DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Civil Engineering and Geosciences

Soil Mechanics I

CT1091

BSc EXAMINATION 2012 - RESIT

ANSWER BOOK

FIFTH PERIOD

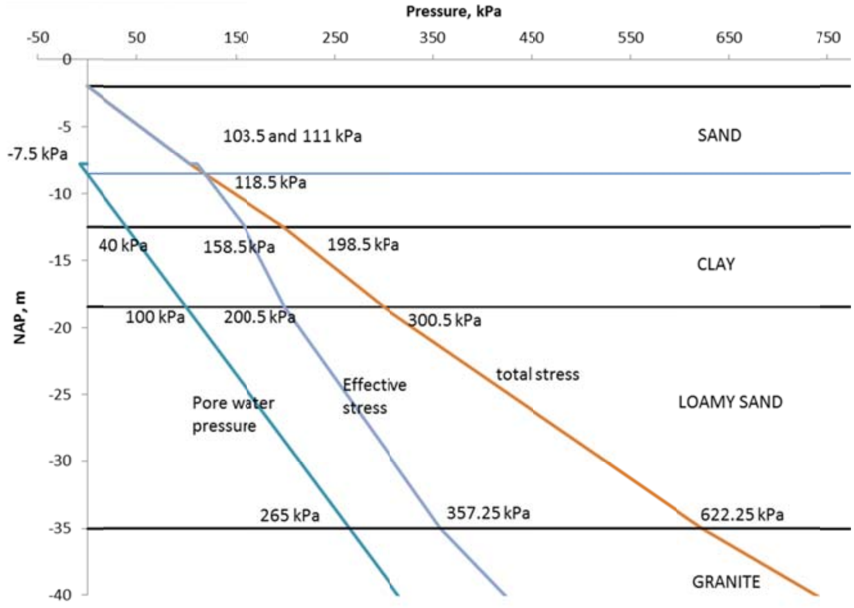
DATE: 31 August 2012 TIME: 09.00 – 12.00

Answer ALL Questions
(Note that the questions carry unequal marks)

Other instructions
Write your name and student number on each sheet

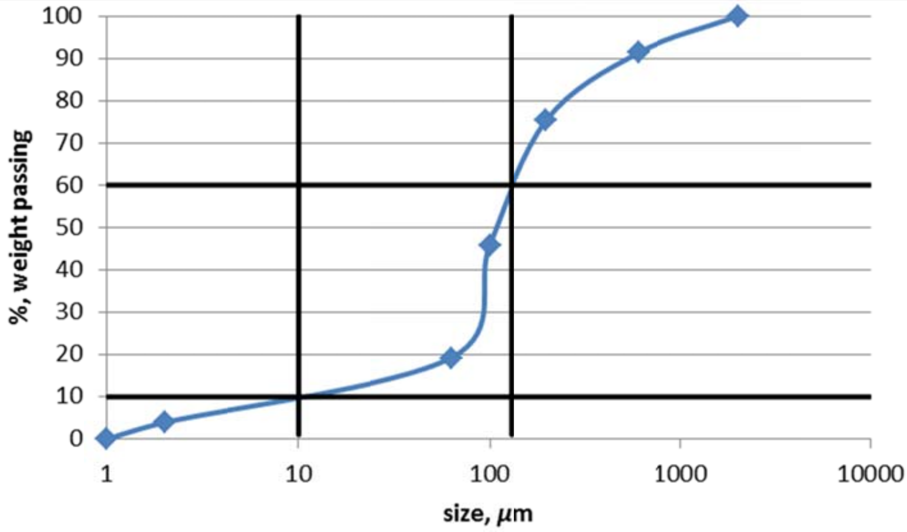
Clearly identify the answer in the answer box

