DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Civil Engineering and Geosciences

Soil Mechanics

CTB2310

BSc EXAMINATION 2014

THIRD PERIOD

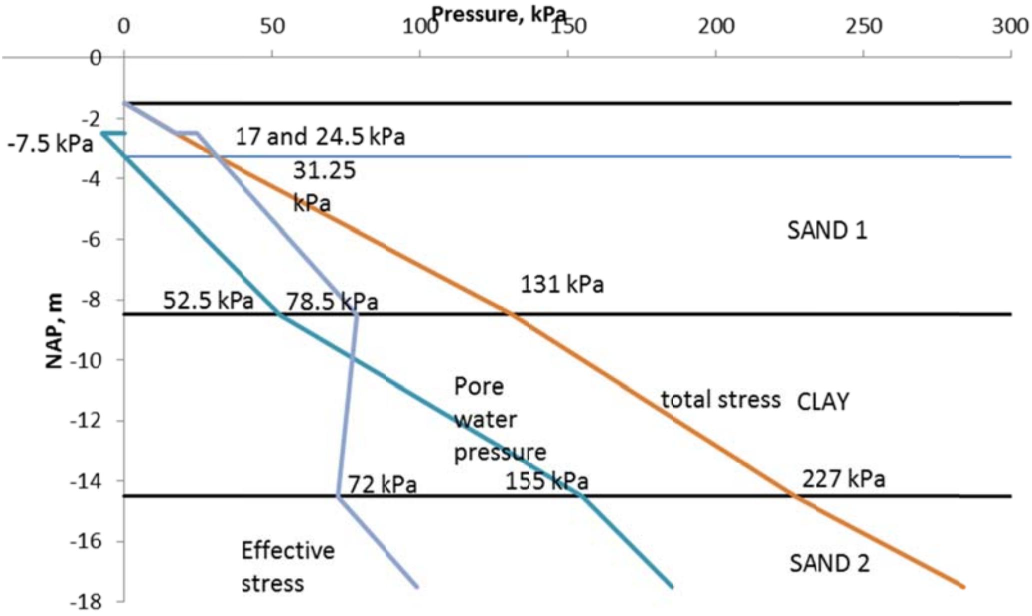
DATE: 14 APRIL 2014

TIME: 14.00 – 17.00

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	Mid height of the clay: σ = (227+131)/2 = 179 kPa σ’ = (78.5+72)/2 = 75.25 kPa After embankment, pwp can dissipate therefore stresses are increase by 5 x 18 = 90 kPa at all locations. Assumption is ‘wide’ embankment. σ = 179+90 = 269 kPa σ’ = 75.25 + 90 = 165.25 kPa	Before *σ* = 179 *kPa* *σ’* = 75.25 *kPa* After *σ* = 269 *kPa* *σ’* = 165.25 *kPa*
1c	Strain: $\varepsilon = \frac{1}{C_p}\ln\left(\frac{\sigma'}{\sigma'_1}\right)$ $\varepsilon = \frac{1}{15}\ln\left(\frac{75.25+90}{75.25}\right) = 0.052$ Deformation, $u=6\times\varepsilon$ Total deformation = $6\times\varepsilon = 0.31$	$0.31m$
1d	Consolidation coefficient: $m_v = \frac{\Delta\varepsilon}{\Delta\sigma} = \frac{0.052}{90} = 0.0006$ $c_v = \frac{k}{\gamma_w m_v} = \frac{3\times10^{-7}}{10\times0.0006} = 5.1\times10^{-5}$ H=3 as sand on both sides, so: $\frac{c_v t_{99}}{h^2} = 1.784,\ t_{99} = 1.784\times\frac{3^2}{5.1\times10^{-5}} = 311860\ s = 87\ hours$	87 hours

Question No.	Workings	Answer
2a	$n = V_v / V$ 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 %
2b	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 = 19.4 kN/m^3 γ_d = 13.9 kN/m^3
2c	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 %
2d	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
2e	Void ratio, *e* = Volume pores / volume solid = 0.000245 / 0.000197 = 1.24	*e* = 1.24

<table>
<tr><th>Question No.</th><th>Workings</th><th>Answer</th></tr>
<tr><td>3a</td><td>

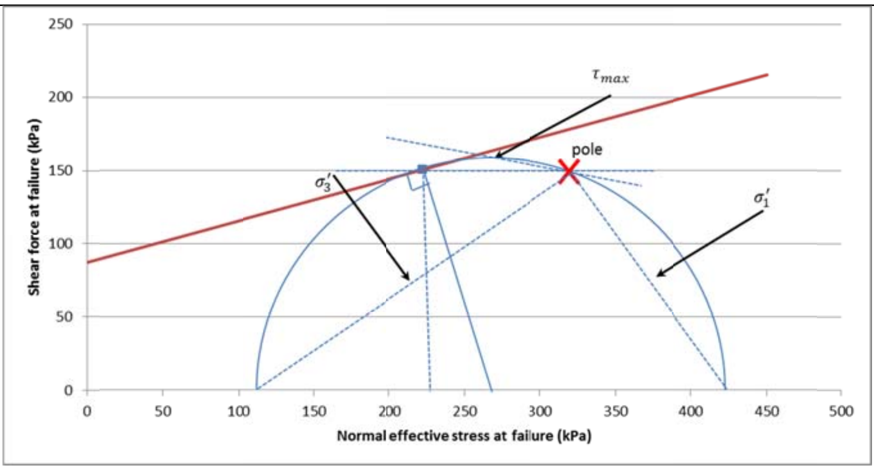
<table>
<tr><th>Test No.</th><th>Normal force, N</th><th>$\boldsymbol{\sigma'_n}$, kPa</th><th>Shear force, N</th><th>$\boldsymbol{\tau}$, kPa</th></tr>
<tr><td>1</td><td>400</td><td>111.1</td><td>427</td><td>118.6</td></tr>
<tr><td>2</td><td>800</td><td>222.2</td><td>542</td><td>150.5</td></tr>
<tr><td>3</td><td>1200</td><td>333.3</td><td>655</td><td>181.9</td></tr>
</table>

