UNIVERSITY OF BOLTON

SCHOOL OF BUILT ENVIRONMENT & ENGINEERING – RAK CAMPUS

BSc(HONS) CIVIL ENGINEERING

SEMESTER THREE EXAMINATION 2010/2011

GEOTECHNICS

MODULE NO: BLT3012

Date: Tuesday 30 August 2011 **Time: 1.00 pm – 3.00 pm**

INSTRUCTIONS TO CANDIDATES:

There are FOUR questions.

Answer THREE questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

Supplementary Geotechnical Information is provided on page 9.

Lined Graph Paper and Supplementary Answer Sheets are available for your use.

Detach Table Q4b and insert into your Answer Booklet using Treasury Tags.

Ensure that you write your Candidate Number or Desk Number on each Figure, Supplementary Sheet or Sheet of Graph Paper you use to answer the selected questions.

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1. A reinforced concrete gravity wall, 1.5m wide at its top and 2m wide at its base, is resting upon and also retains 5.0m of granular soil. A cross section through the wall is shown in Figure Q1.

   Other relevant parameters are:

Granular Soil	Bulk Unit weight	18.0 kN/m^3
	Saturated Unit Weight	19.5 kN/m^3
	Effective friction angle ϕ'	28°
	Ultimate bearing capacity of base	200 kN/m^2

Reinforced concrete Unit weight 24 kN/m^3

Groundwater 2.0m below upper retained surface
Unit Weight of Water 10kN/m^3

Surcharge 15kN/m^2 on upper retained surface

Formulae $K_a = (1 - \sin \phi) / (1 + \sin \phi)$ $K_p = (1 + \sin \phi) / (1 - \sin \phi)$

a) Determine, by calculation, the resultant thrust acting on the back of the retaining wall.

(14 marks)

b) Determine the height of the resultant thrust above the base of the retaining wall and hence determine the Factor of Safety against overturning (ignore water pressures on the base of the foundation).

(4 marks)

c) What are the advantages and disadvantages of using an embedded retaining wall instead of a gravity retaining wall? Ensure that your answer discusses construction practicality as well as technical aspects.

(7 marks)

Total 25 marks

Question 1 continued over the page…

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Question 1 continued

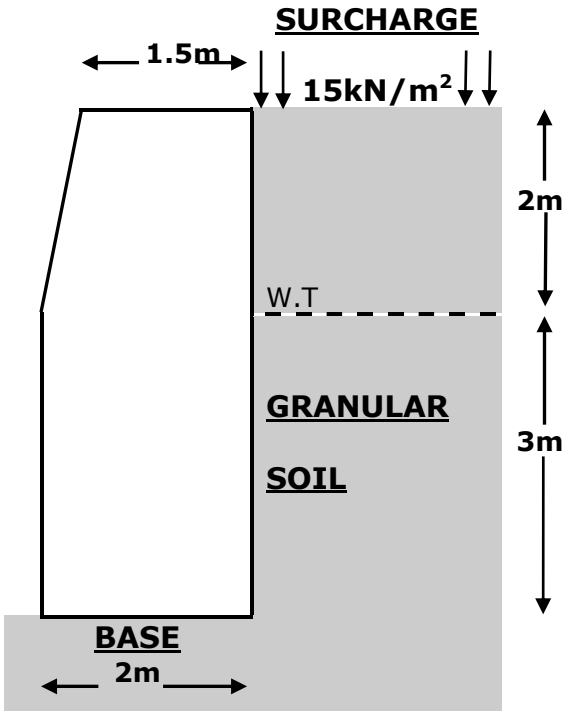

Figure Q1

Please turn the page

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2. a) Publication of the final National Annex of BS EN 1997-1:2004 and BS EN 1997-2:2007 has made an impact on design. Summarise the key changes and specifically describe how foundation design in the United Kingdom has been, and is likely to be affected still further by their introduction.

