Version SKH/3

EGT2
ENGINEERING TRIPOS PART IIA

Monday 8 May 2017   9.30 to 11

Module 3D2

GEOTECHNICAL ENGINEERING II

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
Graph paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Attachment: Geotechnical Engineering Data Book (19 pages).
Engineering Data Book

10 minutes reading time is allowed for this paper

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

1 A circular tunnel with a diameter of 4 m was constructed with its axis at a depth of 25 m below ground level in a uniform body of saturated clay. Two types of measurement were made: the average radial stress developing immediately on the tunnel lining was 150 kPa and the total radial ground movement at the tunnel boundary was 20 mm. The clay had a unit weight of 20 kN m^{-3} and a constant undrained shear strength with depth of 175 kPa.

(a) By assuming that the tunnel lining is smooth and that the tunnel construction is a contracting axisymmetric cylindrical cavity under undrained conditions, analogous to cylindrical cavity expansion, estimate the elastic shear modulus *G* of the clay indicated by the two measurements. [40%]

(b) An 8 m diameter tunnel is to be constructed in the future with its axis at the same depth and in the same clay as for the 4 m diameter tunnel. The designer estimates that the tunnel construction process will lead to the average radial stress developing immediately on the smooth tunnel lining being 200 kPa. What will be the measured total radial ground movement at the tunnel boundary? [20%]

(c) How high would the average radial stress on the 8 m diameter tunnel have to be if there is to be no measured reduction in pore pressure in the clay at the tunnel boundary? What would be the corresponding measured total radial ground movement at the tunnel boundary? [40%]

2 (a) A clay has properties similar to those given in the databook for London Clay. A triaxial element of this clay is one-dimensionally normally consolidated from a slurry (state O′) to a state A′ with an effective vertical stress of 400 kPa. The sample is then permitted to swell one-dimensionally to a state B with a vertical effective stress of 50 kPa. Calculate the corresponding horizontal effective stresses in states A′ and B′ and sketch the stress path in both (σ_v', σ_h') and (p', q) diagrams. In both cases mark critical state stress ratios on the diagrams, distinguishing between compression and extension. [30%]

(b) The soil in state B′ is then subjected to an undrained compression test, during which it remains quasi-elastic until a deviatoric stress q = 75 kPa at state C′ before yielding, and ultimately shears in state D′ at constant q = 90 kPa. Mark these points on the (σ_v', σ_h') and (p', q) diagrams. [30%]

(c) The same soil is at effective stress state B′ in the field at a depth of 2 m, with the water table 4 m below the soil surface. When a 4 m deep unsupported trench is constructed adjacent to the soil element, the clay comes into a new effective stress state E′. Show the stress states on the (σ_v', σ_h') and (p', q) diagrams and discuss the short-term and long-term stability of the trench. [40%]

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3 (a) What is the difference between a drained and an undrained stress path? How do these differences come about both in element tests in the laboratory and in the field? [20%]

(b) A triaxial sample of kaolin whose properties are similar to those given in the databook is isotropically consolidated from slurry to a stress of 200 kPa before being allowed to swell to an isotropic confining stress of 100 kPa. If the triaxial specimen is subjected to an undrained axial compression test, sketch the stress paths followed by the sample in (p', q, v) space and calculate the yield stress and ultimate strength of the sample together with the excess pore-pressures predicted at both yield and failure. [25%]

(c) If the same triaxial specimen is instead subjected to a drained axial compression test, sketch the stress paths followed by the sample in (p', q, v) space and calculate the yield stress and ultimate strength of the sample together with the volumetric strains predicted at both yield and failure. [25%]

(d) The sample is loaded in a drained manner to a deviatoric stress giving a factor of safety of 1.2 against drained failure. If the axial load is then increased rapidly, at what axial stress will failure occur? What was the true factor of safety of the sample against failure? [30%]

4 (a) Describe qualitatively how the factor of safety against collapse for a finite slope in a homogeneous clayey soil might be identified using limit equilibrium methods. [15%]

(b) Describe qualitatively how the factor of safety against collapse for a finite slope in a sandy soil might be identified using the method of slices. [25%]

(c) An infinite slope consists of a 5 m thick layer of calcareous sand overlying impermeable bedrock as shown in Fig. 1. The slope has an angle of 30 degrees to the horizontal. The sand has a critical state friction angle of 25 degrees, G_s = 2.6 and maximum and minimum voids ratios of 0.95 and 0.6 respectively. The sand is compacted to a voids ratio of 0.7 . If the slope is dry, discuss the stability of the slope by considering the strength of the soil. [30%]

(d) If due to heavy rainfall the water table rises to a height 2 m above the bedrock, how this will affect the stability of the slope? [30%]

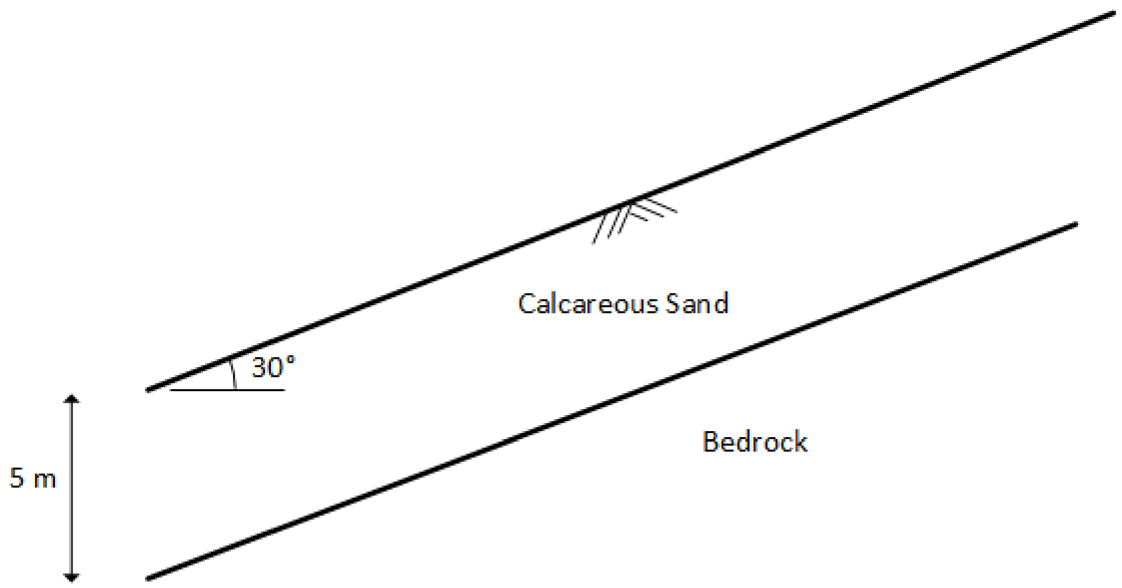

Fig. 1

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Answers

1. a) G=23.8 MPa

   b) 30.0 mm

   c) 14.7 mm

2. a) p'=296 kPa, q= 156 kPa

3. b) at yield, q=70.7 kPa, uexcess=23.6 kPa , strength=35.3 kPa

   at failure, q=79.6 kPa, uexcess=48.5 kPa, strength=39.8 kPa

c) at yield, q=63 kPa, vol strain=0.36% , strength=31.5 kPa

   at failure, q=154.5 kPa, vol strain = 6.57%, strength=77.2 kPa

d) FoS=1.06

4c) FoS=1.26

d) FoS~=0.98