Could draw Mohr's circles, but also can use simultaneous equations for any other the two test, e.g.:

$$427 = c' + 111.1 tan\,\phi'$$
$$542 = c' + 222.2 tan\,\phi'$$

$$c' = 87\ kPa$$
$$\phi' = 15°$$

</td><td>$c' = 87\ kPa$
$\phi' = 16°$</td></tr>
<tr><td>3b
i</td><td>



Marks here just for the Mohr's circle and failure

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<tr><td>3b
ii</td><td>

Centre of circle, *222.2 + 150.5 tan 16° = 265 kPa*
Radius of circle, 150.5 / cos 16° = *157 kPa*

$\sigma_1' = 265 + 157 = 422\ kPa$
$\sigma_3' = 265 - 157 = 108\ kPa$

σ_1' acts at 45°-$\phi'/2$ = 37°
σ_3' acts at 45°+$\phi'/2$ = 53°

</td><td>Unit kPa
$\sigma_1' = 422$
$\sigma_3' = 108$

σ_1' acts at 37°
σ_3' acts at 53°
to horizontal</td></tr>
</table>

3b iii	$$\tau_{max} = 157\ kPa$$ Angle using trig from Pole (which is known from shear failure – opposite side of circle) $tan\ \theta = \frac{157-150}{265-222} =$ 8° to horizontal. (from 7° to 9.5° is acceptable for rounding errors)	τ_{max} $= 157\ kPa$ 8° to horiz.

Question No.	Workings	Answer
4a	Use the Brinch Hansen method. $p_c = cN_c i_c s_c + qN_q i_q s_q + \frac{1}{2}\gamma' B N_\gamma i_\gamma s_\gamma$ No inclination, long structure (i and s factors are 1): $p_c = cN_c + qN_q + \frac{1}{2}\gamma' B N_\gamma$ Calculate N factors: $N_q = \frac{1 + sin\,\phi}{1 - sin\,\phi}\exp(\pi\, tan\,\phi) = 6.4$ $N_c = (N_q - 1)cot\,\phi = 14.8$ $N_\gamma = 2(N_q - 1)tan\,\phi = 3.93$ No effective overburden. Total allowable, p_c: $p_c = 15 \times 14.83 + 0.5 \times 8 \times 12 \times 3.93 = 411\,kPa$ Applied load, p: Effective weight of concrete $((25 - 10) \times 0.25 \times 2) \times (12 \times 20 + 20 \times 5 + 5 \times 12) = 3000\,kN$ (can be slightly less for more accurate determination) Effective weight of fill $(5 - 0.5) \times (12 - 0.5) \times (20 - 0.5) \times (17.5 - 10) = 7568\,kN$ Total load = 10568 kN Total / area = 10568 / (12x20) = 44 kPa FoS = 411/44 = 9.3	FoS = 9.3
4b	Need to consider the shape of the caisson: $p_c = cN_c s_c + qN_q s_q + \frac{1}{2}\gamma' B N_\gamma s_\gamma$ Calculate shape factors: $s_c = 1 + 0.2\frac{B}{L} = 1.12$ $s_q = 1 + \frac{B}{L} sin\,\phi = 1.21$ $s_\gamma = 1 - 0.3\frac{B}{L} = 0.82$ $p_c = cN_c s_c + qN_q s_q + \frac{1}{2}\gamma' B N_\gamma s_\gamma$ $p_c = 15 \times 14.83 \times 1.12 + 0.5 \times 8 \times 12 \times 3.93 \times 0.82$ $= 404\,kPa$	FoS = 4.3

	Weight of concrete $((25)\times 0.25\times 2)\times(12\times 20+20\times 5+5\times 12)=5000\ kN$ (can be slightly less for more accurate determination) Weight of fill $(5-0.5)\times(12-0.5)\times(20-0.5)\times(17.5)=17660\ kN$ Total load = 22660 kN Total / area = 22660 / (12x20) = 94 kPa FoS = 404/94 = 4.3	
4c	Use the Brinch Hansen method. $p_c=cN_ci_cs_c+qN_qi_qs_q+\frac{1}{2}\gamma' BN_\gamma i_\gamma s_\gamma$ In this case need the inclinations factors and no shape factors. Horizontal stress, t: $t=\frac{F\ per\ m}{width}=\frac{100}{12}=8.3\ kPa$ $i_c=1-\frac{t}{c+p\ tan\ \phi}$ $=1-\frac{8.3}{c+44\ tan\ 20°}=0.73$ $i_q={i_c}^2=0.53$ $i_\gamma={i_c}^3=0.39$ $p_c=cN_ci_c+\frac{1}{2}\gamma' BN_\gamma i_\gamma$ $p_c=15\times 14.83\times 0.73+0.5\times 8\times 12\times 3.93\times 0.39$ $p_c=237\ kPa$ FoS = 237/44 = 5.4	FoS = 5.4