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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

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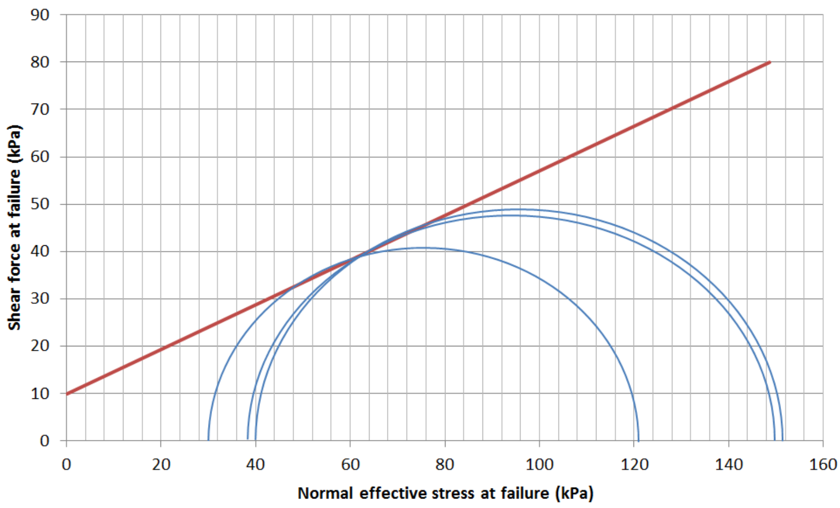
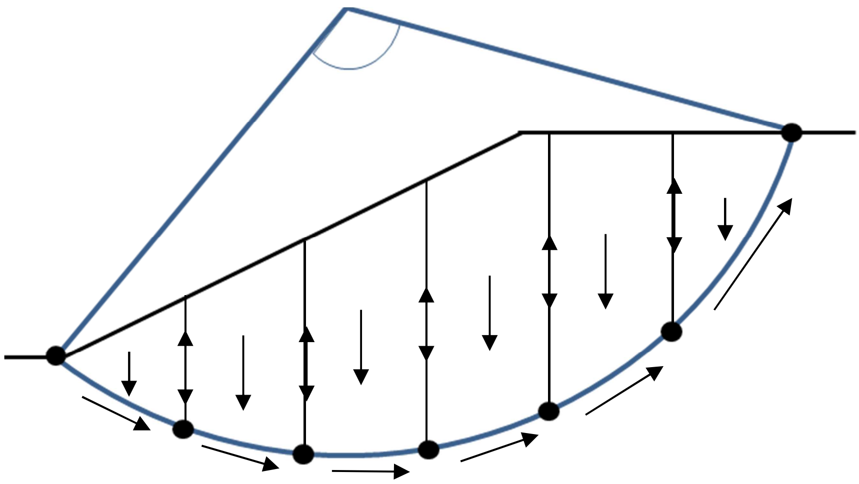
Question No.	Workings	Answer
1a	Test 1 σ_3 = 0 to 100 kPa p_0 = -25 + 0.75 x 100 = 50 kPa p_f = 50 + 0.75 (0.3x93) = 70.9 kPa Test 2 σ_3 = 0 to 200 kPa p_0 = -25 + 0.8 x 200 = 135 kPa p_f = 135 + 0.8 (0.3x112) = 161.9 kPa Test 3 σ_3 = 0 to 300 kPa p_0 = -25 + 0.85 x 300 = 230 kPa p_f = 230 + 0.85 (0.3x116) = 259.6 kPa	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
1b	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°	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°

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.

Answer: FoS = 1.21

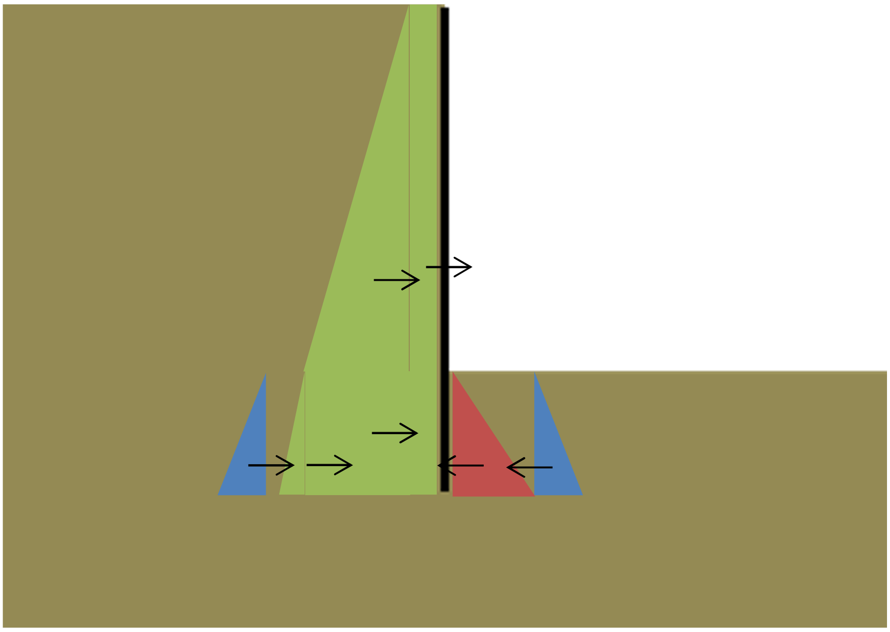
$$A = c + (\gamma h) tan\,\phi$$
$$B = tan\,\alpha\; tan\,\phi \,/\, F$$
$$C = cos\,\alpha\,(1 + B)$$
$$D = A/C$$
$$E = (\gamma h)\,sin\,\alpha$$

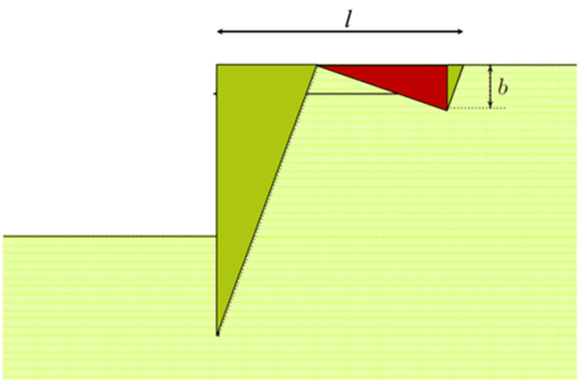
Need to input F is item B. Use 1 for initial estimate.

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 $l = (d+h)\tan\theta + {}^{b}/_{\tan\theta}$ $\theta = 45 - \frac{\phi}{2} = 27.5°$ $l = (6+10)\tan 27.5 + {}^{3}/_{\tan 27.5} = 14.1\ m$	$l = 14.1\ m$