EGT2
ENGINEERING TRIPOS PART IIA

Wednesday 26 April 2017   9.30 to 11

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
Graph paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Attachment: 3D1 & 3D2 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 Deformations have been observed in the quay wall of a small marina on a reservoir's shores. There is some concern about possible causes for the poor performance and an investigation has been commissioned. The quay wall is a 4 m high water-tight sheetpile wall and the backfill is a locally available clayey sand. The original ground is clay. The geometry is illustrated in Fig. 1.

(a) The quality of construction has been an initial concern. Undisturbed specimens were carefully collected from the backfill behind the wall in spring when water level had been at its maximum, 0.5 m below the top of the wall, for weeks.

(i) A section of core of 100 mm diameter and 300 mm length, corresponding to a depth of 3 m weighs 5.238 kg. A small specimen tested for water content had an initial mass of 57.34 g. After oven drying, the specimen weighed 50.26 g. The specific gravity of the soil G_s is 2.68. Calculate the bulk density and water content of the clayey sand. [10%]

(ii) The testing conducted for the design and construction of the quay wall included assessment of compaction curves. Maximum dry unit weight under standard compaction effort was found to be 19.8 kN m^{-3} at an optimum water content of 10.1%. Draw a schematic of the compaction curve and illustrate where the current condition may lie compared to the point of optimum. How does the current status compare with the assumed as-placed conditions represented by the compaction test? Draw a schematic of the compaction curve to illustrate your considerations. [20%]

(b) Piezometers were also installed in the backfill at depths of 1 m and 3.5 m below the ground surface. Shortly thereafter the reservoir was lowered to 1 m below the maximum spring level. After 2 days, the top piezometer measured a gauge pore pressure of -2.7 kPa and the lower one 28 kPa. Plot profiles of pore pressure and vertical effective stress at maximum reservoir level, after 2 days and once the pore pressures have equilibrated. List any assumptions and simplifications. [30%]

(c) Sketch isochrones of excess pore pressure with relevant values at maximum reservoir level, after 2 days and once the pore pressures have equilibrated. Estimate the coefficient of consolidation C_v in swelling. How long does it take 90% of the swelling to occur? [30%]

(d) Discuss how the excess pore pressures immediately after drawdown may affect the stability of the retaining wall and result in the observed deformations. [10%]

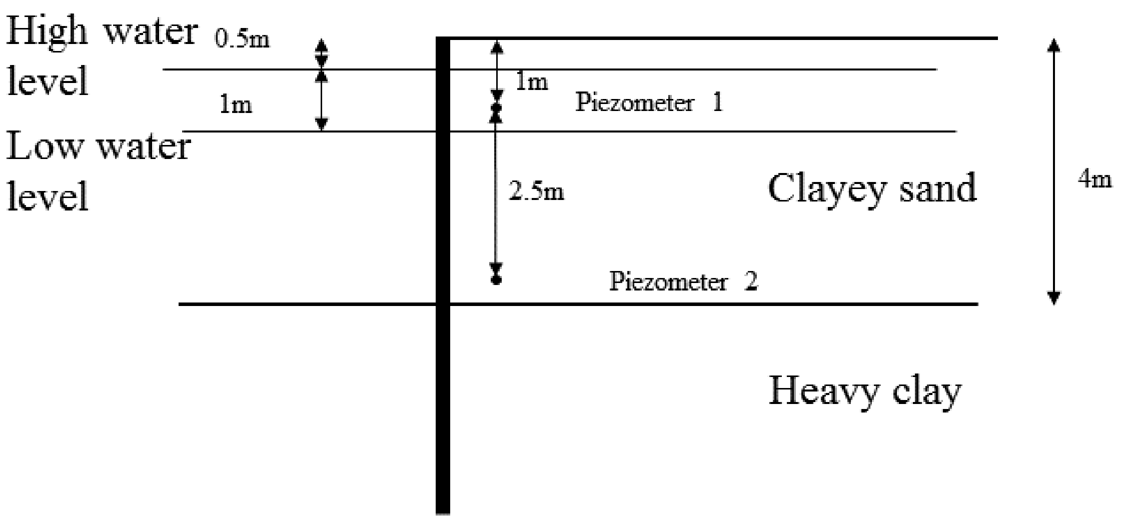

Fig. 1

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2 (a) Show that the rate of work dissipation in a plane strain circular shear fan of radius r in a Tresca material of strength s_u is $2s_u r v \theta$, where v is the velocity of the material entering the fan and θ is the fan angle. [30%]

(b) A shallow strip foundation of width B rests on the surface of a uniform clay soil of strength s_u. If the foundation carries a horizontal load component of $0.5Bs_u$, calculate an upper bound as a function of α on the additional vertical load component V that may be carried by the foundation using the mechanism shown in Fig. 2. The mechanism comprises two rigid soil zones and a shear fan. Slip at the foundation-soil interface can be ignored. [30%]

(c) Calculate the optimum value of α and hence the optimum upper bound on V. [10%]

(d) Calculate a lower bound on the vertical load V that can be carried by the same strip foundation. [30%]

