UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:-

B.Eng. *M.Eng.* *M.Sc.*

Civil Eng 2004: Soil Mechanics part II

COURSE CODE	:	**CIVL2004**
UNIT VALUE	:	**0.50**
DATE	:	**13-MAY-05**
TIME	:	**10.00**
TIME ALLOWED	:	**3 Hours**

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CIVL2004 SOIL MECHANICS II
Second Year B.Eng./M.Eng. Degree
2005 Examination

3 HOURS

*Answer 4 **QUESTIONS** only. All questions carry 25 marks.*

Q1. (a) Define undrained shear strength. Using the assumptions made in the Critical State framework that the critical state locus for clays is defined by:

$v = \Gamma - \lambda.\ln p'$

$q' = M.p'$

where p' and q' are the triaxial invariants and v is the specific volume, derive an expression for the undrained shear strength as a function of water content.

[10 marks]

(b) A site is investigated for the construction of a building. Initial studies show that the ground is made of 20m of soft becoming stiff clay, overlying gravel. The water table is at the ground surface. A number of disturbed samples were recovered from the site at different depths to determine the index properties of the soil. The samples were sealed immediately after they were taken from the ground in order to keep the water content intact. Water contents determined from the samples are summarised in Figure Q1.1. In addition, a good quality sample was retrieved from a depth of 3.3m and taken back to the laboratory for testing in a triaxial apparatus. Results from the tests give the following values for the soil parameters: $\lambda = 0.09$, $N = 2.93$, $\Gamma = 2.87$, $M = 1.0$. The value of specific gravity G_s is equal to 2.7.
Using the correlation between undrained shear strength and water content derived in (a), draw the profile of undrained shear strength with depth. You will draw the plot on the sheet of graph paper provided.

[7 marks]

(c) The building is to be 10m by 10m, and weigh 40MN. The initial proposal for foundations is four strip foundations. Detail of a strip foundation is shown in Figure Q1.2. Based on the values of undrained shear strength calculated in (b) demonstrate that if a factor of safety of 2 is to be applied to the strength the bearing capacity of the clay will not be enough to carry the load. You will assume the same unit weights for the soil and concrete.

[8 marks]

Figures Q1.1.and Q1.2 are attached at the end of the paper.

Q2. (a) Explain what is meant by isotropic compression and by one-dimensional compression. Sketch diagrams using v-lnp' and q'-p' axes to illustrate the relative positions of the isotropic and one-dimensional normal compression lines relative to the critical state line. Where possible give practical examples to illustrate each type of compression and hence identify which you believe to be more commonly relevant to geotechnical design.

[7 marks]

TURN OVER

Question Q2 continues.

(b) Data shown in Table Q2.1 were obtained for isotropic compression and swelling of a specimen of soft clay. The initial water content of the soil was 52%. Calculate the values of the parameters N, λ and κ for this soil.

[11 marks]

(c) What would be the specific volume of a specimen of the same soil subjected to a vertical effective stress of 300kPa under one-dimensional compression?

[7 marks]

The value of G_s is 2.7 and the value of K_0 for the normally consolidated clay is 0.5. The spacing of the isotropic and one-dimensional compression lines in v-lnp' space (i.e. N-N_0) may be assumed to be 0.100. Table Q2.1 is attached at the end of the paper.

Q3. (a) (i) Sketch the standard oedometer test apparatus

(ii) Explain what are isochrones. Sketch their shape and the changes that take place during a consolidation test.

[6 marks]

(b) A 5m high embankment is constructed over a large lateral area to protect a site from flooding. The embankment is built with compacted fill of unit weight 21.5kN/m^3. The site consists of 5m of saturated silt with unit weight 19kN/m^3 overlying 4m of normally consolidated clay having a unit weight of 17.7kN/m^3. The clay overlies bedrock (Figure Q3.1). The water table is at 3m above the top of the clay.

Calculate the component of settlement due to the compression of the silt for which m_v is 2.5 x 10^{-5} m^2/kN and is constant throughout the layer.

[2 marks]

(c) Calculate the component of settlement due to the compression of the clay by using the oedometer test results obtained from testing the clay and shown in Figure Q3.2.

[9 marks]

(d) If the fill was to be removed determine the heave of the ground assuming the expansion of the silt to be negligible.

[7 marks]

Figures Q3.1 and Q3.2 are attached at the end of the paper.

Q4. A four-storey building is to be constructed in London clay. A group of bored piles, of which the geometry is shown in Figure Q4.1, will provide the foundation. Undrained shear strengths determined from laboratory tests on samples retrieved during the site investigation are given in Table Q4.1.

