University of Technology

Building and Construction Eng. Dept.

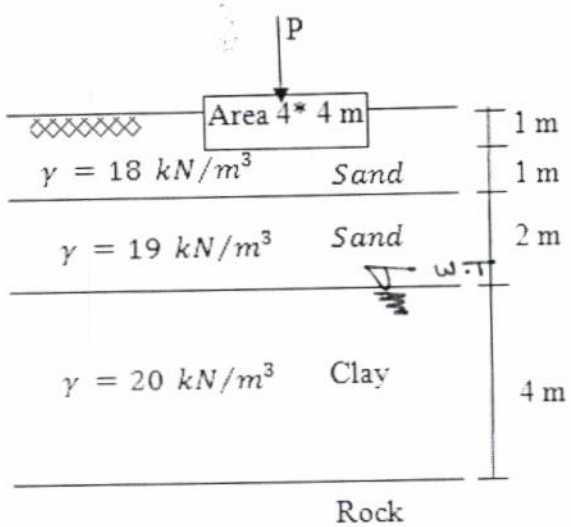
Final Exam / May 2014

Subject : Soil Mechanics — Class: 3rd Year

Branch : All Branches — Time: 3 hrs.

Note: Answer Five Questions Only

Q1 a) For the foundation shown, determine the total applied load (p) that causes a consolidation settlement of (10) cm in the clay layer. Given that $e = 0.72-0.18 \log (\sigma_v^- / 100)$.

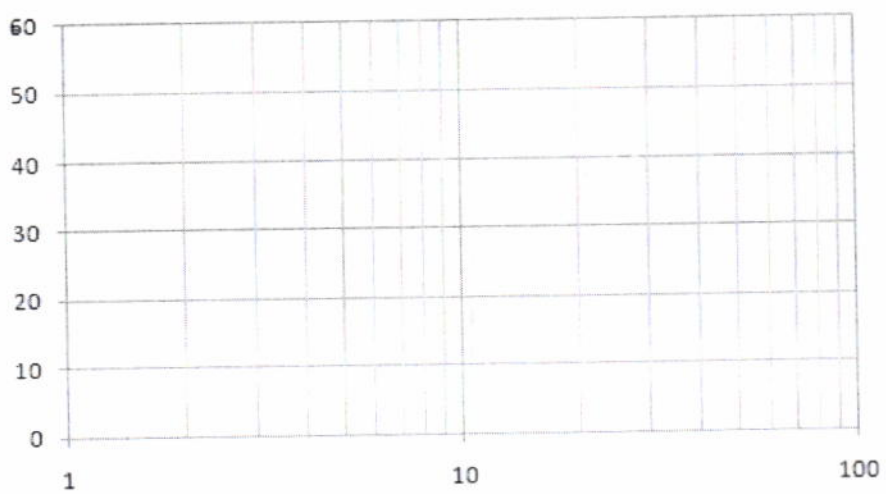


(14 marks)

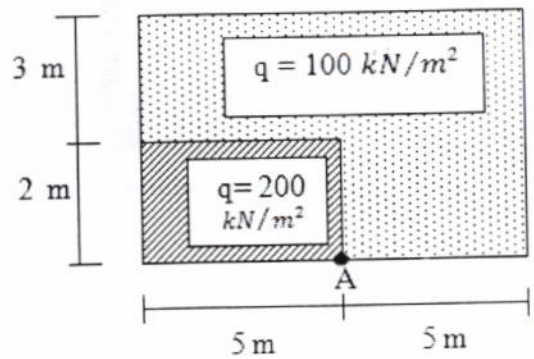
Q1 b) Find the liquid limit and the plasticity index if the plastic limit was 28%. Given that:

Number of taps (عدد الضربات)	6	8	12	26	28	31
Water content %	53.4	52.2	48.3	40.0	38.8	37.1

(6 marks)



Q2-a) Find the vertical stress increment under point A, Z=5m.



n	2	1	0.6	0.4	0.6	0.4
m	1	1	1	1	2	2
Factor	0.198	0.176	0.135	0.10	0.155	0.114

(8 marks)

Q2-b) The following results were obtained from direct shear test on specimens of sand

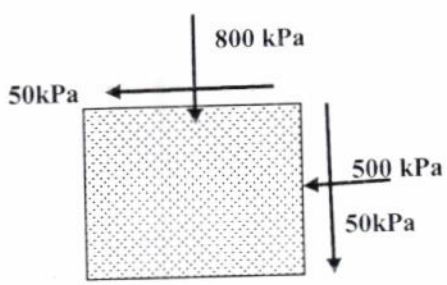
Normal stress (kN/m^2)	50	100
Shear stress at failure (kN/m^2)	49	93

a) **Determine the values of shear strength parameters.**
b) **Would failure occur on a plane within a mass of this sand at a point where shear stress is 122 kN/m^2 and the effective normal stress is 246 kN/m^2.** **(12 marks)**