Ensure that your answer briefly discusses any changes to the way in which the calculations will provide a safe foundation design and refer to the current guidance documents and codes of practice that will be replaced.

(7 marks)

b) A pad foundation, 2.5m square is to be located at a depth of 1.2m in a uniform bearing stratum of firm clay. The water table level is at an assumed depth of 1.2m below ground level (from a recent and reliable site investigation). The clay soil properties are as follows;

Bulk unit weight	γ = 20.0 kN/m^3
Saturated unit weight	γ_{sat} = 21.5 kN/m^3
Total Stress Shear Strength Parameters	c_u = 70.0 kN/m^2
	Φ_u = 0^0
Effective Stress Shear Strength Parameters	c^l = 12.0 kN/m^2
	Φ^l = 28^0

Using Table Q2 determine the safe bearing load that the foundation can support in the short term (in kN).

(10 marks)

NOTE: Clearly state any assumptions made in your calculations to determine the safe bearing load in Q2 b). Use the formulae provided on page 9 and also Table Q2 (as appropriate).

c) Using the data provided for Q2 b) determine the safe bearing load that the foundation can support in the long term (in kN).

(8 marks)

Total 25 marks

Question 2 continued over the page…

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Question 2 continued

ϕ	N_c	N_q	$N\gamma$
0	5.14	1.0	0
1	5.4	1.1	0
2	5.6	1.2	0
3	5.9	1.3	0
4	6.2	1.4	0
5	6.5	1.6	0.1
6	6.8	1.7	0.1
7	7.2	1.9	0.2
8	7.5	2.1	0.2
9	7.9	2.3	0.3
10	8.4	2.5	0.4
11	8.8	2.7	0.5
12	9.3	3.0	0.6
13	9.8	3.3	0.8
14	10.4	3.6	1.0
15	11.0	3.9	1.2
16	11.6	4.3	1.4
17	12.3	4.8	1.7
18	13.1	5.3	2.1
19	13.9	5.8	2.5
20	14.8	6.4	3.0
21	15.8	7.1	3.5
22	16.9	7.8	4.1
23	18.1	8.7	4.9
24	19.3	9.6	5.7
25	20.7	10.7	6.8
26	22.3	11.9	7.9
27	23.9	13.2	9.3
28	25.8	14.7	10.9
29	27.9	16.4	12.8
30	30.1	18.4	15.1
31	32.7	20.6	17.7
32	35.5	23.2	20.8
33	38.6	26.1	24.4
34	42.2	29.4	28.8
35	46.1	33.3	33.9
36	50.6	37.8	40.0
37	55.6	42.9	47.4
38	61.4	48.9	56.2
39	67.9	56.0	66.8
40	75.3	64.2	79.5

Table Q2

Please turn the page

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3. a) A bored pile (16m long and 450mm in diameter) is to be installed into the following soil profile;

Depth m	Description	Unit Weight kN/m^3	c_u kN/m^2	Adhesion Factor α
0 – 4	Firm CLAY	21.0	50.0	0.6
4 – 10	Stiff CLAY	21.5	85.0	0.45
10 - 20	Stiff to very stiff CLAY	22.0	130.0	0.45

The above clay strata are all taken to be fully saturated.

i) Determine the safe load carrying capacity of the pile.

NOTE: Clearly state any assumptions made in your calculations

(14 marks)

ii) What piling options might be considered if a greater load carrying capacity is required but it is not permitted to extend the piles to a greater depth than 16m.

NOTE: Calculations are NOT required for your answer to Q3a)ii).

(5 marks)

b) Describe the testing methods that would be adopted to confirm the carrying capacity for a driven pile installed into a loose to medium dense, becoming dense to very dense, fine to coarse sand and gravel. Briefly discuss the testing methods that might be routinely used to verify the carrying capacity of the pile.