(a) Calculate the required depth of the piles for the required capacity of 9.5MN, using an undrained approach (α-method) to calculate the shaft friction. The end bearing capacity will be calculated using an undrained approach with a value of N_c equal to 9.

[10 marks]

CONTINUED

Question Q4 continues

(b) Calculate the required depth of the piles for the required capacity (9.5MN), using an effective stress approach (β-method) to calculate the shaft friction. The end bearing capacity will be calculated using an undrained approach with a value of N_c equal to 9. A value of 0.4 will be used for β.

[10 marks]

(c) Based on your two results obtained in (a) and (b), draw a sketch of what would be your recommendation for the piled foundation.

[5 marks]

Figure Q4.1 and Table Q4.1 are attached at the end of the paper.

Q5. (a) State the upper bound theorem.

[3 marks]

(b) Derive simple upper and lower bounds for the maximum depth to which a trench with vertical sides may be rapidly excavated in saturated soil.

[7 marks]

(c) Taking the average of these upper and lower bounds, calculate the factor of safety immediately after construction of a trench with vertical sides cut to a depth of 3m in soil with γ=20kN/m^3 and S_u=40kN/m^2.

[5 marks]

(d) If the trench is kept filled with water during construction, what is the factor of safety?

[10 marks]

Q6. A flexible square footing, 5m wide, applies a stress of 100kPa to a very deep layer of clay. The shear modulus G of the clay has been determined as 20MPa.

(a) Draw a profile of the immediate settlement for a section running from the centre of the footing diagonally to one corner of the square.

[18 marks]

(b) What is the area of most serious differential settlement? You will justify your answer.

[7 marks]

Relevant tables and charts for the influence factors are given in the Appendix.

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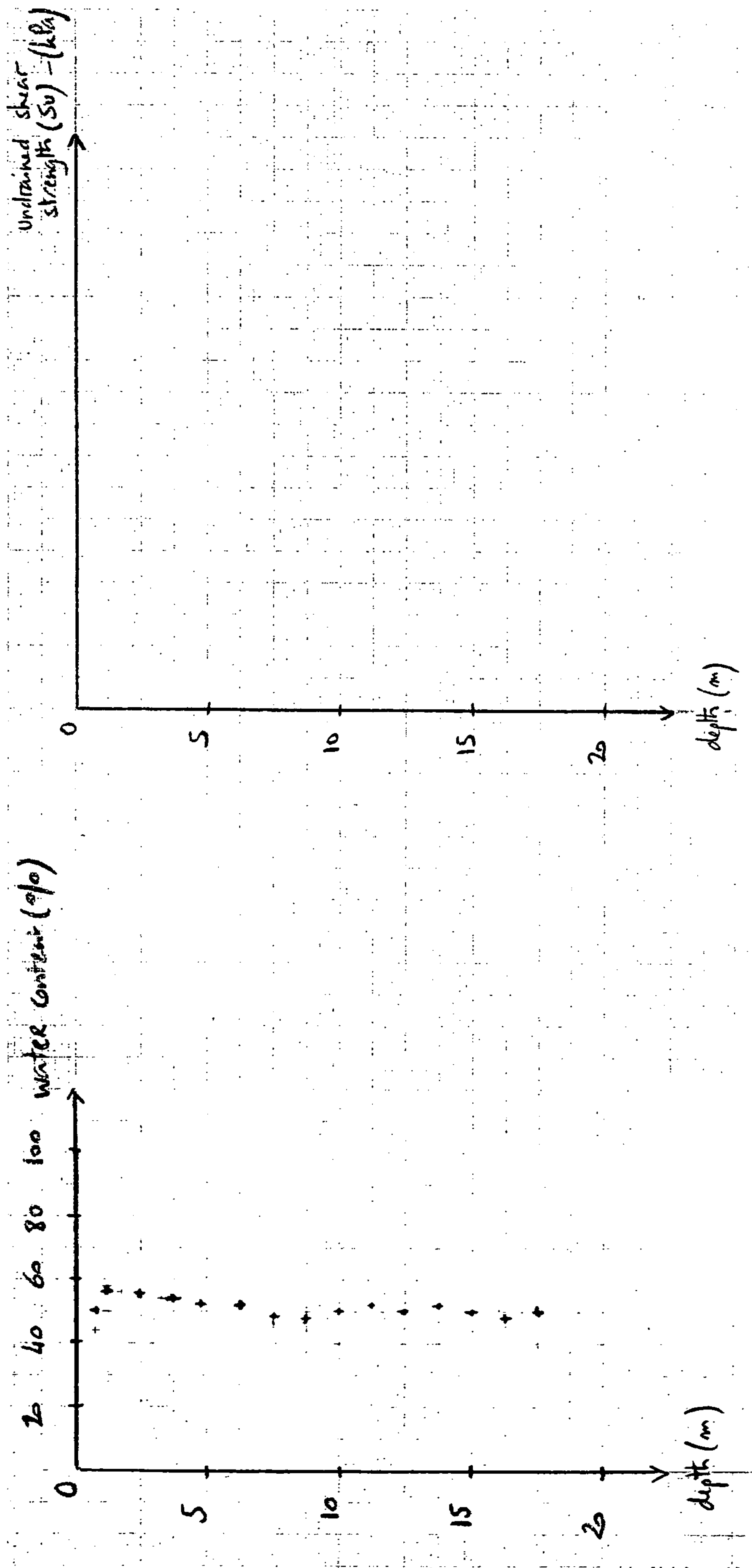

