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DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Civil Engineering and Geosciences

Soil Mechanics

CTB2310

BSc EXAMINATION 2015

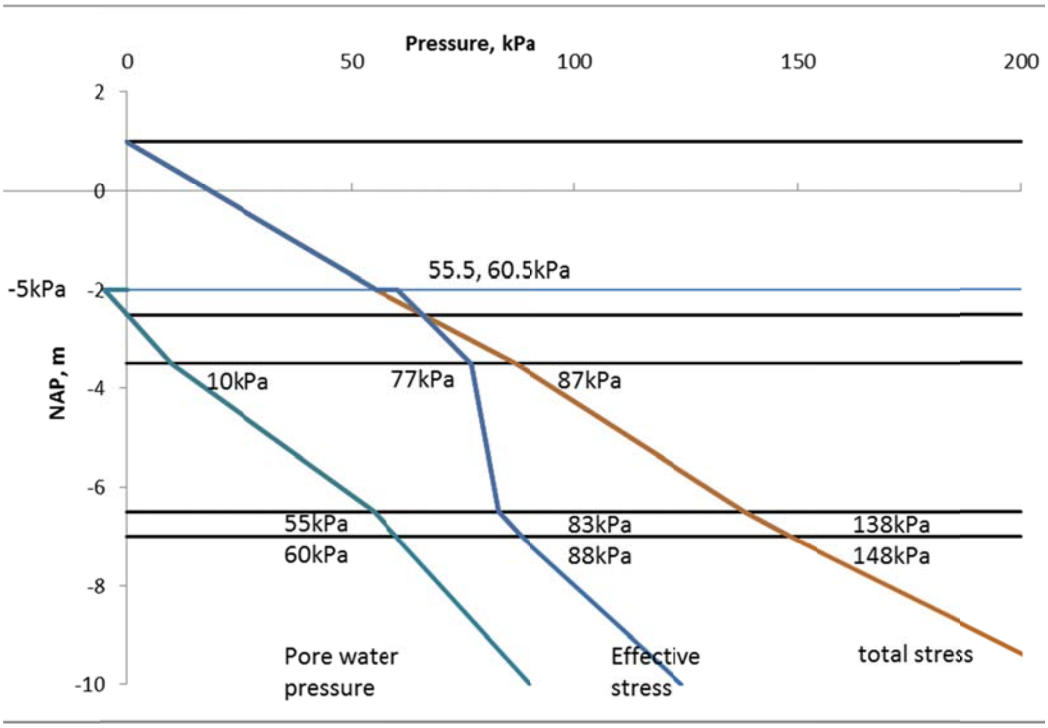
THIRD PERIOD

DATE: 14 APRIL 2015 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	Original values, calculate either by interpolation as 1a: Mid height of the clay: -5m NAP p = (10+55)/2 = 32.5 kPa σ = (87+138)/2 = 112.5 kPa σ' = (77+83)/2 = 80 kPa After excavation p = 32.5 – 1x18.5 = 14 kPa σ = 112.5 – 1x18.5 = 94 kPa σ' = 80 kPa (either by subtraction or recognising it won't change) Immediately after factory construction p = 14 + 150 = 164 kPa σ = 94 +150 = 244 kPa σ' = 80 kPa (either by subtraction or recognising it won't change)	After $\sigma = 244\ kPa$ $\sigma' = 80\ kPa$
1c	Primary strain: $\varepsilon = \frac{1}{C_p}\ln\left(\frac{\sigma'}{\sigma'_1}\right)$ Stresses in other layers by the same method. Top layer $$\varepsilon = \frac{1}{25}\ln\left(\frac{209.5}{78}\right) = 0.040$$ Middle layer $$\varepsilon = \frac{1}{25}\ln\left(\frac{211.5}{80}\right) = 0.039$$	$0.117m$

	Bottom layer $$\varepsilon = \frac{1}{25}\ln\left(\frac{213.5}{82}\right) = 0.038$$ Deformation, $u = \Sigma\, d \times \varepsilon$ Total deformation = $\Sigma\,(1 \times \varepsilon)$ $= 0.040 + 0.039 + 0.038 = 0.117$ m	
1d	Primary and creep strains: $\varepsilon = \left(\frac{1}{C_p} + \frac{1}{C_s}\log\frac{t}{t_0}\right)\ln\left(\frac{\sigma'}{\sigma'_1}\right)$ Additional strains are: $\varepsilon = \left(\frac{1}{C_s}\log\frac{t}{t_0}\right)\ln\left(\frac{\sigma'}{\sigma'_1}\right)$ Top layer $$\varepsilon = \frac{1}{100}\log\frac{7300}{1}\ln\left(\frac{78}{209.5}\right) = 0.38$$ Middle layer $$\varepsilon = \frac{1}{100}\log\frac{7300}{1}\ln\left(\frac{80}{211.5}\right) = 0.038$$ Bottom layer $$\varepsilon = \frac{1}{100}\log\frac{7300}{1}\ln\left(\frac{82}{213.5}\right) = 0.037$$ Deformation, $u = \Sigma\, d \times \varepsilon$ $= 0.038 + 0.038 + 0.037 = 0.112$ m Total deformation = 0.117 + 0.112 = 0.229 m	0.229 m

