UNIVERSITY OF BOLTON

SCHOOL OF THE BUILT ENVIRONMENT & ENGINEERING – RAK CAMPUS

BSc(HONS) IN CIVIL ENGINEERING

SEMESTER TWO EXAMINATION 2009/2010

GEOTECHNICS

MODULE NO: BLT2011

Date: Tuesday 1 June 2010 **Time: 5.00 pm – 7.00 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.

Formulae are provided on page 12.

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

Detach Figure Q1b and insert into your Answer Booklet using Treasury Tags if required.

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

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1. a) Explain the purpose of “Mohr’s stress circles”. Sketch a Mohr’s stress circle diagram for the situation where a triaxial compression test on a cylindrical clay sample has a hypothetical shear plane inclined at an angle of $\alpha°$ from the horizontal. Ensure that you label all axes and key points on your sketch diagram and denote the direction of the principal stresses so that your diagram clearly indicates the purpose of having plotted the diagram.

(6 marks)

b) A series of ‘quick’ unconsolidated undrained triaxial tests were conducted on a sample of clay with the results obtained being as follows:

Test Number	1	2	3
Cell Pressure (kN/m^2)	50	100	200
Vertical Stress at Failure (kN/m^2)	144	201	306

Using Figure Q1b and constructing Mohr’s stress circles, determine the shear strength parameters of the soil sample and then using these values describe the clay soil being tested.

(10 marks)

c) Describe the full range of shear strength testing methods available for different soil types both in the field and in the laboratory. Ensure that your discussions justify the use of specific test methods for specific soil types and also states the advantages and limitations of the methods selected.

(5 marks)

d) Explain what is expected to occur when carrying out a shear box test on very dense sand. Students may find sketch diagrams useful to help illustrate the experimental observations anticipated when very dense sand is being sheared. NOTE: This explanation is intended to cover early stages of shear right through to the point of “shear failure” and beyond.

(4 marks)