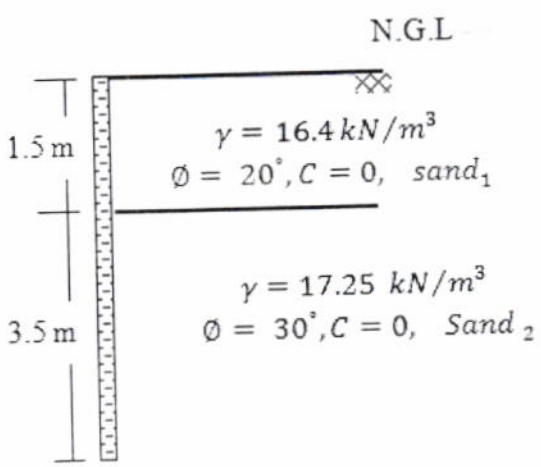
Q3-a)-The stresses on a sample of sand are given in figure below, find:

i- **Major and minor principal stresses and their orientation.**
ii- **Maximum and minimum shear stresses.**

(10 marks)



Q3-b) A rigid retaining wall of 5 m height shown in the figure has two layers of backfill. The top layer to a depth of 1.5 m is sand 1 , having Ø = 20 ° , c =0 and γ=16.4 kN/m^3 . The bottom layer sand 2 having Ø = 30 ° , c =0 and γ=17.25 kN/m^3. Determine the resultant active earth pressure acting on the wall and its position.

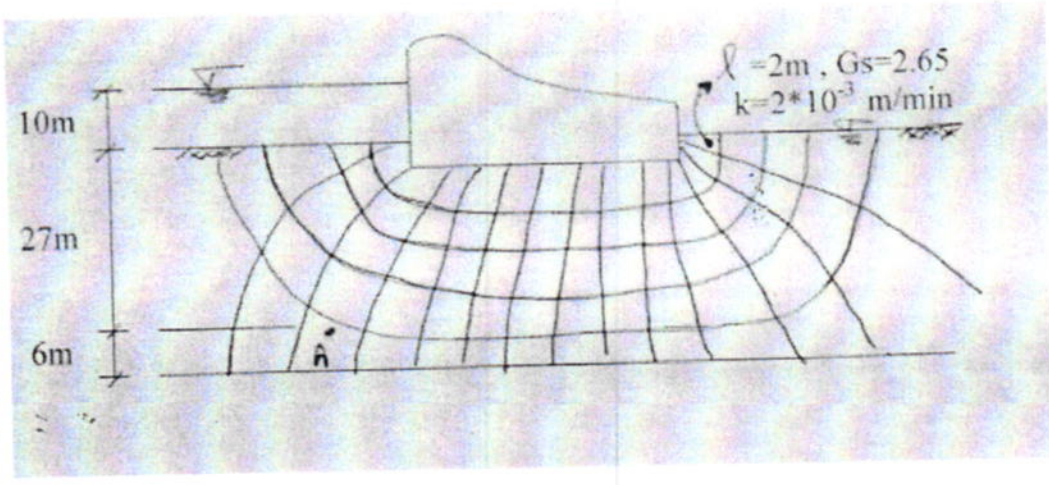


(10 marks)

To be continue

Q4-a) for the flow net shown find:

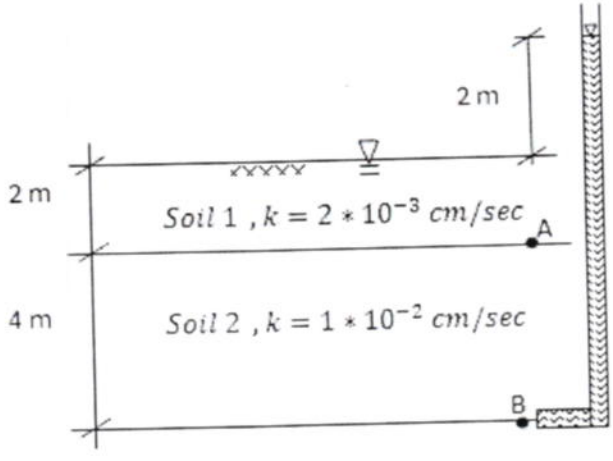
1- **The flow under the dam (given the length of the dam = 50 m)**
2- **Pizometer reading at point A.**
3- **Facto of safety against piping.**



(10 marks)

Q4-b) Given the data for a saturated clayey soil sample: $e_0 = 0.9$
at $\acute{\sigma} = 100\ kN/m^2$, $C_c = 0.4$ and k = $3 * 10^{-7}\ mm/sec$
Compute: a) the void ratio at effective stress of 150 kN/m^2 .
b) the final consolidation settlement, if the soil sample is taken from a stratum of 6m thickness.
c) the time required for 50% settlement, assuming two way drainage.
(10 marks)

Q5- a) For the soil profile shown, find
a) the factor of safety against piping
b) Pizometer reading at point A.
c) Maximum height of pizometer reading at point B.