<table>
<tr><th>Question No.</th><th>Workings</th><th>Answer</th></tr>
<tr><td>2a</td><td>$\Delta p = B(\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3))$
Initially: $(\Delta\sigma_1 - \Delta\sigma_3) = 0$, therefore $\Delta p = B(\Delta\sigma_3)$

$$50 - 0 = B(150 - 0)$$ $$85 - 0 = B(250 - 0)$$ $$120 - 0 = B(350 - 0)$$
Use any of the above eq to determine B=0.33 to 0.34

Use any of the tests to determine A for the second part:
$$-47 - 0 = 0.33(0 + A(410 - 0))$$ $$-70 - 0 = 0.34(0 + A(597 - 0))$$ $$-90 - 0 = 0.34(0 + A(780 - 0))$$
Using the above A = -0.34</td><td>B=0.33 to 0.34

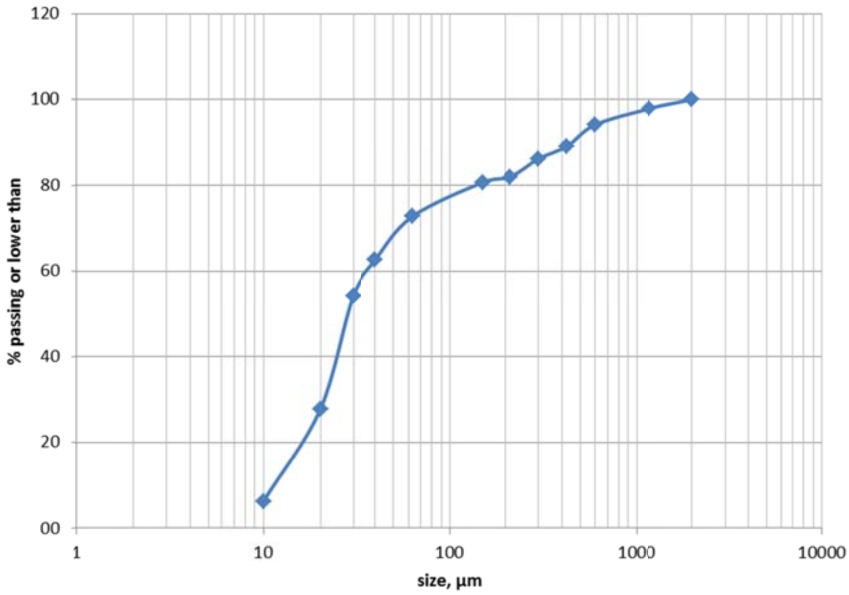
A = -0.34</td></tr>
<tr><td>2b</td><td>Two options: i) draw Mohr's circle or ii) use the expression:
$$\sigma_1' = \sigma_3' tan^2\left(45 + {\phi'}/{2}\right) + 2c' tan\left(45 + {\phi'}/{2}\right)$$
Using any two of the tests, e.g. 1 and 3
<table><tr><th>σ_1 (kPa)</th><th>σ_3 (kPa)</th></tr><tr><td>150 + -47 + 410 = 607</td><td>150 + -47 = 197</td></tr><tr><td>350 + -90 + 780 = 1220</td><td>350 + -90 = 440</td></tr></table>
Therefore $\phi' = 25.6°$, $c' = 35$ kPa</td><td>$\phi' = 25.6°$,
$c' = 35$ kPa</td></tr>
<tr><td>2c</td><td>Various options. Easiest is:
$(\sigma_1 - \sigma_3)/2$ = (1220 – 440) / 2 = 390 kPa

Orientation from Mohr's circle is 45° from both σ_1 and σ_3 and therefore 45° from horizontal and virtical</td><td>390 kPa

45° from horizontal</td></tr>
<tr><td>2d</td><td>Dilates. Negative pore pressure mean soil skeleton is expanding causing negative pore pressures.</td><td>Dilates.</td></tr>
</table>

