GX505

OLLSCOIL NA hÉIREANN, GAILLIMH

NATIONAL UNIVERSITY OF IRELAND, GALWAY

SECOND SEMESTER EXAMINATIONS, 2000

B.E. DEGREE EXAMINATION

SOIL MECHANICS

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Time allowed: *Three hours.*

Attempt a minimum of *five* questions.

Question 1

a) Two saturated soil samples A and B were subjected to an isotropic normal consolidation at a mean effective normal stress of 250 kPa. Both specimens were then axially loaded in triaxial compression tests at a constant cell pressure. Specimen A was loaded in the drained state and specimen B in an undrained state. Calculate the deviator stress, q, the mean effective normal stress, p' and the specific volume, v, at failure if the critical state parameters of the soil were: M = 0.85; N = 2.85; $\lambda = 0.15$; $\kappa = 0.03$ and $\Gamma = 2.65$. Sketch the normal effective stress paths for both the drained and undrained tests. **(10 marks)**

b) Describe a method of determining the failure surface of dense or heavily over consolidated soils. **(2 marks)**

c) Show that for a cylindrical triaxial specimen the total work input is given by:

$$\delta W = p'\delta\varepsilon_p + q\delta\varepsilon_q$$

where p' is the mean effective normal stress, q is the deviator stress, $\delta\varepsilon_p$ is the volumetric strain and $\delta\varepsilon_q$ is the tri shear strain. **(8 marks)**

Question 2

A landslip has occurred along a slip surface parallel to the slope of the ground and inclined at an angle of 13° to the horizontal. The slip surface is at a depth of 5 m below ground surface. The water table is assumed to be at the ground surface and the water flow in the soil prior to the slip was parallel to the slope. The saturated bulk weight of the soil is 15 kN/m^3. If the value of the effective stress parameter, c′, is assumed to be zero, calculate the value of the angle of internal resistance, ϕ', compatible with limiting equilibrium for the slide described above. Calculate the factor of safety if the water table is lowered to 3 m below ground surface. Derive any equations used. **(20 marks)**

Question 3

a) Describe briefly five methods of embankment construction on soft soils. List necessary data required for the design, the constraints, the reliability and the relative cost of each method. **(8 marks)**

b) In a consolidation test on a saturated clay specimen the following readings were obtained after an increment of loading has been applied:

Time (min)	0	1	4	9	16	25	36	49	64	81	100
Settlement (mm x 10^{-2})	0	30	50	70	80	88	94	99	103	106	107

If the average thickness of the specimen is 18.50 mm, find the coefficient of primary consolidation. The stratum of clay from which the specimen is taken is 10 m thick. The clay has a hard permeable stratum above it and an impermeable layer below it. It is estimated that the construction of a building will subject the stratum of soil to the same average increment of stress as used in the test. Calculate the magnitude of primary settlement due to the load increment and the time taken for the building to reach 60% of its settlement given that the time factor $T_{60} = 0.287$. **(10 marks)**

c) If the structure is founded 2m below the surface of the clay, estimate an undrained safe bearing capacity of the clay if its average undrained shear

strength is 45 kPa, the bulk weight of the soil, γ, is 20 kN/m^3 and the N_c factor of 7. **(2 marks)**

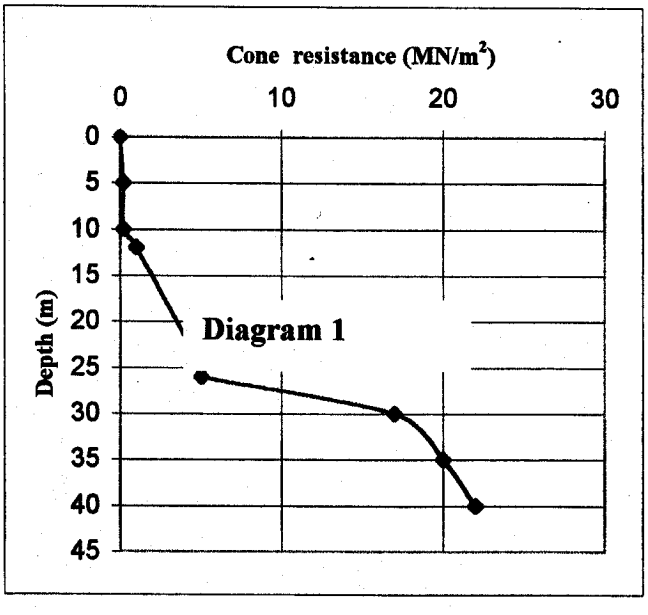
Note: The following equation may be useful: $q_{ult} = S_u \cdot N_c + \gamma \cdot D$ where q_{ult} is the ultimate bearing pressure, S_u is the undrained shear strength, N_c is a bearing capacity factor, γ is the unit weight of the soil and D is the depth of the foundation below the ground surface.

