DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Civil Engineering and Geosciences

Soil Mechanics I – MOCK EXAM II

CT1091

BSc EXAMINATION 2012

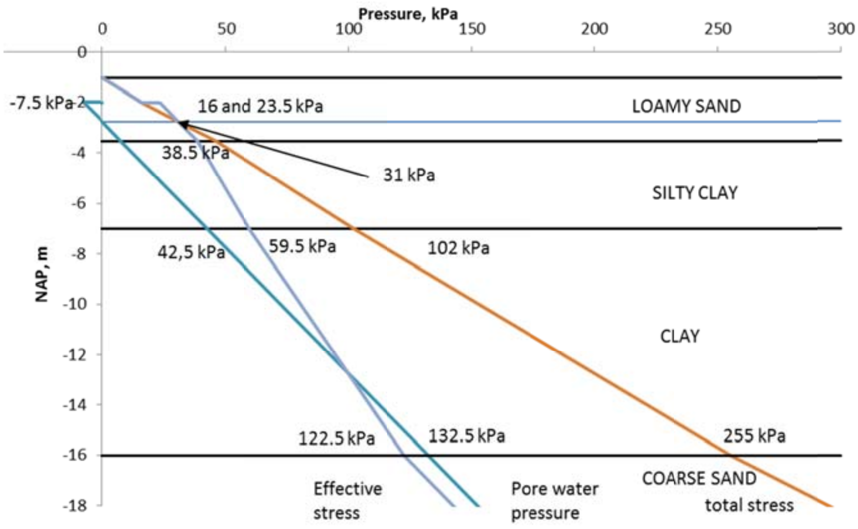
ANSWER BOOK

FOURTH PERIOD

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	 	
1b	5 x 17.5 = 87.5 kPa as pore water will take all additional load until water can drain.	87.5 kPa
1c	Prior to construction can be calculated from either volumetric weight as is 1a or by averaging values at top and bottom of layer. Centre of silty clay, NAP = -5.25 m Pore pressure = 7.5 + (42.5-7.5)/2 = 25 kPa Total stress = 46 + (102-46)/2 = 74 kPa Effective stress = 74 - 25 = 49 kPa Centre of clay, NAP = -11.5 m Pore pressure = 42.5 + (132.5-42.5)/2 = 87.5 kPa Total stress = 102 + (255-102)/2 = 178.5 kPa Effective stress = 178.5 – 87.5 = 91 kPa Pore pressure remains the same after excess pore pressure have dissipated, therefore total stresses and effective stresses all increase by 87.5 kPa. Therefore total stresses are: 161.5 kPa and 266 kPa and effectives stresses are 136.5 and 178.5 kPa.	Before Total stresses: 74 kPa 178.5 kPa Effective stresses: 49 kPa 91 kPa After Total stresses: 161.5 kPa 266 kPa Effective stresses: 136.5 kPa 178.5 kPa
1d	$\varepsilon = \frac{1}{C_p} \ln\left(\frac{\sigma}{\sigma_1}\right)$ $\frac{1}{8} \ln\left(\frac{136.5}{49}\right)$ =0.128, deformation = 0.128 x 3.5 = 0.45 m $\frac{1}{14} \ln\left(\frac{178.5}{91}\right)$ =0.048, deformation = 0.048 x 9 = 0.43 m Total = 0.45 + 0.43 = 0.88 m	0.88 m

Question No.	Workings	Answer
1e	Spacing is 500m therefore maximum r = 250m Head loss can equal the current hydraulic head, i.e. 132.5 / 10 = 13.25 m For a confined aquifer of H=10m $h = h_0 + \frac{Q_0}{2\pi kH}\ln\left(\frac{r}{R}\right)$ $h - h_0 = -13.25 = \frac{Q_0}{2\pi \times 5.9.10^{-6} \times 10}\ln\left(\frac{0.125}{250}\right)$ $Q_0 = 0.0006462\ m^3/s = 2.3\ m^3/\ hour$	$Q_0 = 2.3$ $m^3/\ hour$

<table>
<tr><th>Question No.</th><th>Workings</th><th>Answer</th></tr>
<tr><td>2a</td><td>Stress increase, assuming most load comes from the oil = 20 x 1300 x 10 / 1000 = 260 kPa

Strain, $\varepsilon = m_v \times \sigma$
Deformation = $\varepsilon \Delta h$

<table><tr><th>Depth, m</th><th>Compressibility coefficient, m_v (kPa^{-1})</th><th>Thickness of layer, m</th><th>Strain</th><th>Deformation, m</th></tr><tr><td>1</td><td>0.0001</td><td>2</td><td>0.026</td><td>0.052</td></tr><tr><td>4</td><td>8.0×10^{-5}</td><td>4</td><td>0.0208</td><td>0.083</td></tr><tr><td>10</td><td>3.0×10^{-5}</td><td>8</td><td>0.0078</td><td>0.062</td></tr><tr><td>21</td><td>2.0×10^{-6}</td><td>14</td><td>0.00052</td><td>0.007</td></tr><tr><td></td><td></td><td></td><td>**Total**</td><td>**0.20**</td></tr></table></td><td>0.20 m</td></tr>
<tr><td>2b</td><td>$k = 7.8 \times 10^{-9}\ m/s$
$m_v = 0.00003\ kPa^{-1}$
$\gamma_w = 10\ kN/m^3$

