DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Civil Engineering and Geosciences

Soil Mechanics II

CT2091

BSc EXAMINATION 2012

ANSWER BOOK

MOCK EXAM I

DATE: 2012 TIME: 3 HOURS

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

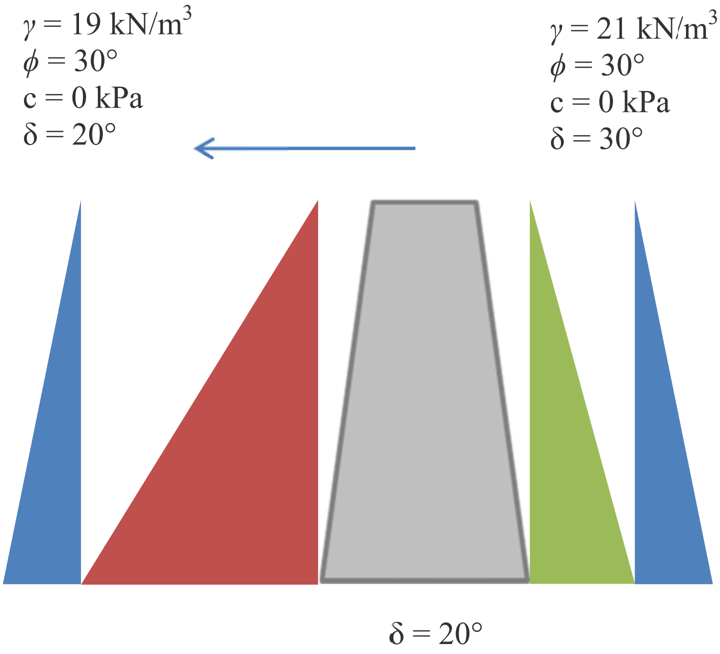
Other instructions
Write your name and student number on each sheet

Clearly identify the answer in the answer box

Question No.	Workings	Answer
1a	Calculate N factors: $$N_q = \frac{1+\sin\phi}{1-\sin\phi}\exp(\pi\tan\phi)$$ $$= \frac{1+\sin 25}{1-\sin 25}\exp(\pi\tan 25) = 10.66$$ $$N_c = (N_q - 1)\cot\phi = 20.72$$ $$N_\gamma = 2(N_q - 1)\tan\phi = 9.011$$	$N_c = 20.72$ $N_q = 10.66$ $N_\gamma = 9.011$
1b	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: $$p_c = cN_c s_c + qN_q s_q + \frac{1}{2}\gamma' B N_\gamma s_\gamma$$ Calculate shape factors: $$s_c = 1 + 0.2\frac{B}{L} = 1.12$$ $$s_q = 1 + \frac{B}{L}\sin\phi = 1.25$$ $$s_\gamma = 1 - 0.3\frac{B}{L} = 0.82$$ Overburden, q: $$q = \gamma h = 20.5 \times 2 = 41\ kPa$$ $$q' = \gamma h - p = 41 - 10 = 31\ kPa$$ Total allowable, p_c: $$p_c = 5 \times 20.72 \times 1.12 + 31 \times 10.66 \times 1.25 + \frac{1}{2} \times 10.5 \times 3 \times 9.01 \times 0.82$$ $$p_c = 646.8\ kPa$$ Applied load, p: Weight of concrete $(5 \times 3 \times 1) \times 25 = 375\ kN$ Weight of soil $(5 \times 3 \times 1) \times 20.5 = 307.5\ kN$ Applied load = 2000 kN Total = 375 + 307.5 + 2000 = 2682.5 kN Total / area = 2682.5 / 15 = 178.8 kPa FoS = 646.8/178.8 = 3.62	FoS = 3.62

1c	Use the Brinch Hansen method. $$p_c = cN_c i_c s_c + qN_q i_q s_q + \frac{1}{2}\gamma' B N_\gamma i_\gamma s_\gamma$$ In this case need the inclinations factors: Horizontal stress, t: $$t = \frac{F}{A} = \frac{600}{15} = 40\ kPa$$ $$i_c = 1 - \frac{t}{c + p\ tan\ \phi} = 0.55$$ (p = 2000/15 + 25x1 + 20.5x1 = 179 kPa) $$i_q = {i_c}^2 = 0.30$$ $$i_\gamma = {i_c}^3 = 0.16$$ $$p_c = cN_c i_c s_c + qN_q i_q s_q + \frac{1}{2}\gamma' B N_\gamma i_\gamma s_\gamma$$ $$p_c = 217.0\ kPa$$ FoS = 217.0/178.8 = 1.2	FoS = 1.2