Question 4

a) Describe briefly the dynamic and static test for piles. Mention the equipment used, how the test is conducted, relative costs and typical results obtained from the test. **(10 marks)**

b) A single pile carries a working load of 900 kN on a site where boring and piezocone results are available. It is proposed to compare the use of a driven and cast in-situ pile using 25C concrete and an enlarged base of 600 mm with a 508mm diameter closed-ended tubular steel pile at a depth of 26m. Previous tests have shown the ultimate base resistance of the pile in the dense sand stratum to be equal to the piezocone test. The piles are to be terminated in this stratum. The factor of safety is 2.5. Ignore the friction down to 12 metres. Use a skin friction coefficient for the piezocone results of 0.012. **(10 marks)**

Depth (m)	Cone resistance (MN/m^2)
0	0
5	0.2
10	0.2
12	1
25	5
26	5
30	17
35	20
40	22



Question 5

a) A piled embankment consists of a series of piles whose pile caps cover approximately 12~25% of the base area. Describe briefly the arching mechanism that occurs in the fill placed over the embankment and the role of the geotextile placed over the pile caps and soft soil. **(6 marks)**

b) A 7 m high retaining wall is to be constructed using two types of geotextile, G15 and G30, which have a design strength of 15 and 30 kN/m respectively. The grids are connected to wall units at 0.5 m intervals and are subjected to a live load of 10 kN/m^2. The wall fill has a bulk weight of 20 kN/m^3 and an effective shearing angle of 35° and the backfill has a bulk weight of 18 kN/m^3 and an effective shearing angle of 30°. Both materials are cohesionless. Determine the length of grid needed and check the wall for sliding resistance. Establish where the G30 grid may be replaced by the G15 grid and carry out a wedge check on the wall at a depth of 2m from the top of the wall. Take the factor of safety of 2, the coefficient of friction, μ, as 0.5 and α, the interaction coefficient between the grid and the fill, as 0.9. **(14 marks)**

Note: the following expressions may be useful.

$$\sigma_v = \frac{\gamma_f h_i + w}{1 - \dfrac{K_{ab}\left(\gamma_b h_i + 3w\right)\left(\dfrac{h_i}{L}\right)^2}{3\left(\gamma_f h_i + w\right)}},$$

where σ_v is the vertical stress, γ_f is the bulk weight of the wall fill, γ_b is the bulk weight of back fill, h_i is the height of soil above the i^{th} grid layer, w is the live load and K_{ab} is coefficient of active earth pressure for the backfill

$$T_{ai} = \frac{L_{ip} \cdot 2\alpha \tan\phi'_f \gamma_f h_i}{factor\ of\ safety}$$

where L_{ip} is the length of the ith grid beyond the potential failure plane, α is the grid/fill interaction coefficient and ϕ'_f is the effective shearing angle of the fill.

Question 6

a) For two dimensional steady state flow of water in an anistropic soil, prove that:

$$k_x \delta^2 h/\delta x^2 + k_y \delta^2 h/\delta y^2 = 0$$

where k_x and k_y are the coefficients of permeability in the x and y directions respectively and h is the head of water. **(6 marks)**

b) A vertical sheet pile extends 6m into a horizontal top soil stratum of permeable material 10 m thick over lying impermeable bedrock. The depth of water at the back of the wall is 10 m above the stratum surface and at the front of the wall is 1m above the stratum surface.

The soil is isotropic and has a permeability of 10^{-6} m/s. Draw the flow net, do one relaxation process on the node values, estimate the steady seepage under the pile and plot the pore water pressure on the back of the sheet pile. **(14 marks)**

Question 7

a) Describe with the aid of sketches the procedure for carrying out a consolidated undrained compression triaxial test on a soil specimen. Distinguish between an isotropic tests and a K_0 test. Write down a typical value of the pore water pressure, A_f, for a normally consolidated soil. What use is made of the pore water pressure parameter B? **(10 marks)**

b) A saturated clay specimen was placed in a triaxial cell with a cell pressure of 200 kPa. The specimen was loaded axially in compression in an undrained test and the maximum observed deviator stress was 50 kPa. If the effective shear strength parameters of the clay were $c' = 10$ kPa and $\phi' = 30°$, find the value of excess pore water pressure generated if the initial pore water pressure was 150 kPa. What was the magnitude of the pore water pressure ratio A_f and the stress history of the clay? **(10 marks)**

Question 8

a) Write concise notes on the SPT and piezocone test. Give a brief description of each instrument, how they are operated and the parameters obtained from the results. Why do the results need to be corrected in each instance? **(10 marks)**

b) A rectangular footing 10m×40m is constructed 3 m below ground surface. The soil stratification under the footing consists of 10 m of soil with a Young's modulus, E, of 20 MN/m^2 and a further 5 m of soil with a Young's modulus of 30 MN/m^2. The footing carries a uniformly distributed load of 50 kN/m^2. Calculate the total settlement in the two soil strata. **(10 marks)**

Note: the following equation is useful: $\delta = \frac{qB\mu_0\mu_1}{E}$ where δ is the settlement in a soil layer, B is the breadth of the footing and μ_0 and μ_1 are influence factors obtained from diagram 2.

