GLASGOW CALEDONIAN UNIVERSITY

BSc (Hons) Environmental
Civil Engineering

SCHOOL OF THE BUILT AND NATURAL ENVIRONMENT

THIRD YEAR

MAY 2007
SESSION 2006/2007

BNEC311: GROUND ENGINEERING

3 HOURS

Attempt FIVE questions

(ALL questions carry equal marks)

Material Supplied: Manuscript (unlined)
Formulae Sheet
Graph Paper
Relevant Design Graphs
Relevant Design Tables
(making a total of NINE figures)
Q1

A site investigation has been carried out at the proposed location of a cut-and-cover tunnel. The detailed report has described the soil as stiff, heavily overconsolidated clay to depth of 30m, overlying bedrock. The engineer has described that in situ tests are required in the stiff clay to provide reliable estimates of its parameters.

Which tests might you consider using for this purpose if you were limited to only one method, which test would you select irrespective of cost?

Describe how this test would be carried out and explain how the results would be interpreted.

In addition to the above, list all the laboratory tests that are also needed in order to provide reliable information about this clay.

Q2

(a) Describe very briefly the use and operation of the following:
   (i) Standpipe piezometer
   (ii) Settlement gauge
   (iii) Standard penetration test
   (iv) Packer test
   (v) In situ falling-head permeability testing

(b) An undisturbed sample of a clay stratum, 2m thick, was tested in the laboratory and the average value of coefficient of consolidation was found to be $2 \times 10^{-7} \text{m}^2/\text{sec}$. If a structure is built in this clay stratum, how long will it take to attain half the ultimate settlement under the load of the structure? Assume double drainage.
Q3 (a) A square footing of side dimension 3.5m is founded at a depth of 1.5m in sand having the following properties:

\[ c = 0, \quad \varphi = 35^\circ, \]
\[ \gamma_{\text{sand (above Water Table)}} = 18 \text{kN/m}^3, \]
\[ \gamma_{\text{sand (below Water Table)}} = 20 \text{kN/m}^3 \]

Determine the ultimate bearing capacity and the net safe bearing pressure of the footing when the water table is:

(i) at the ground surface
(ii) below the base of the foundation

(8) (7)

Compare the above two cases and give comments on both.
(employ a factor of safety of 3 for bearing)

(b) Describe, very briefly, how consolidation is modelled and obtained in laboratory conditions.

(5)

Q4 (a) State what you understand by the terms:

(i) Normally consolidated clay
(ii) Over consolidated clay

(4)

(b) Determine the value of coefficient of consolidation of the clay layer for which a consolidation laboratory test (during an increment of pressure) yielded the following results.
(The initial thickness of the clay specimen under no load was 19mm):

<table>
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<th>Time from start of loading (minutes)</th>
<th>0</th>
<th>0.25</th>
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(16)
Q5 (a) Explain what is meant by negative skin friction and how it affects the load capacity of piles.

(b) A bored pile of total length 9m and diameter 900mm is to be installed in a cohesive soil deposit made up of three clay layers each thickness with the bottom tip of the pile resting on a deposit of firm clay having an undrained shear strength of 80 kN/m². Taking the following values of shear parameters for the cohesive soils, and assuming water table to be away from the proposed pile, determine the ultimate load capacity of this pile.

Assume a factor of safety of 2.5

Base bearing factor Ne = 9.0

Adhesion factor α = 0.33

Clay layer 1: \( C_s = 10 \text{kN/m}^2 \) \( \varphi_s = 0 \)
Clay layer 2: \( C_s = 20 \text{kN/m}^2 \) \( \varphi_s = 0 \)
Clay layer 3: \( C_s = 30 \text{kN/m}^2 \) \( \varphi_s = 0 \)

(Assume “negative skin friction” to be negligible)
Q6 (a) For the footing shown in Figure Q6 (a) below calculate the decrease in vertical stress at 3m, 5m and 10m beneath the point A shown on the footing plan. Assume intensity of load on the area as 100 kN/m²

\[ \text{(15)} \]

\[ \text{(NOT TO SCALE)} \]

\[ \text{Figure Q6 (a)} \]

