Version SAS/3

EGT2
ENGINEERING TRIPOS PART IIA

Wednesday 4 May 2022 9.30 to 11.10

Module 3D1

GEOTECHNICAL ENGINEERING I

Answer not more than ***three*** *questions.*

All questions carry the same number of marks.

The ***approximate*** *percentage of marks allocated to each part of a question is indicated in the right margin.*

Write your candidate number ***not*** *your name on the cover sheet.*

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
Engineering Data Book
CUED approved calculator allowed
3D1 & 3D2: Geotechnical Engineering Data Book (21 pages)

10 minutes reading time is allowed for this paper at the start of the exam.

You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.

You may not remove any stationery from the Examination Room.

1 (a) Derive a relationship between the bulk unit weight of soil γ_b, the specific gravity of soil grains G_s, the void ratio e, unit weight of water γ_w and the degree of saturation S_r. [10%]

(b) Define the plasticity index of soil. What type of soil behaviour would you expect if the plasticity index of a soil is small? [10%]

(c) A fill material was identified at a site that can be used to construct an embankment. When a 0.32 kg sample of the soil from this site was added to 100 ml of water in a measuring jar, the volume increased to 220 ml. Determine the specific gravity of the soil grains. [10%]

(d) The above fill material was subjected to a standard Proctor test. A standard Proctor mould has an internal diameter of 101.6 mm and a height of 116.4 mm. The results in Table 1 were obtained when the soil sample was tested at different water contents. Estimate the optimum moisture content (OMC) and the maximum dry density (MDD) for this material. Explain from a micro-mechanical perspective, why the dry density of the material decreases on either side of the OMC. [40%]

(e) What is a zero air voids line? Estimate the position of this line and plot it on the same graph you drew in part (d). [10%]

(f) Instead of using a standard Proctor test, if you used a modified Proctor test would you get the same OMC and MDD? Which of these tests would you recommend to a contractor building an earth dam with this material? Explain why. [20%]

Table 1

Water content %	6	8	10	12	14	16	18
Sample mass (kg)	1.600	1.745	1.830	1.850	1.770	1.600	1.420

2 A building is constructed on clay between two existing adjacent buildings that apply a surcharge q_0 to either side of the new building. In an attempt to limit the influence of the new building on the existing buildings, greased sheet pile walls (i.e. a strength-less interface) with length equal to the foundation width B are installed at the edges of the new foundation.

(a) Derive an expression for the simplest possible lower bound collapse pressure q_f involving no more than two stress discontinuities. Include a diagram indicating the principal stress orientations and an illustration of the Mohr's circles representing the equilibrium state of stress. [25%]

(b) Derive an expression for an upper bound collapse pressure q_f assuming that a Prandtl stress field is generated at the base of the greased sheet pile wall. Include a diagram of the assumed failure mechanism and a corresponding displacement diagram. [50%]

(c) Comment on the influence the surcharge term has on both the lower and upper bound collapse pressures. [10%]

(d) Comment on the difference between the lower and upper bound collapse pressures. State two ways by which the difference could be minimised. [15%]

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3 A rigid square foundation with width B of 5 m is founded on the surface of a 20 m deep bed of uniform clay overlying impermeable rock and a 5 MN vertical load is applied. The clay has a Young's modulus of 20 MPa, coefficient of consolidation c_v of 20 $\mathrm{m}^2\ \mathrm{year}^{-1}$ and permeability k of $10^{-9}\ \mathrm{m\ s^{-1}}$.

(a) Using the chart given in Fig. 1 in conjunction with the following expression:

$$w_{avg} = \mu_0 \mu_1 \frac{qB}{E}$$

where μ_0 and μ_0 are coefficients, q is the bearing pressure, B is the foundation width and E is Young's modulus, estimate the immediate elastic settlement. [20%]

(b) Estimate the consolidation settlement after 2 years using a one-dimensional parabolic isochrone approximation. [40%]

(c) Calculate the percentage total settlement (ignoring the influence of creep). [20%]

(d) State two techniques that could be utilised to accelerate the settlement process and briefly explain why they would be effective. [10%]

(e) Comment on the accuracy of using the one-dimensional parabolic isochrone consolidation solution to estimate the settlement due to consolidation in part (b), specifically with respect to the assumed drainage path length. Is the settlement calculated to have occurred after 2 years likely to be an under or overestimate? [10%]