(10 marks)

Q.5.b Given : mass of wet sample =254.1 gm , void ratio = 0.6133, volume of air = 1.9 cm^3 , mass of solids = 210 gm . Determine : Degree of saturation , Air content , Dry unit weight.
(10 marks)

Q.6 a) The results shown were obtained at failure in a series of triaxial test on specimens of saturated clay initially 38 mm in diameter and 76 mm long. Determine the values of the shear strength parameters with respect to

a) total stress b) effective stress.

Type of test	All round pressure kN/m^2	Axial load (N)	Axial deformation (mm)	Volume change (ml) (cm^3)
Undrained	200	222	9.83	-
	400	215	10.06	-
Drained	200	467	10.81	6.6
	400	848	12.26	8.2

(10 marks)

Q6. B) Compare between two of the following :

1) **Illite and Montmorlonite.**
2) **Total consolidation settlement in case of one and two way drainage for the same clay layer.**
3) **Relative density and relative compaction.**

(10 marks)

Good Luck

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Q.1 a) $P_o' = 2*18 + 2*19 + 2*10 = 94 \text{ kN/m}^2$

$e_o = 0.72 - 0.18 \log\left(\frac{94}{100}\right) = 0.7248$

$\frac{10}{100} = \frac{0.7248 - e_f}{1 + 0.7248} * 4 \Rightarrow e_f = 0.682$

$0.682 = 0.72 - 0.18 \log \frac{P'_f}{100} \Rightarrow P'_f = 162.55 \text{ kN/m}^2$

$\Delta p = 68.55$

$68.55 = \frac{\left(\frac{P}{16} - 1*18\right) * 4*4}{(4+5)(4+5)} \Rightarrow P = 5840 \text{ kN}$

Q.1 b)

L.L	41
P.L	28
P.I	13

Q.2 a) $m = \frac{5}{5} = 1$, $n = \frac{5}{5} = 1$ $\Rightarrow f = 0.176$

$2 * 0.176 * 100 = 35.2$

$m = \frac{5}{5} = 1$, $n = \frac{2}{5} = 0.4$ $\Rightarrow f = 0.10$ $\quad 0.1 * 100 = 10$

$35.2 + 10 = 45.2 \text{ kN/m}^2$ vertical Stress increment

Q.2 b) $44 = C + 50 \tan\phi$

$93 = C + 100 \tan\phi$

$44 = 50 \tan\phi \Rightarrow \phi = 41.35^\circ$

$C = 5 \text{ kN/m}^2$

for $\sigma = 246$

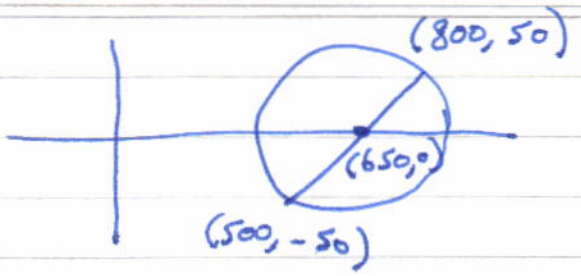
$\tau = 221$ So the failure will not occur

Q.3 a)

$\sigma_1 = 650 + R$

$\sigma_3 = 650 - R$

$D = \sqrt{300^2 + 100^2} = 316.22$



$R = 158.11$

$\sigma_1 = 808.11$, $\sigma_3 = 491.89$

$\tau_\theta = \frac{\sigma_1 - \sigma_3}{2} \sin 2\theta \Rightarrow 50 = \frac{808.11 - 491.89}{2} \sin 2\theta$

$\tau_{max} = 50 \text{ kN/m}^2$ $\quad \theta = 9.217$

$\tau_{min} = -50 \text{ kN/m}^2$

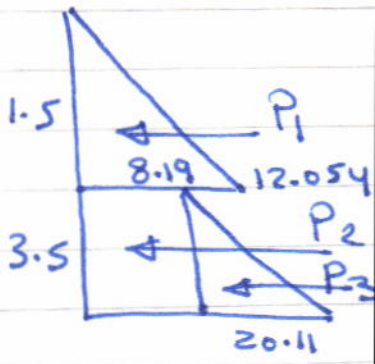
Q.3 b) $Ka_1 = 0.49$, $Ka_2 = 0.333$

Depth	σ_v	$\sigma_h = \gamma H Ka - 2c\sqrt{Ka}$
0	0	0
1.5	24.6	$24.6 * 0.49 = 12.054$
1.5	24.6	$24.6 * 0.333 = 8.19$
5	84.975	$84.975 * 0.333 = 283$