Total 25 marks

Question 1 continued over the page…

Question 1 continued

Seat / Candidate Number : …………………………………………………

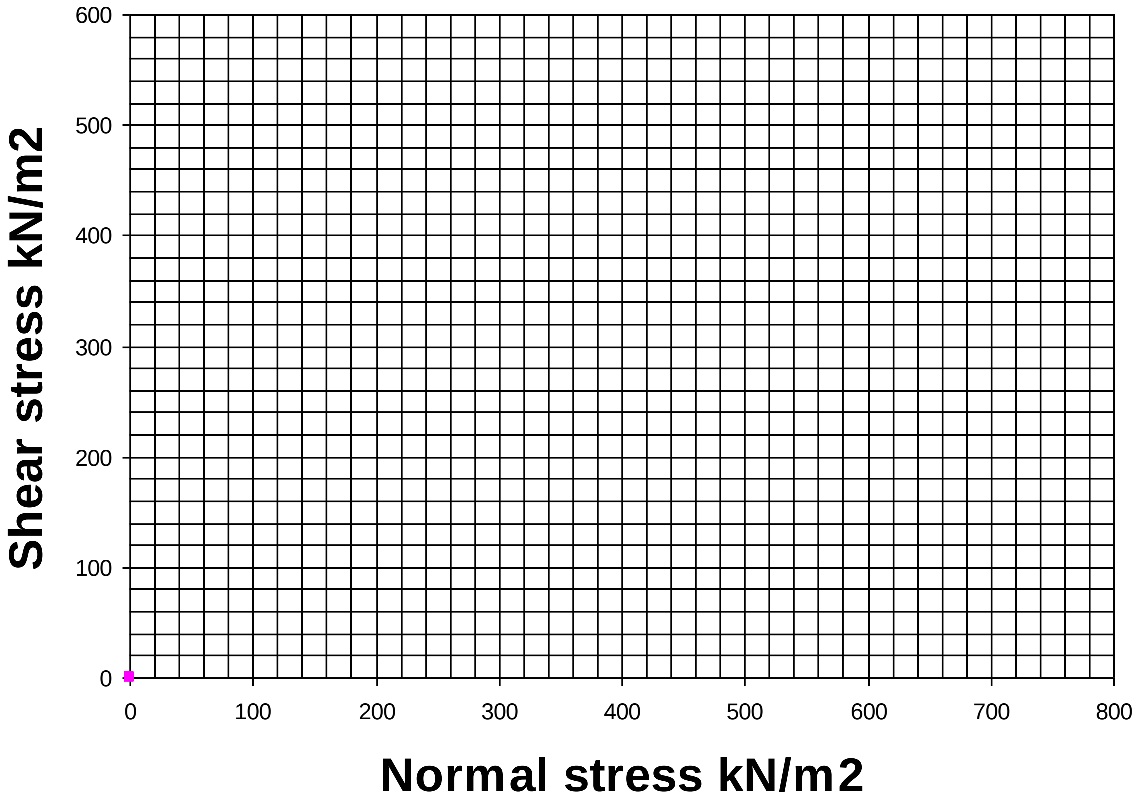

Figure Q1b

Please turn the page

2. a) A flexible foundation of length 4m and breadth 3m is to exert a uniform pressure of 250kN/m^2 on the surface of a 10m layer of soil with a bulk unit weight of 20kN/m^3. Using Figure Q2a, determine the immediate settlement under the centre of the foundation if the elastic soil stiffness (E) is assumed to be 6MN/m^2.

(8 marks)

b) A flexible foundation of length 4m and breadth 3m is to exert a uniform pressure of 250kN/m^2 on the surface of a layer of soil of assumed infinite thickness with a bulk unit weight of 20kN/m^3. Using Figure Q2b, determine the total stress at a depth of 5m beneath the centre of the foundation.

(6 marks)

c) The following results were obtained from an oedometer test on a specimen of saturated clay :

Applied Stress (kN/m^2)	0	25	50	100	200	400	800
Void Ratio	1.008	0.973	0.944	0.901	0.855	0.806	0.759

i) Using this applied stress and void ratio data determine the value of m_v for an effective stress range from150kN/m^2 to 400kN/m^2.

(7 marks)

ii) Calculate the consolidation settlement for a 4m thick layer of this clay, when the effective stress changes from 150kN/m^2 to 400kN/m^2.

(4 marks)