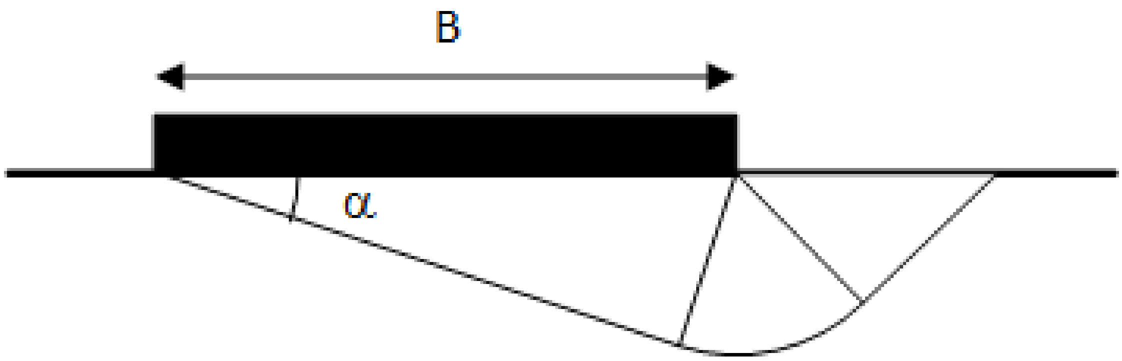

Fig. 2

3 An 8 m high L-shaped concrete retaining wall 0.5 m thick is to be constructed on a clay foundation as shown in Fig. 3. The retaining wall is founded on clay with an undrained shear strength s_u of 40 kPa and retains sand with a friction angle of 35°. Assume that the unit weights of concrete and sand are 24 kN m^{-3} and 18 kN m^{-3} respectively.

(a) Estimate the active force P_A acting on the plane A-A' shown in Fig. 3. Assume the active force to act in a horizontal direction. [10%]

(b) Identify and compute the other forces acting on the combined soil-wall system and compute the factor of safety against sliding. Assume that the clay mobilises full shear strength on the clay-wall interface. [20%]

(c) Assuming the sand above the heel of the retaining wall to be part of the retaining wall system and converting from $V-H-M$ loading to $V-H$ loading on an equivalent foundation, determine the stability of the retaining wall against bearing capacity failure. [40%]

(d) Due to heavy rainfall the water table in the backfill rises to a height of 2 m above the clay surface, while the water table at the front of the wall remains in its original position. Investigate the stability of the wall due to both sliding and bearing capacity failures. Assume the saturated unit weight of the sand to be 21 kN m^{-3}. [30%]

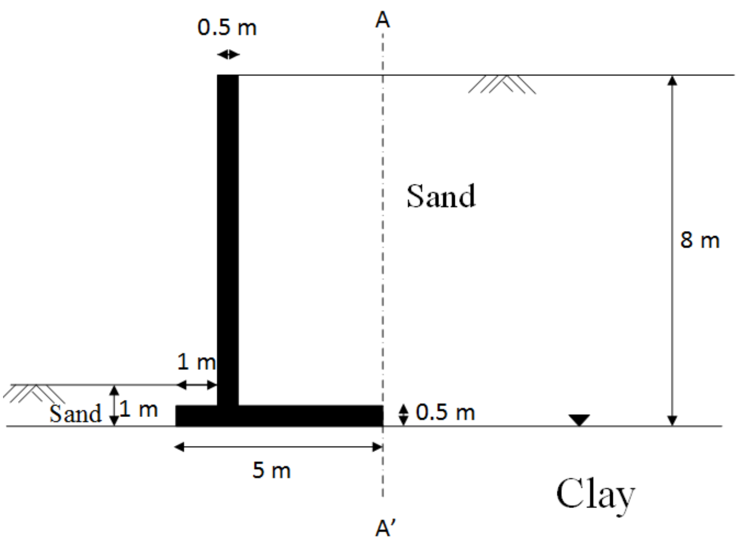

Fig. 3

4 Pre-loading is to be used at a site to ensure most of the consolidation settlement is accumulated before the start of construction. The site consists of 8 m of lightly overconsolidated clay underlain by 2 m of dense sand above bedrock. The water level is 0.5 m above ground level. The pre-consolidation load will consist of 5 m of silty sand with unit weight of 20 kN m^{-3} as placed. A specimen retrieved from a depth of 4 m is tested in the oedometer with the results given below:

σ_v' (kPa)	1	12.5	25	50	100	200	400	100	25
height (mm)	25.0	24.9	24.8	24.5	23.9	23.1	21.8	22.1	22.5

The clay has a specific gravity G_s of 2.71 and the measured initial water content of the specimen is 39.6%.

(a) Estimate values for Γ, λ, κ, and preconsolidation pressure from the consolidation curve. [35%]

(b) Calculate the vertical effective stress at 4 m depth before the placement of the pre-load. [15%]

(c) Estimate the settlement due to the pre-loading. [25%]

(d) The plot of specimen height vs $\sqrt{time}$ is reproduced in Fig. 4. Estimate the coefficient of consolidation C_v. Calculate the time expected for 90% of the settlements to occur. Comment on this result and on ways to improve constructibility and performance. [25%]

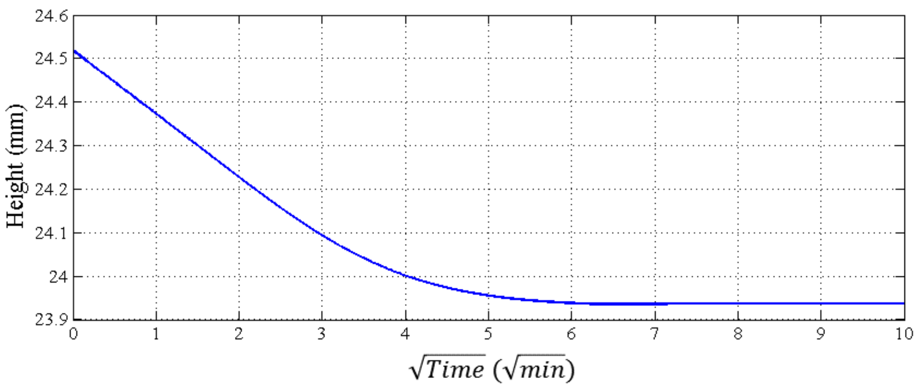

Fig. 4

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