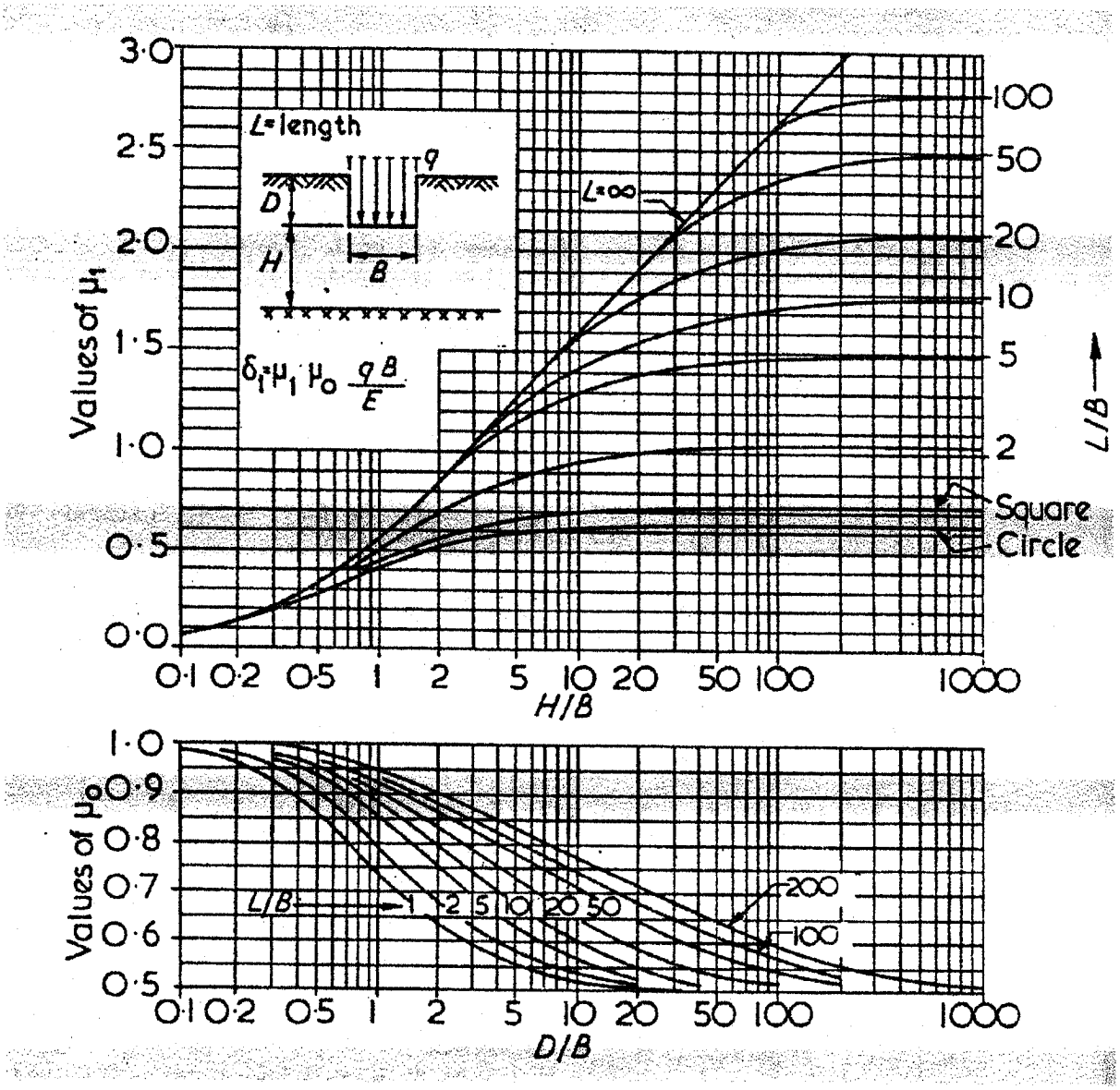

L=length
q
D
H
B
$\delta_i = \mu_1 \mu_0 \frac{qB}{E}$
Values of μ_1
3·0
2·5
2·0
1·5
1·0
0·5
0·0
L=∞
100
50
20
10
5
2
L/B
Square
Circle
0·1 0·2 0·5 1 2 5 10 20 50 100 1000
H/B
Values of μ_0
1·0
0·9
0·8
0·7
0·6
0·5
L/B
1 2 5 10 20 50
200
100
0·1 0·2 0·5 1 2 5 10 20 50 100 1000
D/B

Diagram 2