FIGURE Q1.1

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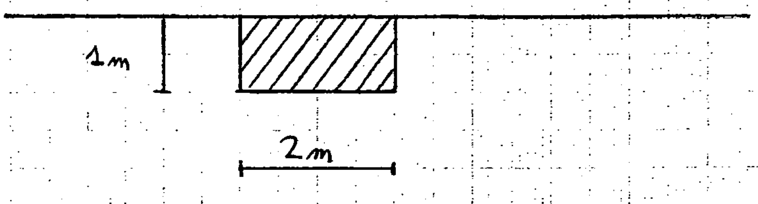

FIGURE Q1.2

p' (kPa)	ε_v (%)
100	1.03
200	5.50
400	9.89
800	13.78
400	12.56

TABLE Q2.1

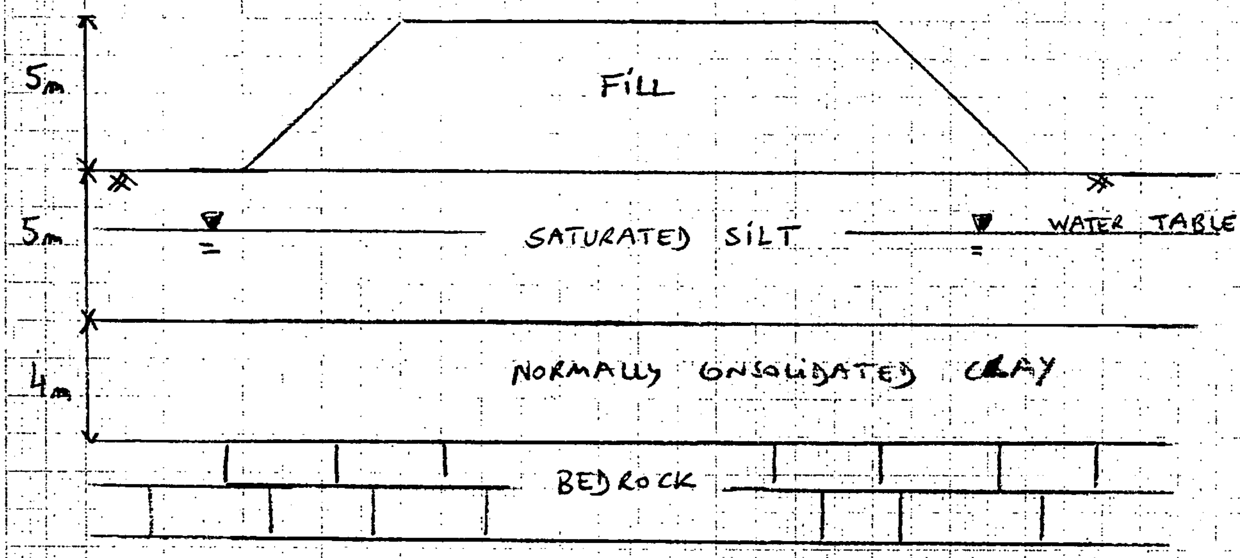

FIGURE Q3·1

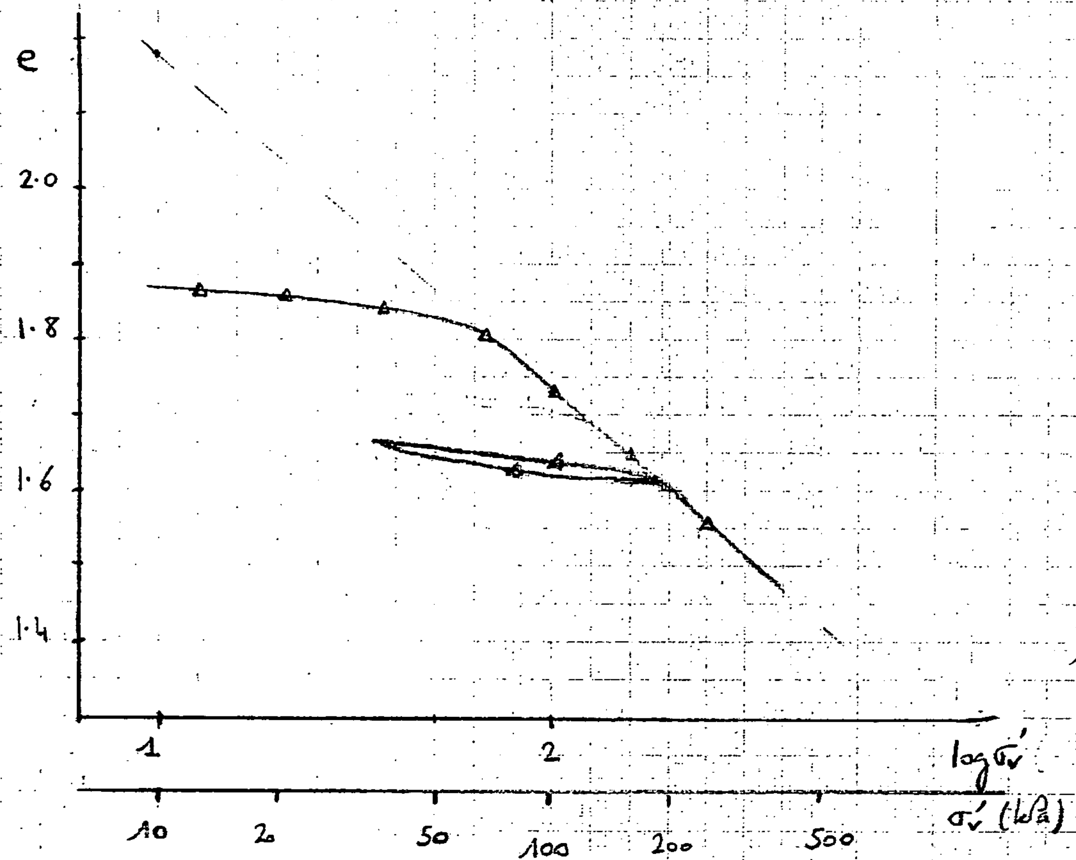

FIGURE Q3·2

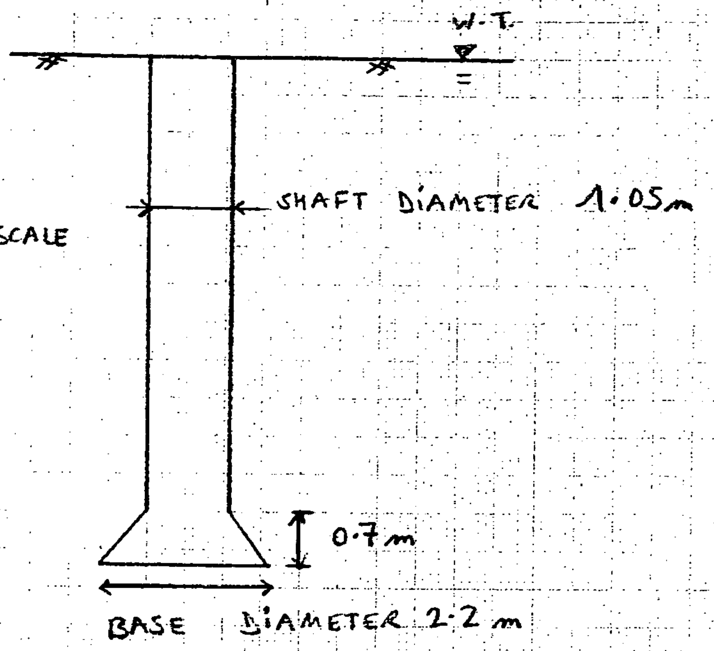

FIGURE 4·1

depth (m)	undrained shear strength S_u (kPa)
3.9	99
7.1	101
9.8	103
12.9	148
16.1	151
20.5	149
25.4	153

TABLE Q4·1

Rectangular loading: corner settlement

L/B	I_ρ	L/B	I_ρ	L/B	I_ρ	L/B	I_ρ
1	0.561	1.6	0.698	2.4	0.822	5	1.052
1.1	0.588	1.7	0.716	2.5	0.835	6	1.11
1.2	0.613	1.8	0.734	3	0.892	7	1.159
1.3	0.636	1.9	0.75	3.5	0.94	8	1.201
1.4	0.658	2	0.766	4	0.982	9	1.239
1.5	0.679	2.2	0.795	4.5	1.019	10	1.272

Stress distribution beneath the corner of a foundation

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