Question No.	Workings	Answer
1a	Recognise that there is one stream line at the edge of the sheet pile and also one at the base. Potential lines include both soil surfaces. Option 1 Stream lines = 4.5 Potential lines = 8 Option 2 Stream lines = 5 Potential lines = 10	Option 1 SLs = 4.5 accept 4 to 5 PLs = 8 Option 2 SLs = 5 accept 4 to 5 PLs= 10
1b	Flow into the excavation can be calculated via: $Q = 2\frac{n_s}{n_n}k\Delta hB$ note 2 is from symmetry. Option 1 – stream bands 3.5 or 4 is ok (half in centre), 7 potential bands $Q_1 = 2 \times \frac{3.5}{7} 3.7 \times 10^{-5} \times 9B = 0.000333\, m^3/s\ \ /m$ Q_1 =1.2 $m^3/hour\ \ /m$ Option 2 – stream bands 4 (half in centre) , 9 potential bands $Q_2 = 2 \times \frac{4}{9} 3.7 \times 10^{-5} \times 9B = 0.000296\, m^3/s\ \ /m$ Q_2 =1.07 $m^3/hour\ \ /m$	Q_1 =1.2 $m^3/hour\ \ /m$ Q_2 =1.07 $m^3/hour\ \ /m$
1c	Critical point for liquefaction is at the downstream end of the flow path. Two methods: calculate effective stress or calculate critical gradient. Critical gradient is $i_{crit} = -\frac{\gamma_s - \gamma_w}{\gamma_w} = -\frac{20-10}{10} = -1.0$ Option 1 Gradient over last square is: dH = -9/7 = -1.29 m dz = 0.5 m dH/dz = -2.57 **Risk** of liquefaction Option 2 Gradient over last square is: dH = -9/9 = -1 m dz = 1.0 m dH/dz = -1.00 **Borderline risk** of liquefaction Method for checking effective stress: Option 1 Total stress at base of last square = 0.5 x 20 = 10 kPa PWP due to gravity = 0.5 x 10 = 5 kPa PWP due to flow = dHγ_w = 1.29 x 10 = 12.9 kPa Effective stress = 10 - (5+12.9) = -7.9 kPa <0 therefore at risk.	Yes, option 1 will liquify. Option 2 is borderline.

Question No.	Workings	Answer
2a		
2b	3 layers, 2m thickness, therefore centres of layers are NAP –13.5, -15.5 and -17.5 m respectively. Calculated from base of layer above (or could calculate from volumetric weights): <u>Layer 1</u> σ= 198.5 + 1x17 = 215.5 kPa p= 40 + 1x10 = 50 kPa σ'= 215.5 - 50 = 165.5 kPa <u>Layer 2</u> σ= 198.5 + 3x17 = 249.5 kPa p= 40 + 3x10 = 70 kPa σ'= 249.5 - 70 = 179.5 kPa <u>Layer 3</u> σ= 198.5 + 5x17 = 283.5 kPa p= 40 + 5x10 = 90 kPa σ'= 283.5 - 90 = 193.5 kPa Load applied is 3 x 18 = 54 kPa Total and effective stresses increase by this amount:	Stresses in kPa Before L1 σ=215.5 σ'=165.5 L2 σ=249.5 σ'=179.5 L3 σ=283.5 σ'=193.5 After L1 σ=269.5 σ'=219.5 L2 σ=303.5 σ'=233.5 L3 σ=337.5 σ'=247.5

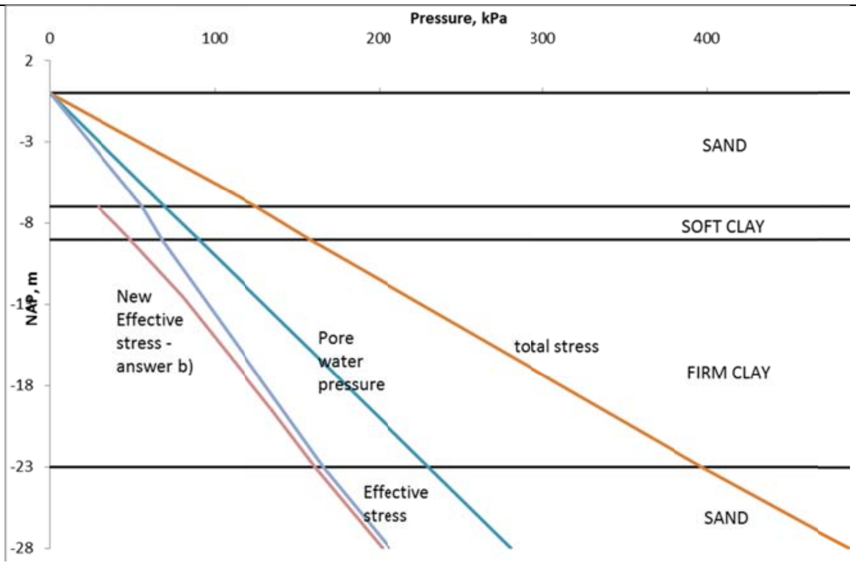
2c	$\varepsilon = \frac{1}{C_p}\ln\left(\frac{\sigma'}{\sigma_1'}\right)$ $\frac{1}{16}\ln\left(\frac{219.5}{165.5}\right)$ =0.0176, deformation = 0.0176 x 2 = 0.035 m $\frac{1}{16}\ln\left(\frac{233.5}{179.5}\right)$ =0.0164, deformation = 0.0164 x 2 = 0.033 m $\frac{1}{16}\ln\left(\frac{247.5}{193.5}\right)$ =0.0154, deformation = 0.0164 x 2 = 0.031 m Total clay deformation = 0.035 + 0.033 + 0.031 = 0.099 m	0.099 m
2d	$m_v = 1/C_p\sigma_1' = 1/(16x179.5) = 0.00035$ kPa^{-1} $c_v = k/\gamma_w m_v = 3.4x10^{-8} / (10x9.7x10^{-6}) = 9.7x10^{-6}$ m^2/s can consider consolidation to be complete when consolidation coeff is 1.74 (will also accept 2) $c_v t_{99\%} / h^2 = 1.784$ $t_{99\%}$ = 1,644,273 seconds or 19 days for consolidation coeff = 2: $t_{99\%}$ = 1,843,356 seconds or 21 days	1,644,273 seconds or 19 days

