DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Civil Engineering and Geosciences

Soil Mechanics I

CT1091

BSc EXAMINATION 2012

ANSWER BOOK

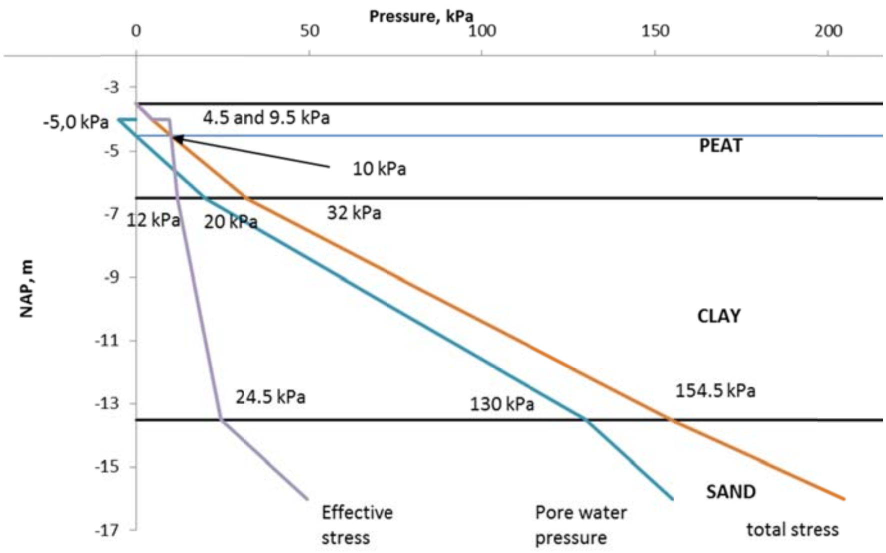
FOURTH PERIOD

DATE: 27 June 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		
1b	2 layers, 3.5m thickness, therefore centres of layers are NAP – 8.25 and -11.75 m respectively. Interpolating between top and base of layer (note must do this for pwp): <u>Layer 1</u> σ= 32 + ¼ (154.5 – 32) = 62.6 kPa p= 20 + ¼ (130 – 20) = 47.5 kPa σ'= 62.6 - 47.5 = 15.1 kPa <u>Layer 2</u> σ= 32 + ¾ (154.5 – 32) = 123.9 kPa p= 20 + ¼ (130 – 20) =102.5 kPa σ'= 123.9 – 102.5 = 21.4 kPa Load applied is 4.5 x 18 = 81 kPa Total and effective stresses increase by this amount: <u>Layer 1</u> σ= 62.6 + 81 = 143.6 kPa p= 47.5 kPa σ'= 15.1 +81 = 96.1 kPa <u>Layer 2</u> σ= 123.9 + 81 = 204.9 kPa p= 102.5 kPa σ'= 21.4 + 81 = 102.4 kPa	All answers in kPa Before: <u>Layer 1</u> σ= 62.6 σ'= 15.1 <u>Layer 2</u> σ= 123.9 σ'= 21.4 After: <u>Layer 1</u> σ= 143.6 σ'= 96.1 <u>Layer 2</u> σ= 204.9 σ'= 102.4

1c	$\varepsilon = \frac{1}{C_p} \ln\left(\frac{\sigma}{\sigma_1}\right)$ $\frac{1}{20} \ln\left(\frac{96.1}{15.1}\right)$ =0.092, deformation = 0.092 x 3.5 = 0.32 m (rounding to 0.33 m acceptable) $\frac{1}{20} \ln\left(\frac{102.4}{21.4}\right)$ =0.078, deformation = 0.078 x 3.5 = 0.27 m Total clay deformation = 0.32 + 0.27 = 0.59 m	0.59 m (0.60 m due to rounding ok)
1d	$\varepsilon = \frac{1}{C_p} \ln\left(\frac{\sigma}{\sigma_1}\right)$ For peat, NAP at centre = -5 m: Before: σ= 10+0.5x11 = 15.5 kPa p= 0.5x10 = 5 kPa σ'= 15.5-5 = 10.5 kPa σ= 15.5 + 81 = 96.5 kPa p= 5 kPa σ'= 10.5 +81 = 91.5 kPa $\frac{1}{10} \ln\left(\frac{91.5}{10.5}\right)$ =0.22, deformation = 0.216 x 3 = 0.65 m Total = 0.59 + 0.65 = 1.25 m	1.25 m (1.26 m due to rounding ok)