Total 25 marks

Question 2 continued over the page…

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Question 2 continued

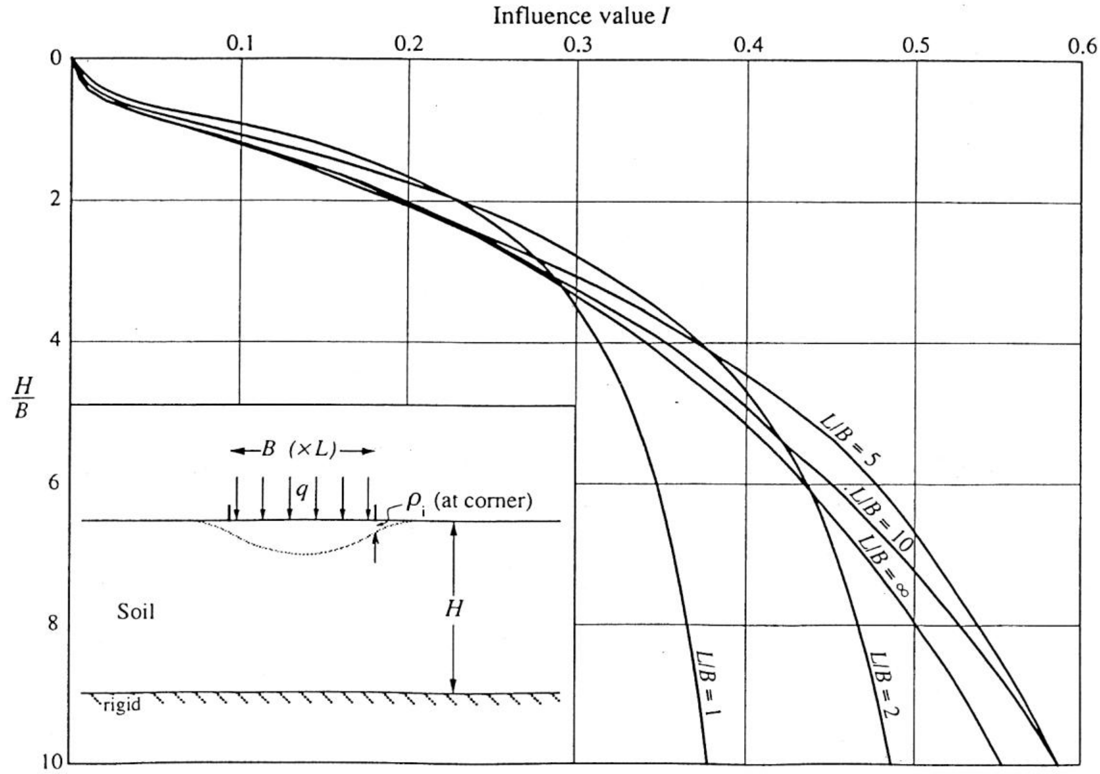

Figure Q2a

Question 2 continued over the page…

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Question 2 continued

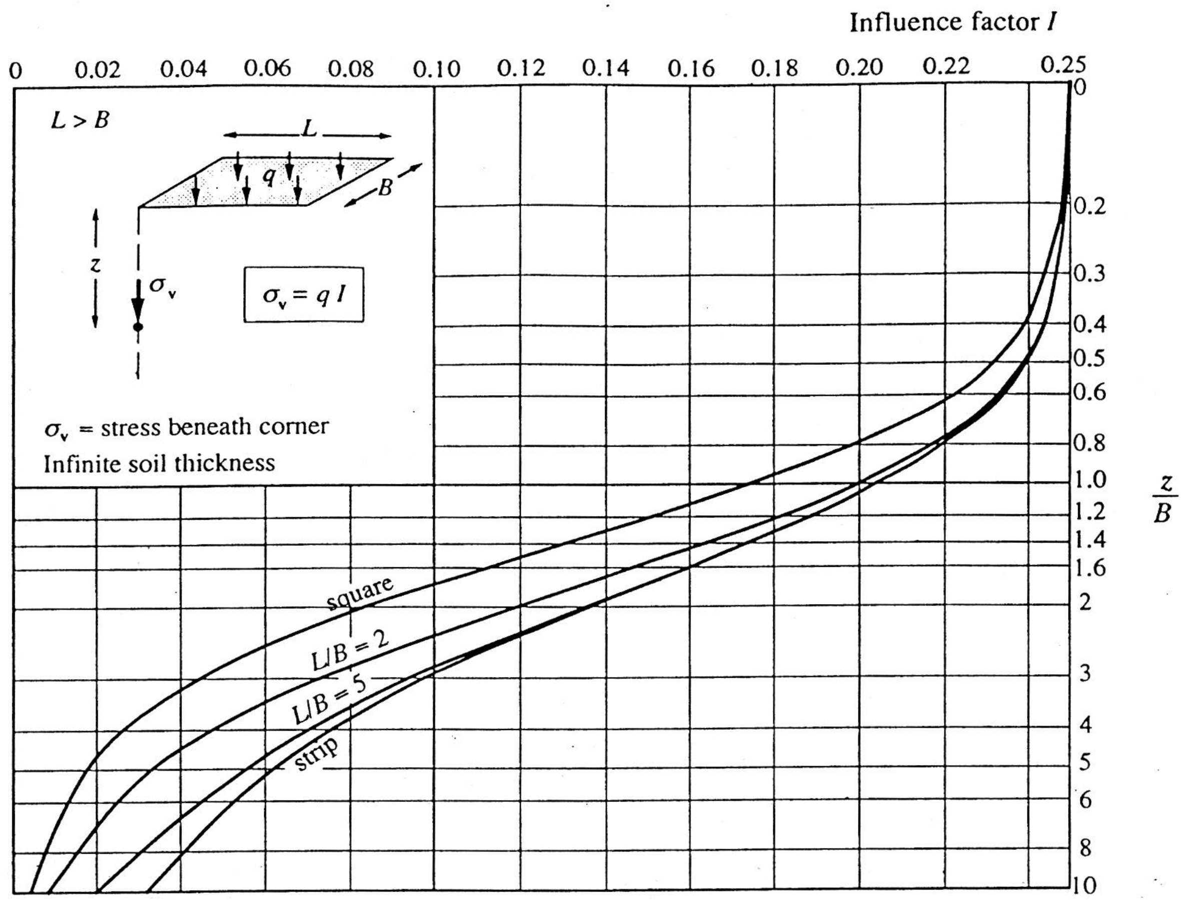

Fig Q2b

Please turn the page

3. a) A trunk road embankment, 5m high, is to be built on an 10m thick layer of soft clay ($m_v = 0.6m^2/MN$, $c_v = 6m^2/year$), which overlies a relatively impermeable layer of very stiff to hard clay that can be assumed to act as a rigid stratum.

The embankment is constructed using a sandy gravel ($\gamma_b = 22kN/m^3$).

i) calculate the total consolidation settlement expected within the soft clay layer.

(4 marks)

If the road can tolerate a further uniform settlement of 30mm after placement of the upper bituminous surfacing materials, and the surfacing materials are assumed to add no further weight to the embankment, then calculate;

ii) the earliest time after placement of the embankment material before the bituminous surfacing materials can be laid such that no more than 30mm of settlement occurs after that time.

(6 marks)

b) If 300mm diameter vertical sand drains can be installed down through the entire depth of soft clay prior to construction of the embankment, and these be connected to a granular surface drainage layer, then what square grid spacing would be required to achieve all but 30mm of the consolidation settlement of the soft clay layer within one month of completion of the embankment. The soft clay properties are as for Q3a) and also $c_h = 9m^2/year$.

(15 marks)

NOTE: Figure Q3a and Table Q3b are available for the solution to question 3a) and 3b)