(b) A cutting in cohesive soil has a slope angle of 35° and a vertical height of 10m. Using Taylor’s stability method determine the factor of safety against shear failure for the case:

\[ C_s = 40 \, \text{kN/m}^2 \quad \varphi_v = 0 \quad \gamma = 18 \, \text{kN/m}^3 \quad D = 2\text{m} \]

\[ \text{(5)} \]
A rectangular foundation 1.5m x 3.5m is to be found at a depth of 0.7m below the surface of a deep stratum of soft saturated clay having a unit weight of 18.5kN/m$^3$.

Undrained and drained shear strength tests establish the following soil parameters:

(a) $\varphi_u = 0^\circ$, \hspace{1cm} $c_u = 25$ kN/m$^2$

(b) $\varphi_u = 30^\circ$, \hspace{1cm} $c = 0$

Determine the ultimate bearing capacity of the foundation using Terzaghi’s formula (i) immediately after construction and (ii) some years after construction, explaining any differences from the result obtained from part (a) above. (30)

End of Paper
\[ q_a = cN_c + \gamma Z N_q + 0.5 \gamma B N_y \]
\[ q_n = 1.3cN_c + \gamma Z N_q + 0.4 \gamma B N \gamma \]
\[ q_s = cN_c (1 + 0.3 \frac{B}{L}) + \gamma Z N_q + 0.5 \gamma B N (1 - 0.2 \frac{B}{L}) \] - rectangular
\[ q_{net} = cN_c + \gamma Z (N_q - 1) + 0.5 \gamma B N \gamma \]
\[ F = \frac{C_r}{\gamma A_N} \quad F = \frac{\tan \phi'}{\tan \beta} \]
\[ F = \frac{m - m}{\gamma} \quad F = \frac{\gamma' \tan \phi}{\gamma \tan \beta} \]
\[ Q_{c, \text{outlet}} = Q_h + Q_s \quad Q_{c, \text{outlet}} = Q_h + Q_s \]
\[ Q_h = N_c A_b \quad Q_s = \sigma'_{ab} N_q A_b \]
\[ Q_s = \sigma'_{ab} A_s \quad Q_s = A_c \sigma_{ab} K_c \tan \delta \]
\[ S_a = \frac{m v A_0'}{H} \quad S_a = \frac{qB}{E} \cdot (1 - v') \gamma \]
\[ S_b = \frac{e_s - e_i}{1 + e_s} \quad S_{\text{TOTAL}} = S_a \quad S_b \]
\[ C_c = \frac{e_s - e_i}{\log(\sigma_i / \sigma_s)} \quad c = \text{wGs} \]
\[ N_{\text{corr}} = 15 + \frac{1}{2} (N - 15) \quad m_c = \frac{1}{1 + e_s} \frac{d e}{d p} \]
\[ \sigma_2 = \sigma_{fr} \quad T = \frac{C_s t}{H^2} \]
\[ K_s = \frac{1 - \sin \phi}{1 + \sin \phi} \quad K_a = \frac{1}{K_s} \]

Effective width (Meyerhof) = \[ B - 2e \quad F = \frac{1}{\Sigma W \sin \alpha} \left( \frac{c' b + W (1 - r_c) \tan \phi \sec \alpha}{1 + \tan \phi \tan \beta} \right) \]
### Bearing capacity factors

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<th>No</th>
<th>Ng</th>
<th>φ</th>
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Values of Nc after Prandtl
Nc after Reissner
Nc after Hansen

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F1
For a rectangular footing of longer side L

\[ N_c (rectangle) = \left[ 0.84 + 0.16 \frac{B}{L} \right] N_c (square) \]
Estimation of $N'$ from the test value $N$ (after Thorburn, 1963).
\( \left( \sigma_z = \frac{Q}{2z} I_p \right) \) Boussinesq's influence factor for a point load

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<th>( r/z )</th>
<th>( I_p )</th>
<th>( r/z )</th>
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