73 = \frac{452}{V_t} \Rightarrow V_t = 261.3 \ cm^3$

$\gamma_d = \frac{\gamma_{wet}}{1+w} \Rightarrow \gamma_{total} = 1.73(1+0.26)$

$= 21.8 \ kN/m^3$

$17.3 = \frac{2.7}{1+e} * 10 \Rightarrow e = 0.56$

$n = \frac{e}{1+e} = \frac{0.56}{1+0.56} = 0.36$

(Q.3 A) $\Delta h_{t_A} = 24, \ \Delta h_{t_B} = 16$

$i_A = \frac{24}{40} = 0.6, \ i_B = \frac{16}{40} = 0.4$

$V_B = 0.05 * 0.4 = 0.02 \ cm/s$

$V_{sB} = \frac{V_B}{n} = \frac{0.02}{\frac{0.6}{1+0.6}} = 0.053 \ cm/s$

we have to find K_A

$K_A * 0.6 * A = 0.05 * 0.4 * A \Rightarrow K_A = 0.0333$

$V_A = 0.0333 * 0.6 = 0.02 \ cm/s$

$V_{sA} = \frac{0.02}{\frac{0.5}{1+0.5}} = 0.06 \ cm/s$

$FS = \frac{\frac{\gamma_{sat} - \gamma_w}{\gamma_w}}{\frac{\Delta h}{L}}$

$\gamma_{sat A} = \frac{2.65 + 0.5}{1+0.5} * 10 = 21$

$1 = \frac{\frac{21-10}{10}}{\frac{\Delta h}{40}} \Rightarrow \Delta h_{t_A} = 44$

$\gamma_{sat B} = \frac{2.67 + 0.6}{1+0.6} * 10 = 20.43$

$0.0333 * \frac{44}{40} A = 0.05 * \frac{\Delta h_{t_B}}{40} A \Rightarrow \Delta h_{t_B} = 29.3$

hydraulic head $= 44 + 29.3 = 73.3$

(Q.3 B)

Test	Shear Stress gm/cm^2	Normal Stress gm/cm^2
1	$\frac{52.272 * 1000}{36} = 1452$	2500
2	801	750

$\tau = c + \sigma \tan\phi$

$1452 = c + 2500 \tan\phi$ — (1)

$801 = c + 750 \tan\phi$ — (2)

$651 = 1750 \tan\phi \Rightarrow \phi = 20.4 \Rightarrow c = 522 \ gm/cm^2$

Q.4 A) $q = KH \frac{N_f}{N_d}$

$= 5.2 * 10^{-5} * 11 * \frac{5}{17} = 0.0001682$ $m^3/s/m$ length

$\Delta h = \frac{11}{17} = 0.647$

Point	h_t	h_e	h_p	u
B	23.824	15.5	8.324	83.24
C	23.177	15.5	7.677	76.77
D	22.53	15.5	7.03	70.3
E	21.883	15.5	6.383	63.83
F	21.236	15.5	5.736	57.36
G	20.589	15.5	5.089	50.89
H	19.942	15.5	4.442	44.42
I	19.295	15.5	3.795	37.95

$h_{eA} = 4.4$, $h_{tA} = h_{tD} = 22.53 \Rightarrow h_{pA} = 18.13$

Q.4 B) For $U = 50\%$, $T_v = \frac{\pi}{4}(0.5)^2 = 0.196$

$m_v = \frac{a_v}{1+e} = \frac{\frac{\Delta e}{\Delta p}}{1+e_o} = \frac{\frac{1.22 - 0.98}{430 - 215}}{1 + 1.22} = 0.502 * 10^{-3}$ m^2/kN

$C_v = \frac{K}{m_v \gamma_w} = \frac{0.3 * 10^{-8} \text{ m/s}}{0.502 * 10^{-3} * 10} = 5.97 * 10^{-7} \frac{m^2}{s}$

$= 0.0516$ m^2/day

$S_{cf} = m_v * \Delta p * H$

$= 0.502 * 10^{-3} * 215 * 3 = 0.32379$ m

$= 32.379$ cm

$S_{ct} = U * S_{cf} = 0.5 * 32.379 = 16.19$ cm

Q5 A) $P.I = 67 - 35 = 32$ ∵ % pasing #200 > 50

From chart the Soil is MH or OH ∴ the Soil fine use chart

Q5 B) $P_o' = 5*16 + 10(20-10) = 180$

$$q_{net} = \frac{150000}{20*32} - 180 = 54.375$$

For layer ①

$$\Delta P = \frac{54.375*20*32}{(20+5)(32+5)} = 37.62$$

$P_o' + \Delta P = 180 + 37.62 = 217.62 < P_c'$ 230

use $S_{cf} = \frac{Cr}{1+e_o} H \log \frac{P_o' + \Delta P}{P_o'}$

$$= \frac{0.01}{1+0.8} * 10 \log \frac{180 + 37.62}{180}$$

$= 4.579$ mm

For layer ②

$$\Delta P = \frac{54.375*20*32}{(20+15)(32+15)} = 21.15$$

$S_{cf} = m_v \Delta P H$

$= 4*10^{-5} * 21.15 * 10 * 1000 = 8.46$ mm

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S_c total $= 4.579 + 8.46 = 13.039$ mm

$\frac{1}{100} = 4*10^{-5} * \Delta P * 10 \Longrightarrow \Delta P = 25$ kN/m²

$$25 = \frac{q_{net}*20*32}{(20+15)(32+15)}$$

$q_{net} = 64.26$ kN/m²

Q.6 A)

$\sigma_d = 482 \Rightarrow \sigma_1 = \sigma_3 + 482$

$\theta = 45 + \frac{\phi}{2} \Longrightarrow \phi = 30^\circ$ Sand $\Rightarrow c = 0$

$$\sin\phi = \frac{\frac{\sigma_1 - \sigma_3}{2}}{c\cot\phi + \frac{\sigma_1 + \sigma_3}{2}}$$

$$\sin 30 = \frac{\sigma_1 - \sigma_3}{\sigma_1 + \sigma_3}$$

$$\sin 30 = \frac{\sigma_3 + 482 - \sigma_3}{\sigma_3 + 482 + \sigma_3}$$

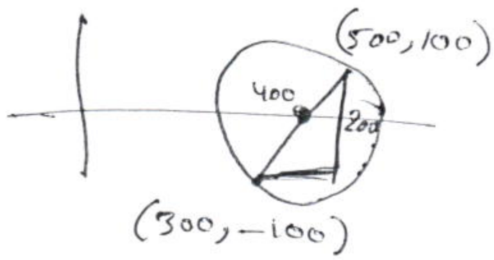
$$\frac{1}{2} = \frac{482}{2\sigma_3 + 482} \Longrightarrow \sigma_3 = 241$$

$\sigma_1 = 723$

Q.6 B)

$D = \sqrt{200^2 + 200^2} = 282.84$

$r = 141.42$



$\sigma_1 = 400 + 141.42 = 541.42$

$\sigma_3 = 400 - 141.42 = 258.58$

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

$$100 = \frac{541.42 - 258.58}{2}\sin 2\theta$$

$\sin 2\theta = 0.707$

$2\theta = 45$

$\theta = 22.5$