Question No.	Workings	Answer
2a	Full active and passive forces at failure. Use equations for lateral earth coefficients. $$K_p' = \frac{1+sin\phi'}{1-sin\phi'} = 2.46$$ $$K_a' = \frac{1-sin\phi'}{1+sin\phi'} = 0.405$$ Active forces: $\frac{1}{2}K_a\gamma'(d+h)^2 = 0.5 \times 0.405 \times 18.5 \times 6.5^2 = 158\ kN$ Passive forces: From upper triangle (road), $\frac{1}{2}K_p\gamma' d^2 = 0.5 \times 2.46 \times 20 \times 0.5^2 = 6.2kN$ From lower rect, $K_p(\gamma' d_{road})d_{soil} = 2.46 \times 20 \times 0.5 \times 1.0 = 24.6kN$ From lower triangle, $\frac{1}{2}K_p\gamma' {d_{soil}}^2 = 0.5 \times 2.46 \times 18.5 \times 1^2 = 22.8kN$ Sum of forces = 105.0 kN	Marks for all individual or summed forces
2b	Weight of concrete: $B(h+d)\gamma = 1.75 \times 6.5 \times 25 = 284\ kN$ per metre Resistance to sliding: $R = Wtan\ \delta' = 118\ kN$ FoS = 118 / 105 = 1.12	FoS = 1.12
2c	Include the effects of water by using effective stresses and then adding on forces due to water. Active forces: $\frac{1}{2}K_a\gamma'(d+h)^2 = 0.5 \times 0.405 \times (18.5-10) \times 6.5^2 = 73\ kN$ $\frac{1}{2}K_0\gamma'(d+h)^2 = 0.5 \times 1 \times 10 \times 6.5^2 = 211\ kN$ Passive forces: From upper triangle (road), $\frac{1}{2}K_p\gamma' d^2 = 0.5 \times 2.46 \times 10 \times 0.5^2 = 3.1kN$ From lower rect, $K_p(\gamma' d_{road})d_{soil} = 2.46 \times 10 \times 0.5 \times 1.0 = 12.3kN$ From lower triangle, $\frac{1}{2}K_p\gamma' {d_{soil}}^2 = 0.5 \times 2.46 \times 8.5 \times 1^2 = 10.5kN$ $\frac{1}{2}K_0\gamma'(d)^2 = 0.5 \times 1 \times 10 \times 1.5^2 = 11.25\ kN$ Sum of forces = 247.0 kN FoS = 118 / 247 = 0.48 (fails)	FoS = 0.48 (fails)

Question No.	Workings	Answer
3a	 For a conservative design maximise active pressure, minimise passive and minimise frictional resistance.	
3b	Lateral forces: Active earth pressure coefficients from table (can check from eq): $K'_p = 4.45$ $K'_a = 0.385$ Forces must be in effective stresses. Passive force, $Q_p = \frac{1}{2}K_p(\gamma - \gamma_w)d^2 = \frac{1}{2} \times 4.45 \times (19 - 10) \times 20^2 = 8014\ kN/m$ Active force, $Q_a = \frac{1}{2}K_a(\gamma - \gamma_w)d^2 = \frac{1}{2} \times 0.385 \times (21 - 10) \times 20^2 = 847\ \ kN/m$ Note we can ignore the forces due to water as they are equal on both sides.	$Q_{ph} = 6940\ kN/m$ $Q_{ah} = 796\ \ kN/m$

	We need to resolve to the horizontal direction: $Q_h = Qsin\,(\alpha - \delta)$ $Q_{ah} = 847\ sin\,(80 - 30) = 796\ kN$ $Q_h = 8014\ sin\,(80 - -20) = 6940\ kN$	
3c	Balance of forces (per m) 7500 – 6940 + 796 = 1356 kN Resistance from the ground must equal: 1356*2 = 2712 kN Resistance from sliding = W tan δ Therefore, W = 2712 / tan 20 = 7451 kN Volume = 7451 / 25 = 298 m^3 Test of approx. width is 298 / 20 = 15 m (seems rather high, so could increase depth or foundation width)	298m^3

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<tr><th>Question No.</th><th>Workings</th><th>Answer</th></tr>
<tr><td>4a</td><td>

$\Delta p = B\Delta\sigma_3$ as there is no difference between principle stresses

<table>
<tr><th>Cell pressure, kPa</th><th>Pore water pressure, kPa</th><th>B</th></tr>
<tr><td>100</td><td>0</td><td></td></tr>
<tr><td>200</td><td>82</td><td>0.82</td></tr>
<tr><td>300</td><td>177</td><td>0.95</td></tr>
<tr><td>400</td><td>277</td><td>1.00</td></tr>
<tr><td>500</td><td>377</td><td>1.00</td></tr>
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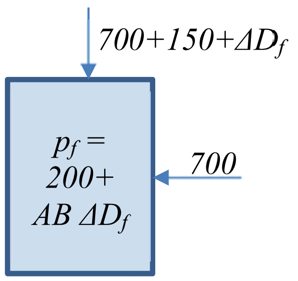
</td><td>See table</td></tr>
<tr><td>4b</td><td>

Note that B=1 for all additional compression stages as air has been compressed and found.

Can draw all stages to build up picture of what is happening. Final loading step to failure looks like:



$A = -0.2$

$p_f = 200 + -0.2\Delta D_f$

$\sigma_3' = \sigma_3 - p = 700 - 200 + 0.2\Delta D_f = 500 + 0.2\Delta D_f$

$\sigma_1' = \sigma_1 - p = 700 + 150 + \Delta D_f - 200 + 0.2\Delta D_f$

$= 650 + 1.2\Delta D_f$

Also failure of material is defined by (noting c'=0)

$$\sigma_1' = \sigma_3' \frac{1 + \sin\phi'}{1 - \sin\phi'}$$

$$\sigma_1' = 3.69\,\sigma_3'$$

$$650 + 1.2\Delta D_f = 3.69\,(500 + 0.2\Delta D_f)$$

$$\Delta D_f = 2587\ kPa$$

$$D_f = 2587 + 150 = 2737\ kPa$$

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$D_f = 2737\ kPa$

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