Total 25 marks

Question 3 continued over the page…

Question 3 continued

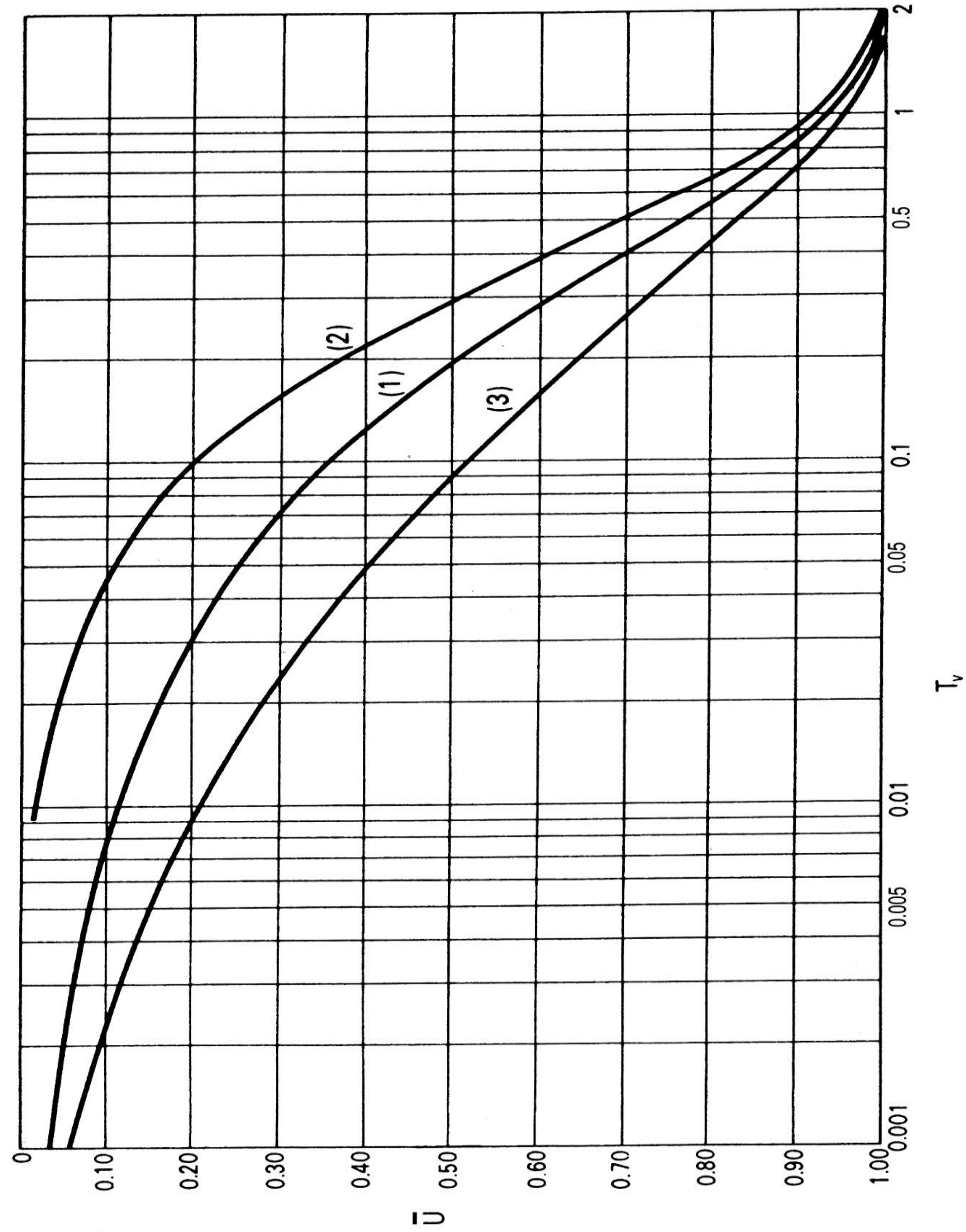

Figure Q3a

Question 3 continued over the page…

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Question 3 continued

Degree of Consolidation	Dimensionless Radial Time Factor T_r for varying values of 'n' (where $n = R / r_d$)										
U_r (%) n =	5	10	15	20	25	30	40	50	60	80	100
10	0.012	0.021	0.026	0.030	0.032	0.035	0.039	0.042	0.044	0.048	0.051
20	0.026	0.044	0.055	0.063	0.069	0.074	0.082	0.088	0.092	0.101	0.107
30	0.042	0.070	0.088	0.101	0.110	0.118	0.131	0.141	0.149	0.162	0.172
40	0.060	0.101	0.125	0.144	0.158	0.170	0.188	0.202	0.214	0.232	0.246
50	0.081	0.137	0.170	0.195	0.214	0.230	0.255	0.274	0.290	0.315	0.334
55	0.094	0.157	0.197	0.225	0.247	0.265	0.294	0.316	0.334	0.363	0.385
60	0.107	0.180	0.226	0.258	0.283	0.304	0.337	0.362	0.383	0.416	0.441
65	0.123	0.207	0.259	0.296	0.325	0.348	0.386	0.415	0.439	0.477	0.506
70	0.137	0.231	0.289	0.330	0.362	0.389	0.431	0.463	0.490	0.532	0.564
75	0.162	0.273	0.342	0.391	0.429	0.460	0.510	0.548	0.579	0.629	0.668
80	0.188	0.317	0.397	0.453	0.498	0.534	0.592	0.636	0.673	0.730	0.775
85	0.222	0.373	0.467	0.534	0.587	0.629	0.697	0.750	0.793	0.861	0.914
90	0.270	0.455	0.567	0.649	0.712	0.764	0.847	0.911	0.963	1.046	1.110
95	0.351	0.590	0.738	0.844	0.926	0.994	1.102	1.185	1.253	1.360	1.444
99	0.539	0.907	1.135	1.298	1.423	1.528	1.693	1.821	1.925	2.091	2.219

Table Q3b

4. a) Explain, with the aid of sketch diagrams, why a site investigation needs to extend down to a specific depth below a proposed foundation to ensure that an adequate design is achieved for such a foundation. Students are expected to make reference to stress distribution theory in their explanations and should also comment on why the depth of investigation needs to be different for an infinitely long strip foundation as opposed to a finite sized square pad foundation.