$c_v = \frac{k}{\gamma_w . m_v} = \frac{7.8 \times 10^{-9}}{10 \times 0.00003} = 0.000026\ m^2/s$</td><td>$c_v = 0.000026\ m^2/s$</td></tr>
<tr><td>2c</td><td>When consolidation is complete, $\frac{c_v t_{99}}{h^2} = 1.784$ but will also accept the answer for $\frac{c_v t_{99}}{h^2} = 2$

$\frac{1.784h^2}{c_v} = t_{99} = \frac{1.784 \times 14^2}{0.000026} = 1.34 \times 10^7 s = 0.43\ years$

Or

$\frac{2h^2}{c_v} = t_{99} = \frac{2 \times 14^2}{0.000026} = 1.51 \times 10^7 s = 0.48\ years$</td><td>0.43 years</td></tr>
</table>

2d	Could either do this by algebra or by completing the result numerically. 1) $c_v = \frac{k}{\gamma_w . m_v}$ and $t_{99} = \frac{1.784h^2}{c_v}$ Therefore, $t_{99} = \frac{1.784\gamma_w . m_v h^2}{k}$ $h_{new} = \frac{h_{old}}{2}$ and $k_{new} = \frac{k_{old}}{2}$ So $t_{99new} = \frac{1.784\gamma_w . m_v \left(\frac{h_{old}}{2}\right)^2}{\frac{k_{old}}{2}} = \frac{1.784\gamma_w . m_v {h_{old}}^2}{2k_{old}} = \frac{t_{99old}}{2}$ 2) As in 2c, 0.21 or 0.24 years	New location. $t_{99new} = \frac{t_{99old}}{2}$ Or 0.2 years
2e	Similar approach to above: Drainage path is twice as long, i.e. $2h_{old}$ $t_{99new} = \frac{1.784\gamma_w . m_v (2h_{old})^2}{k} = \frac{4 \times 1.784\gamma_w . m_v {h_{old}}^2}{k}$ $= 4 \times t_{99old}$	Proved.

Question No.	Workings	Answer
3a	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 = 5 Potential lines = 8 Option 2 Stream lines = 5 Potential lines = 10	Option 1 SLs = 5 PLs = 8 Option 2 SLs = 5 PLs= 10
3b	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 $Q_1 = 2 \times \frac{3.5}{7} 2.9 \times 10^{-5} \times 7B = 0.000203\, m^3/s\ \ /m$ Q_1 =0.731 $m^3/hour\ \ /m$ Option 2 – stream bands 3.5 or 4 is ok (half in centre) , 9 potential bands $Q_2 = 2 \times \frac{3.5}{9} 2.9 \times 10^{-5} \times 7B = 0.000158\, m^3/s\ \ /m$ Q_2 =0.568 $m^3/hour\ \ /m$	Q_1 =0.731 $m^3/hour\ /\ m$ Q_2 =0.568 $m^3/hour\ /\ m$
3c	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 $i_{crit} = -\frac{\gamma_s-\gamma_w}{\gamma_w} = -\frac{19-10}{10} = -0.9$ Option 1 Gradient over last square is: dH = 7/7 = 1 m dz = -0.5 m dH/dz = -2 **Risk** of liquefaction Option 2 Gradient over last square is: dH = 7/9 = 0.78 m dz = -1.0 m dH/dz = -0.78 **No risk** of liquefaction Method for checking effective stress: Option 1 Total stress at base of last square = 0.5 x 19 = 9.5 kPa PWP due to gravity = 0.5 x 10 = 5 kPa PWP due to flow = dHγ_w = 1 x 10 = 10 kPa Effective stress = 9.5- (5+10) = -5.5 kPa <0 therefore at risk.	Yes, option 1.

Question No.	Workings	Answer
4a	$n = V_v / V$ Volume of sample, $V = 225 \times 50^2 \times \pi / 4 = 4.42 \times 10^5$ mm^3 = 0.000442m^3 Volume of solid from water = 0.197 / 1000 = 0.000197 m^3 Volume of voids = 0.000442 – 0.000197 = 0.000245 m^3 n = 0.000245/0.000442 = 0.554	n = 0.554 or 55.4 %
4b	Mass of saturated soil = 612+0.000245x1000x1000 = 857 g Weight = 8.57 N or 0.00857 kN Saturated volumetric weight, γ = 0.00857 / 0.000442 = 19.4 kN/m^3 Mass of dry soil = 612 g = 0.00612 kN Saturated volumetric weight, γ_d = 0.00612 / 0.000442 = 13.9 kN/m^3	γ = 18.3 kN/m^3 γ_d = 13.9 kN/m^3
4c	Degree of saturation, $S = V_w / V_v$ Initial water mass = 721 – 612 = 109 g = 0.109 kg Initial water volume = 0.109 / 1000 = 0.000109 m^3 S = 0.000109 / 0.000245 = 0.445 or 44.5%	S = 0.445 or 44.5 %
4d	Volume of soil particles = 0.000197 m^3 Density, $\rho_s=M_s/V_s$ = (612 / 1000) / 0.000197 = 3107 kg/m^3	ρ_s = 3100 kg/m^3
4e	Void ratio, *e* = Volume pores / volume solid = 0.000245 / 0.000197 = 1.24	*e* = 1.24