DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Civil Engineering and Geosciences

Soil Mechanics II

CT2091

BSc EXAMINATION 2012

ANSWER BOOK

MOCK EXAM II

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

Name: P Vardon CT2091

<table>
<tr><td>Question No.</td><td>Workings</td><td>Answer</td></tr>
<tr><td>1a</td><td>Test 1
σ_3 = 0 to 100 kPa
p_0 = -25 + 0.75 x 100 = 50 kPa
p_f = 50 + 0.75 (0.3x93) = 70.9 kPa

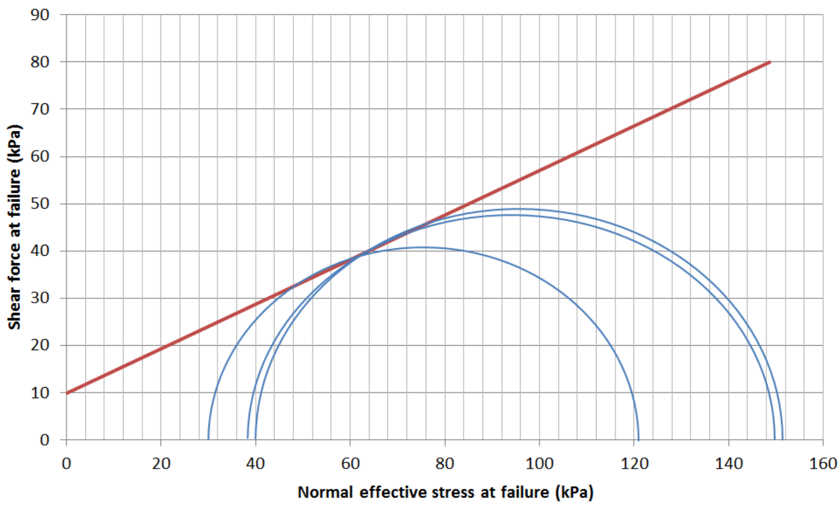
Test 2
σ_3 = 0 to 200 kPa
p_0 = -25 + 0.8 x 200 = 135 kPa
p_f = 135 + 0.8 (0.3x112) = 161.9 kPa

Test 3
σ_3 = 0 to 300 kPa
p_0 = -25 + 0.85 x 300 = 230 kPa
p_f = 230 + 0.85 (0.3x116) = 259.6 kPa</td><td>Test 1
p_0 = 50 kPa
p_f = 70.9 kPa

Test 2
p_0 = 135 kPa
p_f = 161.9 kPa

Test 3
p_0 = 230 kPa
p_f = 259.6 kPa</td></tr>
<tr><td>1b</td><td>At failure:
Test 1
σ_3 = 0 to 100 kPa
$\sigma_3'_f$ = 100 – 70.9 = 29.1 kPa
$\sigma_1'_f$ = 193 – 70.9 = 122.1 kPa

Test 2
$\sigma_3'_f$ = 200 – 161.9 = 38.1 kPa
$\sigma_1'_f$ = 312 – 161.9 = 150.1 kPa

Test 3
$\sigma_3'_f$ = 300 – 259.6 = 40.4 kPa
$\sigma_1'_f$ = 412 – 259.6 = 156.4 kPa


From Mohr's circle: c'=10 kPa, ϕ'=30°</td><td>Answers in kPa

Test 1
$\sigma_3'_f$ = 29.1
$\sigma_1'_f$ = 122.1

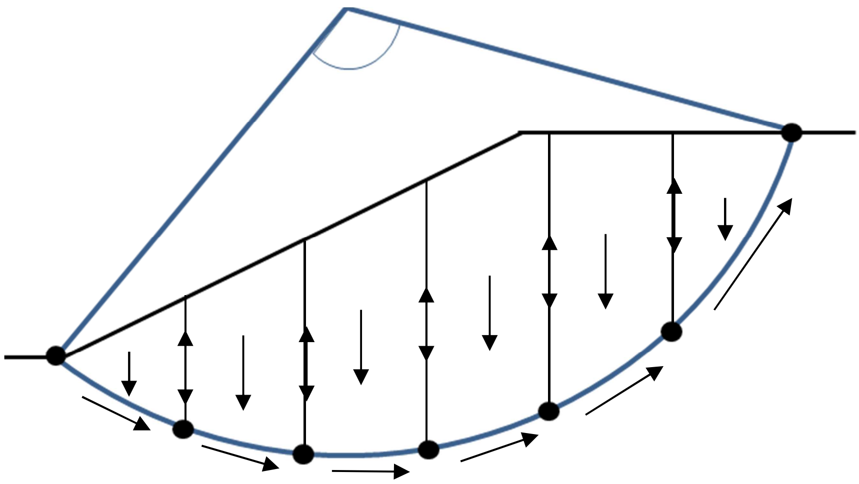
Test 2
$\sigma_3'_f$ = 38.1
$\sigma_1'_f$ =150.1