Question No.	Workings	Answer
3a	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 likely to be 1 or very close): $$p_c = cN_c + qN_q + \frac{1}{2}\gamma' B N_\gamma$$ Calculate N factors: $$N_q = \frac{1 + sin\ \phi}{1 - sin\ \phi}\exp(\pi\ tan\ \phi) = 6.4$$ $$N_c = (N_q - 1)cot\ \phi = 14.8$$ $$N_\gamma = 2(N_q - 1)tan\ \phi = 3.93$$ Overburden $$q = \gamma' d = 5.5$$ Total allowable, p_c: $$p_c = 257.7 + \ 21.6BkPa$$ Applied load, p_a: $$p_a = \frac{350}{B}kPa$$ FOS: $$FOS = \frac{p_c}{p_a} = 2$$ Solve for B: $$257.7B + \ 21.6B^2 = 2 \times 350$$ $$B = 2.28m$$	B = 2.28 m
3b	Against use the Brinch Hansen method. Calculate N factors: $$N_q = \frac{1 + sin\ \phi}{1 - sin\ \phi}\exp(\pi\ tan\ \phi) = 18.4$$ $$N_c = (N_q - 1)cot\ \phi = 30.1$$ $$N_\gamma = 2(N_q - 1)tan\ \phi = 20.1$$ Overburden $$q = \gamma' d = 16.5$$ Total allowable, p_c: $$p_c = 1358.5 + \ 110.5BkPa$$ Applied load, p_a: $$p_a = \frac{350}{B}kPa$$ FOS:	B = 0.495 m

	$$FOS = \frac{p_c}{p_a} = 2$$ Solve for B: $$1358.5B + 110.5B^2 = 2 \times 350$$ $$B = 0.495m$$	
3c	Use the Brinch Hansen method. For undrained loading, only c_u is used. $$p_c = c_u N_c i_c s_c$$ $$N_c = 5.14$$ Calculate σ_1' and σ_3' recognising that they coincide with vertical and horizontal stresses: $$\sigma_1' = z\gamma' = 1.5 \times 11 = 16.5\ kPa$$ $$K_0 \approx 1 - \sin\phi' = 0.5$$ $$\sigma_3' = K_0\sigma_1' = 8.25\ kPa$$ Undrained shear strength: $$c_u = c' + (\sigma_1' - \sigma_3')\tan\phi'$$ $$c_u = 40\ kPa$$ Bearing capacity: $$p_c = 40 \times 5.14 = 204.4\ kPa$$ Load: $$p_c = \frac{350}{B} = \frac{350}{0.495} = 707.1\ kPa$$ FOS = 204.4 / 707.1 = 0.29	FoS = 0.29
3d	In this case need the inclination factors are needed and again no shape factors. $$p_c = cN_c i_c + qN_q i_q + \frac{1}{2}\gamma' B N_\gamma i_\gamma$$ $$FOS = \frac{p_c}{p_a} = 1.5$$ Therefore p_c is required to be: $$p_c = 1.5 \times \frac{350}{0.495} = 1060.6\ kPa$$ Express bearing capacity in terms of i_c ($i_q = {i_c}^2$ and $i_\gamma = {i_c}^3$): $$p_c = cN_c i_c + qN_q {i_c}^2 + \frac{1}{2}\gamma' B N_\gamma {i_c}^3$$ $$1060.6 = 1054.9 i_c + 303.6 {i_c}^2 + 54.7 {i_c}^3$$ $$i_c = 0.8$$ Horizontal stress, t: $$i_c = 1 - \frac{t}{c + p\ tan\ \phi}$$ $$0.8 = 1 - \frac{t}{35 + (\frac{350}{0.495})\ tan\ 30°}$$ Solving for t: $$t = 88.6\ kPa$$ $$F\ per\ m = t \times B = 88.6 \times 0.495 = 43.8 kN/m$$	$43.8 kN/m$

Question No.	Workings	Answer
4a		
4b	PI = w_L-w_P = 73-32 = 41%	41%
4c	Water content = Mass of water / mass of solid Mass of water = initial mass – particles mass M_w = 375 – 238 (total from grain size analysis) = 137 grams w = M_w / M_s = 137 / 238 = 0.576	0.576 or 57.6%
4d	n = V_v / V n = 137 / 200 = 0.69	0.69
4e	ρ_d=M_s/V = 238 / 200 * 1000 = 1190 kg/m^3	1190 kg/m^3
4f	High Plasticity Silt (MH) or Poorly Graded Silt (MP)	MH or MP
4g	10^{-8} to 10^{-6} m/s	10^{-8} to 10^{-6} m/s