(6 marks)

b) Explain, using detailed principles of soil mechanics, the process of 'consolidation' for a given saturated cohesive soil subject to an increase in loading for a civil engineering structure.
NOTE: Ensure that your answer explains all the 'soil mechanics' terms used and also that your explanation of the process extends right from the time immediately prior to foundation construction and also to a suitable point in time after construction has been completed, outlining the changes in internal state of the soil and the stresses/forces active throughout such process.

(6 marks)

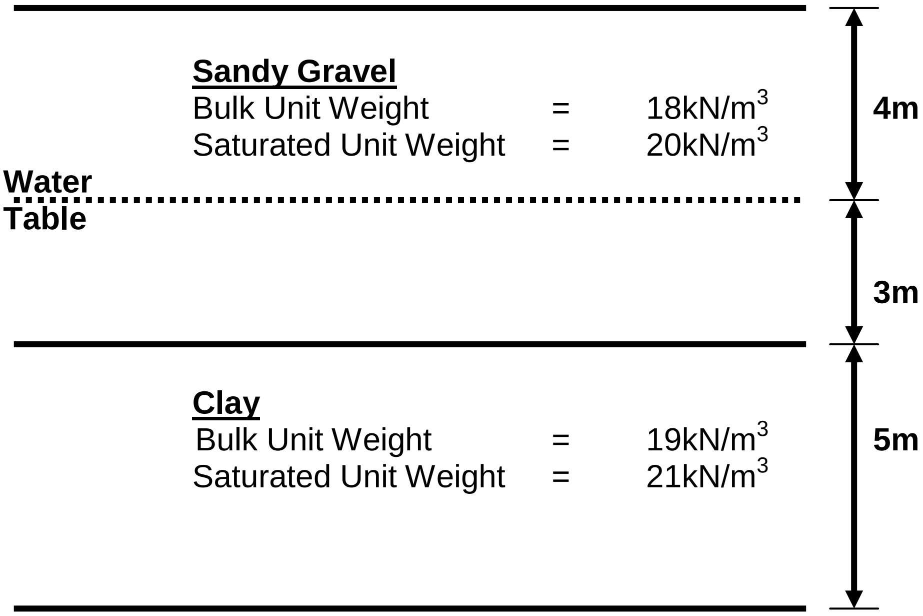
c) Using Figure Q4 c determine the total stress, pore water pressure and effective stress at each strata change and at the location of the water table and hence plot a graph to illustrate their variation with depth from ground surface to a depth of 12m below ground level. The water table is located at a depth of 4m below ground level within a 7m thick deposit of sandy gravel overlying 5m of clay.

(13 marks)

Total 25 marks

Question 4 continued over the page…

Question 4 continued



NOTE: Assume that Unit Weight of Water = 10kN/m^3

Figure Q4c

END OF QUESTIONS

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Formulae

$$\rho_I = \frac{qB}{E_u} \cdot I$$

$$q = \frac{k\,h\,.\,N_f}{N_d}$$

$$\Delta e = \frac{\Delta H}{H} \cdot (1 + e_o)$$

$$m_v = \frac{\Delta e}{\Delta\sigma} \cdot \frac{(1)}{(1 + e_o)}$$

$$\sigma_v = \sigma_v' + u$$

$$\Delta H = m_v\, \Delta\sigma_v'\, H$$

$$\sigma_v = q\, I$$

$R = 0.564\ S$ (square grid)

$(1 - U) = (1 - U_r)(1 - U_v)$

$T_r = (c_h\, t) / (4R^2)$

$T_v = (c_v\, t) / d^2$

END OF PAPER