Test 3
$\sigma_3'_f$ = 40.4
$\sigma_1'_f$ = 156.4

c'=10
ϕ'=30°</td></tr>
</table>

Question No.	Workings	Answer
2a	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: $$p_c = cN_c + qN_q + \frac{1}{2}\gamma' B N_\gamma$$ Calculate N factors: $$N_q = \frac{1 + sin\ \phi}{1 - sin\ \phi}\exp(\pi\ tan\ \phi) = 1.0$$ Use $\phi = 0.001°$ $$N_c = (N_q - 1)cot\ \phi = 5.14$$ $$N_\gamma = 2(N_q - 1)tan\ \phi = 0$$ No effective overburden. Total allowable, p_c: $$p_c = 25 \times 5.14 = 128\ kPa$$ Applied load, p: Weight of concrete $(25 \times 0.25 \times 2) \times (12 \times 20 + 20 \times 5 + 5 \times 12) = 5000\ kN$ 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 = 2682.5 / (12x20) = 94 kPa FoS = 128/94 = 1.36	FoS = 1.36
2b	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: $$s_c = 1 + 0.2\frac{B}{L} = 1.12$$ $$s_q = 1 + \frac{B}{L}sin\ \phi = 1.0$$ $$s_\gamma = 1 - 0.3\frac{B}{L} = 0.82$$ $$p_c = cN_c s_c + qN_q s_q + \frac{1}{2}\gamma' B N_\gamma s_\gamma = 143.9\ kPa$$ FoS = 144/94 = 1.52	FoS = 1.52

2c	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: $$p_c = cN_c i_c s_c$$ Horizontal stress, t: $$t = \frac{F\ per\ m}{width} = \frac{100}{12} = 8.3\ kPa$$ $$i_c = 1 - \frac{t}{c + p\ tan\ \phi} = 0.66$$ $$i_q = {i_c}^2 = 0.44$$ $$i_\gamma = {i_c}^3 = 0.30$$ $$p_c = 86.0\ kPa$$ FoS = 86/94 = 0.91	FoS = 0.91

Question No.	Workings	Answer
3a		
3b	Appropriate method is Bishop. Could also use Fellenius, but assumptions are less robust and equilibrium is not maintained – reduce 1 mark if used.	FoS = 1.21

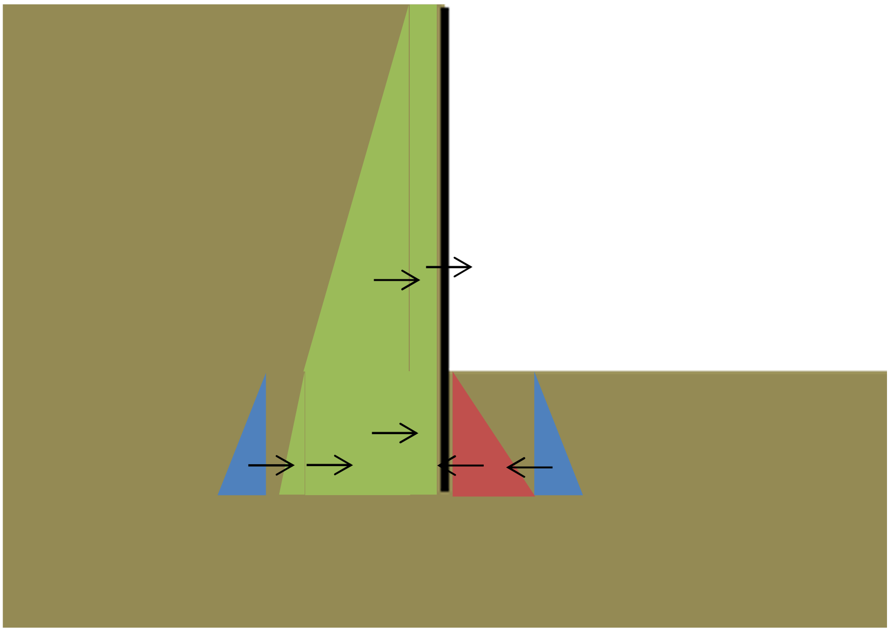
$$A = c + (\gamma h) tan\, \phi$$
$$B = tan\, \alpha\, tan\, \phi\, /\, F$$
$$C = cos\, \alpha\, (1 + B)$$
$$D = A/C$$
$$E = (\gamma h)\, sin\, \alpha$$

