GX502

OLLSCOIL NA hÉIREANN, GAILLIMH

NATIONAL UNIVERSITY OF IRELAND, GALWAY

SECOND SEMESTER EXAMINATIONS, 1999

B.E. DEGREE EXAMINATION

SOIL MECHANICS

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Time allowed: *Three* hours.
Attempt *five* questions.

1. (i) Describe, with the aid of sketches, the procedure for carrying out isotropic consolidated undrained and drained compression triaxial tests on saturated soil specimens. Write down a typical value of the pore pressure parameter, A_f, for a normally consolidated sensitive soil. What use is made of the pore water pressure parameter B? (8 marks)

   (ii) The following values were calculated for the axial loading stage of an isotropic consolidated undrained triaxial compression test on a saturated soil specimen:

$(\sigma_1-\sigma_3)/2$ (kN/m^2)	0	30	50	80	90	100
$(\sigma_1'+\sigma_3')/2$ (kN/m^2)	300	290	280	260	240	200

   where σ_1 and σ_3 are principal total stresses, and σ_1' and σ_3' are principal effective stresses. The cell pressure was maintained at 400 kN/m^2 during the test. What are the values of the pore water pressure measured during the test. Plot an effective stress path for the test results. Calculate A_f. Is the soil overconsolidated or normally consolidated? If it is possible, calculate a value for the effective stress parameter, ϕ'. (12 marks)

2. (i) For two-dimensional steady state flow of water in an anisotropic soil, prove that

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

   where k_x and k_y are coefficients of permeability in the x and y directions respectively, and h is the head of water. (8 marks)

   (ii) A concrete dam rests on a 16 m deep horizontal stratum of soil. The dam, which has a base width of 32 m, retains water to a height of 8 m. A cut-off wall of sheet piling is driven into the soil to a depth of 8 m at the upstream face of the dam. Downstream of the dam, the water-table is at the ground surface of the soil. The soil has coefficients of permeability of 8×10^{-6} m/s and 2×10^{-6} m/s in the horizontal and vertical directions respectively. Calculate the seepage loss per metre length of the dam. Plot the water pressure distribution at the front and back of the sheet pile wall and underneath the dam. (12 marks)

3. (i) Using the Fellenius method of slices for circular slip analysis, determine a safety factor expression, in terms of effective stress, for the stability of a slope. State clearly the assumptions made. (8 marks)

(ii) A constructed embankment is 6.0 m high. It has side slopes of 1 vertical to 1.5 horizontal. An assumed circular failure surface has a radius of 9 m; the circle centre of the failure surface is at a level of 9 m above the original horizontal ground surface and is 2.5 m horizontally in from the toe of the embankment on the embankment side. The unit weight of the soil is 20 kN/m^3 and the shear strength effective stress parameters are c' = 10 kN/m^2 and $\phi' = 33^0$. The pore water pressure ratio for the soil can be taken as 0.5. Determine the factor of safety for the assumed failure surface using a method of slices. (12 marks)

4.(i) Describe with the aid of neat sketches how you would obtain the following parameters for a saturated soil:

(a) the preconsolidation pressure;
(b) the coefficient of secondary consolidation; and
(c) the coefficient of primary consolidation.

Discuss the significance of the preconsolidation pressure in relation to the drainage and strength characteristics of the soil. (8 marks)

(ii) In a consolidation test on a saturated clay specimen, the following readings were obtained after an increment of loading had 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 during consolidation under the increment of load was 18.50 mm, find the coefficient of primary consolidation. The stratum of saturated clay from which the specimen was 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 clay 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 this settlement given that the time factor T_{60}= 0.287. (12 marks)

5. (i) Explain, using diagrams, the importance of using a drainage system behind a retaining wall when the original water-table in the retained soil is at ground surface. Use a sloping drainage system to illustrate your answer. (6 marks)

(ii) Show how you would design a reinforced earth wall of height 10 m to carry a surcharge of 60 kPa. The allowable stress in the reinforcing elements is 120 N/mm^2. The unit weight of the granular fill is 20 kN/m^3. The effective shear strength parameter ϕ' for the fill is 30^0. Illustrate how you would check for sliding, bearing capacity and rotational slip failures. State any assumptions you make. (14 marks)

6. (i) Prove that the specific volume, v, of a saturated soil can be given by the following expression:

$$v = \frac{1+w}{1+w-w(\gamma/\gamma_w)}$$

where w is the moisture content and γ and γ_w are the unit weights of the soil and water respectively. (6 marks)

(ii) Two specimens of saturated soil A and B were subjected to isotropic normal consolidation at a mean normal effective stress of 300 kPa. Both specimens were then axially loaded in triaxial compression tests with constant cell pressure. Specimen A was loaded in a drained state and specimen B in an undrained state. Calculate the values of the deviator stress, q, the mean normal effective stress, p' and the specific volume, v, at failure if the critical state parameters of the soil were: $M = 0.80$; $N = 2.80$; $\lambda = 0.12$; $\kappa = 0.03$ and $\Gamma = 2.60$. Sketch the effective stress paths for both the consolidation and axial loading stages. (12 marks)

(iii) How can you establish whether the behaviour of a soil is likely to be elastic or not when you know the values of q, p' and v? (2 marks)

7. A sheet pile wall is to be used to retain sand to a depth of 6 m. The sand has a bulk unit weight of 18 kN/m^3, an angle of internal resistance, ϕ', of 30^0 and its surface is level with the top of the piles. Design a suitable arrangement for:

(i) a cantilever sheet pile construction; and
(ii) an anchored sheet pile construction where the anchor tie-rods are 1.4 m below the top sand surface and are spaced 2.5 m apart horizontally along the sheet pile wall.
List any assumptions made and calculate the proportion of the possible passive resistance that is mobilised on the embedded length of the sheet piling for both constructions. (20 marks)

8. (i) Describe briefly three types of driven piles and three types of bored piles; discuss the advantages and disadvantages of driven and bored piles. (8 marks)

(ii) A 0.5 m diameter pile is driven to a depth of 12 m into a surface layer of clay 20 m deep. The water table and the top of the pile are at ground surface. Corrected piezocone end resistance readings, qt, varied linearly from 2000 kN/m^2 at the ground surface to 5000 kN/m^2 at the bottom of the soil layer. The average friction on the piezocone sleeve was 250 kN/m^2. The cone resistance factor for the clay, N_{kt}, which is defined as:

$$N_{kt}=(q_t-\sigma_{vo})/s_u$$

has a value of 16 and σ_{vo} and s_u are the total overburden pressure and undrained shear strength respectively. The clay has a unit weight of 18 kN/m^3. Determine the ultimate bearing capacity of the pile.
For the same pile dimensions and soil arrangement, determine the ultimate bearing capacity of a square group of 25 piles spaced on a grid with 1.0 m centres. What is the efficiency of the pile group? Explain any assumptions you make. (12 marks)