Question No.	Workings	Answer
2a	Density = mass / volume Mass = 450g = 0.45kg Volume = $(\pi * 50^2 / 4) \times 200 \times 10^{-9} = 0.00039m^3$ Density, $\rho = 0.45 / 0.00039 = 1154kg/m^3$	1154 kg/m^3
2b	$\gamma = W/V$ $= \rho * g$ $=1154*10 = 11540N/m^3 = 11.5kN/m^3$	11.5 kN/m^3
2c	Soil is very light. Probably peat.	Peat
2d	$\gamma = W/V$ W = 0.383*10 = 3.83N $V = (\pi * 50^2 / 4) * 173 * 10^{-9} = 0.00034m^3$ $\gamma = 3.83 / 0.00034 = 11264$ N/m3 $= 11.3kN/m^3$	11.3 kN/m^3
2e	Water content, $w = W_w/W_p$ (weight water / weight particles) W_w=450 – 383 = 67g W_p= 383g w = (67 / 383) * 100 = 17.5%	17.5%
2f	Original Void ratio, e_o $e = V_v / V_s$ $V_s = M_s * g / \gamma_s = 0.383$(kg) * 10 / 15000(N/m3) $= 0.255 \times 10^{-3} m^3$ $V_v = V_t – V_s = 0.00039 – 0.000255 = 0.135 \times 10^{-3} m^3$ (or could calculate from weight of water) $e_o = 0.135 / 0.255 = 0.53$ (dimensionless) New Void ratio, e_n $V_s = 0.255 \times 10^{-3} m^3$ $V_v = V_t – V_s = 0.00034 – 0.000255 = 0.085 \times 10^{-3} m^3$ (or could calculate from weight of water) $e_n = 0.085 / 0.255 = 0.33$ (dimensionless)	0.53 (dimensionless) 0.33 (dimensionless)
2g	e = n/(1-n) therefore n = e / (1+e) $n_o = 0.53 / 1.53 = 0.346$ $n_n = 0.33 / 1.33 = 0.248$	0.346 0.248

Question No.	Workings	Answer
3a	Problem of vertical flow. Specific discharge, q (m/s), is $$q = -k\frac{dh}{dL} = -3.3 \times 10^{-8}\frac{(-1.75 - -5)}{15} = 7.2 \times 10^{-9} m/s$$ Discharge (m^3/s) = qA = $7.2 \times 10^{-9} \times \frac{2000^2\pi}{4} = 0.0225 m^3/s$ 0.0225 x 3600 = 80.9 m^3/hour	80.9 m^3/hour
3b	Again similar problem to 3a $q = -k\frac{dh}{dL}$, therefore $dh = -dL\frac{q}{k}$ $q = \frac{Q}{A} = \frac{125/3600}{2000^2\pi/4} = 1.105 \times 10^{-8} m/s$ dh = 5.02 m water height is 0.02 m NAP, approximately sea level	0.02 m NAP (accept 0.00 m due to rounding)
3c	Liquefaction can occur when effective stress equals zero. Total stresses at the base of the soil layer = (15 – d) x 17 Where d is the depth of excavation. Pore water pressure at the base of soil layer = (20 - 1.75) x 10 = 182.5 kN/m^3 Therefore: Excavation level, d = 15 - (182.5/17) = 4.26 m	4.26 m
3d	Effective stress just below the structure must be positive to avoid floatation. (d here is depth to top of culvert) Pore water pressure = du/dx x (d+h) = (182.5/15) x (5+3.5) = 103.4 kPa Total stress = d x γ + (t x (h+w))x25 = 5x17 + (t x (3.5+2))x25 = 85 + 137.5 t Note weight of culvert is divided by 2 as 2 m wide. (103.4 – 85)/137.5 = 0.134m	0.134m

Question No.	Workings	Answer
4a	$c_v = \frac{k}{\gamma_w m_v}$ Clay 1: $c_v = \frac{7.2\times10^{-8}}{10\times0.0007} = 0.00001\ m^2/s$ Clay 2: $c_v = \frac{4.4\times10^{-7}}{10\times0.0002} = 0.00022\ m^2/s$	$0.00001\ m^2/s$ $0.00022\ m^2/s$
4b	For clay layer 1 $\sigma = 127$ kPa $\varepsilon = m_v\ \sigma = 0.0007 \times 127 = 0.089$ deformation = 0.089 x 5 = 0.445 m For clay layer 2 $\sigma = 127$ kPa $\varepsilon = m_v\ \sigma = 0.0002 \times 127 = 0.0254$ deformation = 0.0254 x 20 = 0.508 m Total deformation = 0.445 + 0.508 = 0.953 m	0.953 m
4c	Time for consolidation is proportional to h^2/c_v Layer 1: h = d/2 = 2.5 m $h^2/c_v = 2.5^2 / 0.00001 = 607\ 640$ Layer 2: h = d = 20 m $h^2/c_v = 20^2 / 0.00022 = 1\ 818\ 000$ 600 000 < 1800 000 therefore layer 1 consolidates faster NB. If forgot layer 2 can only drain one way answer is opposite. Award 50% of the mark.	layer 1 consolidates faster
4d	Notice that only need to do the calculation on the slower layer, layer 2. $(c_v\ t_{99\%}) / h^2 = 1.784$ (will accept 2) Therefore $t_{99\%} = 1.784\ h^2/c_v = 1.784 \times 1\ 818\ 000 = 3240\ 000$ sec = 37.5 days For constant = 2, answer is 42.1 days.	37.5 days

Question No.	Workings	Answer
4e	At 80% complete (U=0.8) From the chart $(c_v\, t_{80\%}) / h^2 \approx 0.57$ Therefore, using the slowest layer $t_{80\%} \approx 0.57\ h^2/c_v$ =1036 000 sec And the top layer will then be $(c_v\, t) / h^2$ = 1036 000 / 607 640 = 1.71, therefore nearly fully consolidated. Deformation on the surface is then: 1.0 x 0.445 + 0.8 x 0.508 = 0.85 m	0.85 m