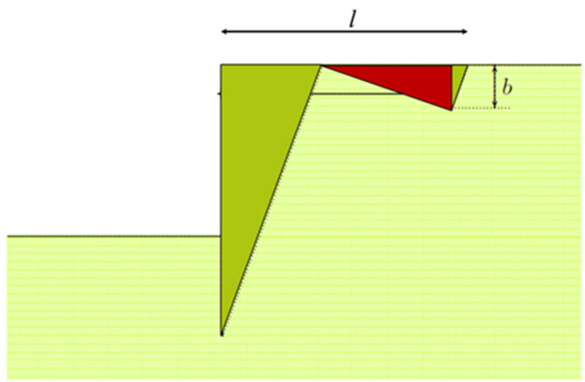
Need to input F is item B. Use 1 for initial estimate.

Slice	Angle to horiz., α (°)	h mid-slice (m)	A	B	C	D	E
1	-20.4	1.12	31.76	-0.03	0.91	35.03	-7.03
2	-6.0	3.10	34.87	-0.01	0.99	35.39	-5.82
3	8.05	4.56	37.18	0.01	1.00	37.09	11.49
4	22.65	5.50	38.66	0.04	0.96	40.42	38.12
5	39.20	5.02	37.90	0.07	0.83	45.65	57.05
6	64.60	2.10	33.31	0.18	0.51	65.57	34.15
					$\Sigma D =$	259.15	
						$\Sigma E =$	127.97

$F = \frac{\Sigma C}{\Sigma D}$ =2.03

Note can to iterate to get better solution. For exam purposes no need to iterate.

Question No.	Workings	Answer
4a	 Active and passive forces shown above. Locations of action at 1/3 height (from base) of triangles and at mid-height of rectangles. Note active force is made up of 2 triangles and 2 rectangles.	
4b	Active earth pressure coefficients: $$K'_p = \frac{1+\sin\phi'}{1-\sin\phi'} = 3.69$$ $$K'_a = \frac{1-\sin\phi'}{1+\sin\phi'} = 0.27$$ Triangular forces: $= \frac{1}{2}K\gamma' d^2$ Rectangular forces: $= K\gamma' d^2$ or $Kd\sigma$ Active forces: From surcharge, $K_a d\sigma = 0.27 \times 16 \times 10 = 43.4kN$ at $8m$ from top From upper triangle, $\frac{1}{2}K_a\gamma' d^2 = 0.5 \times 0.27 \times 18 \times 10^2 = 244kN$ at $6.7m$ from top From lower rect, $K_a(\gamma' h)d = 0.27 \times (18 \times 10) \times 6 = 293kN$ at $13m$ from top From lower triangle, $\frac{1}{2}K_a\gamma' d^2 = 0.5 \times 0.27 \times (18-10) \times 6^2 = 39kN$ at $14m$ from top From water, $\frac{1}{2}K_0\gamma' d^2 = 180kN$ at $14m$ from top	FoS = 1.18

	Passive forces: From lower triangle, $\frac{1}{2}K_p\gamma' d^2 = 0.5 \times 3.69 \times (18 - 10) \times 6^2 = 531kN$ at *14m* from top From water, $\frac{1}{2}K_0\gamma' d^2 = 180kN$ at *14m* from top Moments around tension anchor (note 2m below surface): Anticlockwise: $43.4 \times 6 + 244 \times 4.7 + 293 \times 11 + 39 \times 12 + 180 \times 12 = 7246\ kN$ Clockwise: $531 \times 12 + 180 \times 12 = 8537\ kN$ FoS = 8537/7246 = 1.18	
4c	Horizontal equilibrium to determine T (tension +ive direction) $T = 43 + 244 + 293 + 39 - 531$ $T = 87.6\ kN$	$T = 87.6\ kN$
4d	Calculate length, l:  *l* = active zone from pile + passive zone from anchor $l = (d + h)\tan\theta + {}^{b}/_{\tan\theta}$ $\theta = 45 - \frac{\phi}{2} = 27.5°$ $l = (6 + 10)\tan 27.5 + {}^{3}/_{\tan 27.5} = 14.1\ m$	$l = 14.1\ m$