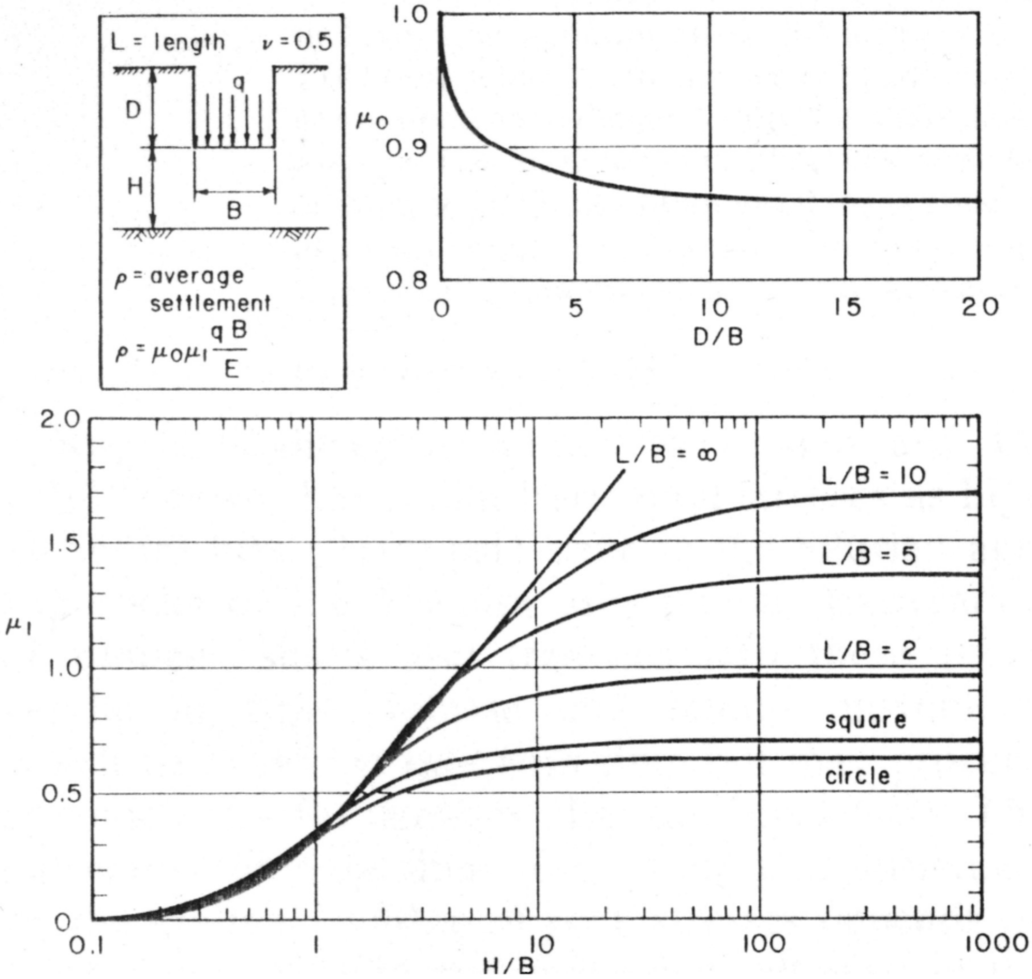

Fig. 1

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4 An electricity pylon with a weight of 200 kN is supported by a square foundation at each of its four corners, which are oriented in a 10 m by 10 m grid. The foundations have width B of 2 m, and are embedded to a depth of 0.25 m in sand with friction angle ϕ of 35° and total unit weight γ of 20 kN m^{-3}. The manufacturer requires that the foundations be able to resist a horizontal load of 25 kN applied to the tip of the pylon, which is at a height of 20 m above ground level.

(a) Calculate the ultimate vertical bearing capacity of the four corner foundations. Use the relationships recommended by Eurocode 7 for the bearing capacity and relevant modification factors. [40%]

(b) Assuming that the corner foundations are attached to the pylon with frictionless ball joints, estimate the factor of safety against failure due to the application of the manufacturer specified design horizontal load. Assume a value of t_h of 0.5. [40%]

(c) Given a soil-foundation interface friction coefficient μ of 0.3, and ignoring the influence of embedment, check the factor of safety against sliding failure. [15%]

(d) Comment on the difference between the factors of safety derived in parts (b) and (c). [5%]

END OF PAPER