Question No.	Workings	Answer
3a	$\gamma = W/V$ $W = W(kg) * 10 = 628 / 1000 * 10 = 6.28$ N $V = 325 \times \pi \times 36^2 / 4 = 330\ 809\ mm^3 = 0.000331\ m^3$ $\gamma = 6.28 / 0.000331 = 18984\ N/m^3 = 18.98\ kN/m^3$	18.98 kN/m^3
3b	Clay on sieve size 1 μm, Silt on sieve size 2 μm, Sand above Therefore V_{clay} = 8 ml, W_{clay} = 21 /1000 * 10 = 0.21 N V_{silt} = 32 ml, W_{silt} = 81 /1000 * 10 = 0.81 N V_{sand} = (46+41+20+11) = 118 ml, W_{sand} = (141+157+84+46) /1000 * 10 = 4.28 N	V_{clay} = 8 ml W_{clay} = 0.21 N V_{silt} = 32 ml, W_{silt} = 0.81 N V_{sand} = 118 ml W_{sand} = 4.28 N
3c	Mass of Peat = 603 – 530 = 73 g $V = 73 / 1000 / 1100 \times 100^3 = 66.4$ ml $\%_{peat}$ = 66.4 / 331 x 100 = 20.1% $\%_{sand}$ = 118 / 331 x 100 = 35.6% Mass of water = 628 – 603 = 25g V = 25x1 = 25 ml $\%_{water}$ = 25 / 331 x 100 = 7.6% V = 331 – (8+32+118+66.4-25) = 81.4 ml $\%_{air}$ = 81.4 / 331 x 100 = 24.6%	$\%_{peat}$ = 20.1% $\%_{sand}$ = 35.6% $\%_{water}$ = 7.6% $\%_{air}$ = 24.6%
3d	$n = V_v / V$ = (25+81.4) / 331 = 0.235 * 100 = 32.1%	32.1% or 0.32

3e		
3f	From figure: $D_{10} = 10$, $D_{60} = 130$ $C_u = 130 / 10 = 13$, Well graded S – sand W – well graded	$C_u = 13$ S W

Question No.	Workings	Answer

4a



NAP	PWP	Total stress	Effective stress
0	0	0	0
-7	70	126	56
-9	90	158	68
-23	230	396	166
-28	280	486	206

4b

This question is difficult – generous marking.

Use Flamant for either strip load or line load. Could also use Newmark but would involve multiple drawings.

If use line load must state it is due to clay being 7m from surface.

Centre of soft clay:
NAP -8 m
Initial conditions from above
p = 80 kPa
σ= 142 kPa
σ'= 62 kPa

In firm clay (2 layers)
NAP -12.5 and -19.5
For 12.5 m:
p = 125 kPa
σ= 217.5 kPa
σ'= 92.5 kPa

For 19.5 m:
p = 195 kPa
σ= 336.5 kPa
σ'= 141.5 kPa

$$\sigma = \frac{2p}{\pi}\left[arctan\left(\frac{a}{z}\right) + \frac{az}{a^2 + z^2}\right]$$

z is depth and a = width / 2 = 2.5

p = -5 x 18 + 60 = -30 kPa

In this case z is 3, 7.5 and 14.5

Change in stress (kPa)
Layer 1
-22.7
Layer 2
-11.9
-6.5

For drawing see sketch in a)

4c

Change in stress (kPa)	Layer thickness (m)	C_{10}	Strain	Deformation (m)
	Layer 1			
-22.7	2	6	-0.033	-0.066
	Layer 2			
-11.9	7	17	-0.0035	-0.025
-6.5	7	17	-0.0012	-0.0084

Total deformation is 0.066 + 0.025 + 0.0084 = 0.099 m rise.

Full marks here is method is correct and answer is wrong due to wrong stresses being input.

-0.099 m
Or 0.099m
rise