$P_1 = 12.054 * 1.5 * 0.5 = 9.04$ acting 4m from base

$P_2 = 8.19 * 3.5 = 28.665$ acting at 1.75m

$P_3 = 20.11 * 3.5 * 0.5 = 35.19$ acting at 1.1666 from base



$P_{total} = 72.895$

$h = \frac{9.04 * 4 + 28.665 * 1.75 + 35.19 * 1.166}{72.895} = 1.747 \text{ m}$ from base

Q.4 a) $q = K H \frac{Nf}{Nd} * L$

$= 2 * 10^{-3} \frac{m}{min} * 10m * \frac{5}{14} * 50m = 0.357 \ m^3/min$

$\Delta h = \frac{10}{14} = 0.714$

$u_{tA} = 43.2.5 * 0.714 = 41.215$

$h_{cA} = 6$

$h_{pA} = 35.25$

$F.S = \frac{ic}{ie} = \frac{1}{\frac{0.714}{2}} = 2.8$

Q.4 b) $S_{cf} = \frac{C_c}{1+e_o} H \log \frac{P_o' + \Delta P}{P_o'}$

$= \frac{0.4}{1+0.9} * 6 * \log \frac{100+50}{100} = 0.222 \ m$

$S_{cf} = \frac{\Delta e}{1+e_o} H \Rightarrow 0.222 = \frac{0.9 - e_f}{1+0.9} * 6$

$e_f = 0.8297$

for $U = 50\% \Rightarrow T_v = 0.19625$

$0.222 = m_v * \Delta P * H \Rightarrow m_v = 7.44 * 10^{-4} \ m^2/kN$

$C_v = \frac{K}{m_v \gamma_w} = \frac{3 * 10^{-7} \frac{mm}{s} * 10^{-3} * 60 * 60 * 24}{7.44 * 10^{-4} \frac{m^2}{kN} * 10 \frac{kN}{m^3}}$

$C_v = 0.00348 \ m^2/day$

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

$0.19625 = \frac{0.00348 t}{3^2} \Rightarrow t = 507 \ day$

Q.5 a) $\Delta h_{t_1} + \Delta h_{t_2} = 2$ ——— ①

$2*10^{-3} * \frac{\Delta h_{t_1}}{2} * A = 1*10^{-2} * \frac{\Delta h_{t_2}}{4} * A$ ——— ②

Solving $\Delta h_{t_1} = 1.43$ m, $\Delta h_{t_2} = 0.57$

$i_1 = 0.715$, $i_2 = 0.143$

① $F.S = \frac{i_c}{i_e} = \frac{1}{0.715} \approx 1.4$ o.k

② $h_{t_A} = 6 + 1.43 = 7.43$

or $h_{t_A} = 8 - 0.57 = 7.43$

$h_{e_A} = 4 \Rightarrow h_{p_A} = 7.43 - 4 = 3.43$ or 1.43m above ~.G.L

③ $F.S = \frac{i_c}{i_e} \Rightarrow 1 = \frac{1}{i_e} \Rightarrow i_e = 1$

$i_c = \frac{\Delta h_{t_1}}{l_1} \Rightarrow \Delta h_{t_1} = 2$

Sub in equ ② we get

$\Delta h_{t_2} = 0.8$

h p max. at B = 8.8 m

Q.5 B) $e = 0.6133$, $V_a = 1.9$ cc, $m_s = 210$ gm

mass of water = 44.1 gm, $V_w = 44.1$ cc

$w = \frac{44.1}{210} = 21\%$

$V_v = 1.9 + 44.1 = 46\ cm^3$

$e = \frac{V_v}{V_s} \Rightarrow V_s = 75\ cm^3$

$V_t = 75 + 46 = 121\ cm^3$

$S = \frac{V_w}{V_v} = \frac{44.1}{46} = 95.87$

$A = \frac{V_a}{V_t} = \frac{1.9}{121} = 1.57\%$

$\gamma_d = \frac{210}{121} = 1.73$ gm/cm^3 or 17.3 kN/m^3

Q.6 A) $L_o = 76\,mm$, $A_o = 1135\,mm^2$, $V_o = 86 \times 10^3\,mm^3$

$A_c = A_o \frac{1-\varepsilon_v}{1-\varepsilon_a}$

	σ_3	$\Delta L/L_o$	$\Delta V/V_o$	Area (mm^2)	σ_d kN/m²	σ_1
	200	0.129		1304	170	370
a)	400	0.132		1308	164	564
b)	200	0.142	0.077	1222	382	582
	400	0.161	0.095	1225	691	1091

$c' = 20\,kN/m^2$

$\phi = 26$