(6 marks)

Total 25 marks

Please turn the page

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4. a) Briefly discuss the allocation of soil properties and use of an appropriate analysis method to address slope stability for the following situations;

(i) a steep embankment 6m high formed by compacting thin layers of sand and gravel

(3 marks)

(ii) a 5m deep and 10m wide cutting 34^o from the horizontal in a firm clay

(3 marks)

b) A cutting, 8.0m in vertical height, has a side slope of 30^o from the horizontal and is excavated in a thick stratum of saturated clay with the following properties;

Saturated unit weight, γ_{sat} = 18.81 kN/m^3
Unit weight of Water, γ_w = 9.81 kN/m^3

Strength parameters with respect to effective stress;
$c' = 14.5$ kN/m^2
$\Phi' = 15^o$

A trial slip surface of radius, R = 15.0m and sector angle, $\theta = 57^o$, allows the sector to be divided into 6 slices, each 2.075m wide, where slice number 1 is adjacent to the toe.

Complete the table shown in Table Q4b and hence determine the long term factor of safety, F, of the trial slip surface using the Swedish (Fellenius) analysis which uses the equation below;

$$F = \frac{c' R \theta_{rad} + \Sigma (W \cos\alpha - u l) \tan\phi'}{\Sigma W \sin\alpha}$$

(15 marks)

c) Describe how implementation of BS EN 1997 will affect slope stability analysis compared with the current method of analysis as shown in Q4(b) above. In particular discuss how the terms in the equation above may vary according to BS EN 1997.

(4 marks)

Total 25 marks

Question 4 continued over the page…

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Question 4 continued

Slice No.	**Slice Width b (m)**	**Slice Height, h (m)**	**α (°)**	**Weight W (kN)**	**W sin α**	**W cos α**	**l b /cos α (m)**	**u l**	**(Wcos α - ul)**
1	2.075	0.72	-6.03						
2	2.075	2.10	0.00						
3	2.075	3.20	8.51						
4	2.075	3.93	16.20						
5	2.075	4.29	25.02						
6	2.075	4.41	33.57						
				Sum Σ				**Sum Σ**	

Candidate Number / Seat Number ……

Table Q4b

Complete the missing rows of data in the cells above in Table Q4b and then use the data to complete your answer to Question Q4 b).

END OF QUESTIONS

Please turn the page (for one page of Supplementary Geotechnical Information)

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Supplementary Geotechnical Information

q_f = ultimate bearing capacity

q_n = net bearing capacity $= q_f - \sigma_o = q_f - \gamma D$ (Total stresses)

$= q_f - \sigma_o{}^1 = q_f - (\gamma D - \gamma_w h_w)$ (Effective stresses)

q_s = safe bearing capacity = $\frac{q_n}{F}$ and F = $\frac{q_f}{q_n}$ = 3.0 usually

q_a = allowable bearing capacity = $\frac{q_n}{F} + \gamma D = \frac{q_f - \gamma D}{F} + \gamma D$

Shallow Foundations

c , ϕ soil

Terzaghi : $q_f = c\, N_c\, s_c + \gamma\, D\, N_q\, s_q + 0.5\, B\, \gamma\, N_\gamma\, s_\gamma$

Where N_c ; N_q ; N_γ ; s_c ; s_q ; s_γ are bearing capacity and shape factors (from tables)

Shape of footing	s_c	s_q	s_γ
Strip	1.0	1.0	1.0
Rectangle	$1.0 + (B/L)(N_q/N_c)$	$1.0 + (B/L)\tan\phi'$	$1.0 - (B/L)0.4$
Circle or square	$1.0 + (N_q/N_c)$	$1.0 + \tan\phi'$	0.6

- modified when Water Table present , $\gamma_{sub} = \gamma_{sat} - \gamma_w$

c soil (ϕ =0)

Skempton : $q_f = cN_c + \gamma D$ N_c from Skempton's graph (for D/B values)

ϕ soil (c = 0)

q_a from graph using corrected N values