Version GB/3

EGT2
ENGINEERING TRIPOS PART IIA

Tuesday 21 April 2015 9.30 to 11.00

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 A coastal site is to be reclaimed and developed. The soil profile, shown in Fig. 1, consists of 12 m of clay, underlain by a medium dense sand. The water level is 2 m above the soil surface.

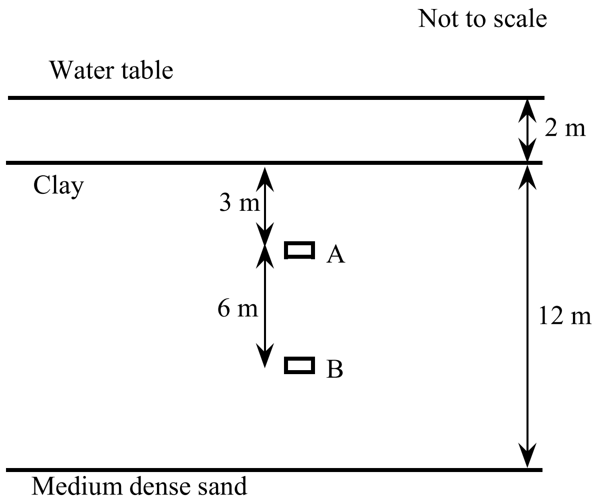

Fig. 1

An oedometer test is performed on a specimen taken from a depth of 3 m, with the results shown in Fig. 2. The specimen initial water content was 63% and the soil has a specific gravity of 2.70.

(a) (i) Calculate the total unit weight for this specimen. [10%]

(ii) Calculate the total and effective stresses at A. [10%]

(b) (i) Calculate λ and κ for this specimen. [10%]

(ii) A second specimen from 9 m depth was also tested. The values of λ and κ are similar, but this specimen is normally consolidated with a water content of 72%. Calculate the expected settlement of the clay if 4 m of fill (γ_t = 20 kN m^{-3}) are placed over the clay. Assume that specimens A and B are representative of the properties of the clay around them. [25%]

(c) The specimen height vs time for the load increment from 50 kN m^{-2} to 100 kN m^{-2} is shown in Fig. 3. Determine the value of the coefficient of consolidation, C_v. Assume double drainage for the specimen during the test. [10%]

(d) (i) A piezometer monitors pore pressures in the middle of the clay layer. Sketch your predicted isochrone at 6 months after placement of the fill. [10%]

(ii) Six months after construction the total pore pressure measured by the piezometer is 132 kN m^{-2}. What is the excess pore pressure after 6 months? Compare with your estimate from part (d)(i). [15%]

(iii) The settlement after 6 months is 0.26 m. Is this consistent with the pore pressure dissipated in the field based on the measurements? [10%]

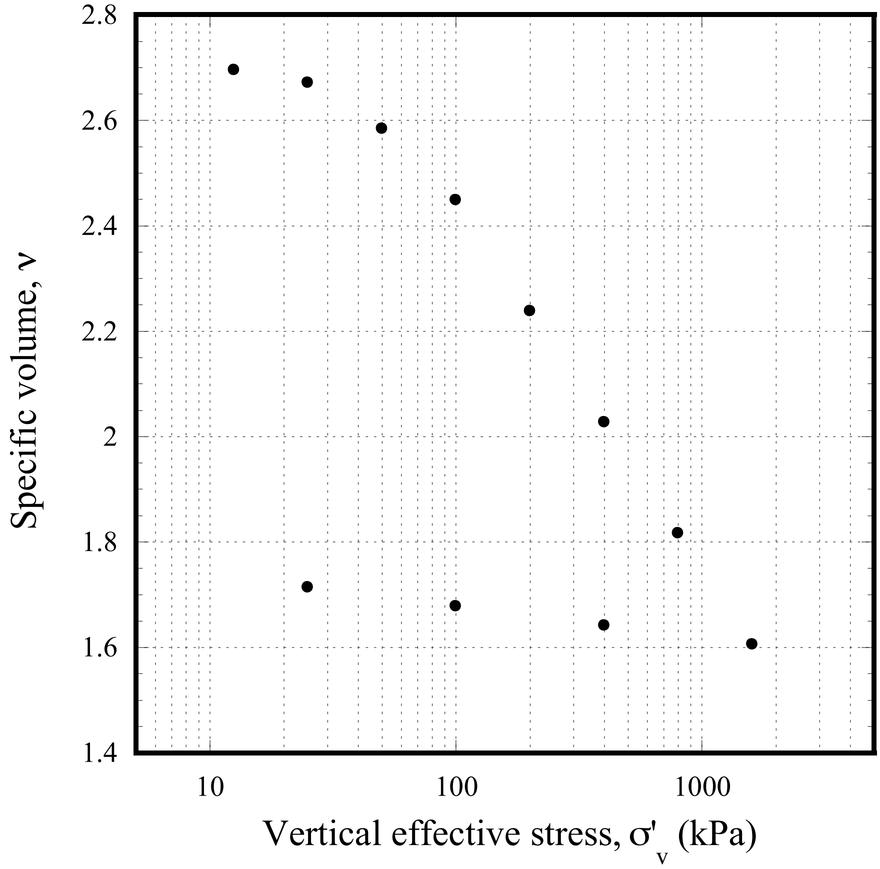

Fig. 2

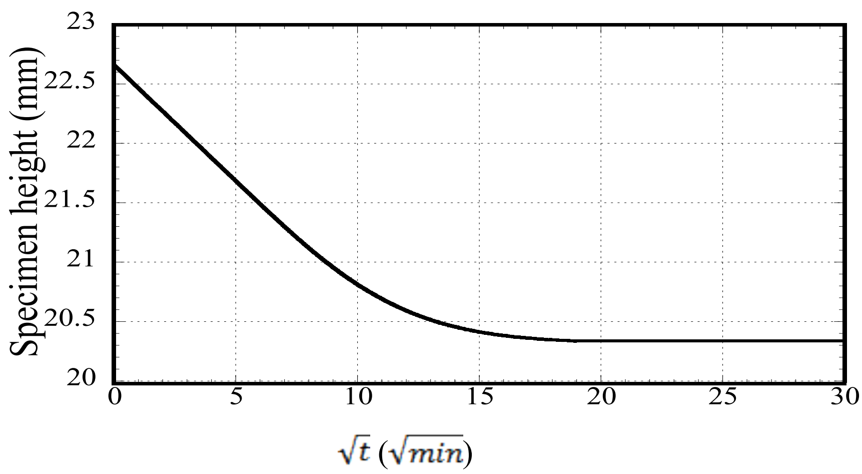

Fig. 3

2 A standard Proctor compaction test was conducted on a clayey sand considered for a construction project, with the results reported below:

Water content (%)	2.58	5.12	7.66	12.74	17.82
Dry density (kg m^{-3})	1803	1885	1967	1988	1824

The specific gravity of this soil is 2.74.

(a) (i) An additional specimen was prepared and compacted. The soil extruded from the compaction mould had a mass of 2.13 kg. After drying in the oven, the specimen mass was 1.93 kg. The mould standard volume is 944 cm^3. Calculate the water content, dry unit weight and saturation of the soil. [10%]

(ii) Draw the compaction curve. Identify the maximum dry unit weight and optimum water content. [10%]

(iii) A modified AASHTO compaction test (heavier hammer and more blows/layer) is also carried out. Where would this test plot relative to the standard Proctor test? Sketch a curve on the same graph prepared in part (a)(ii). [10%]

(b) (i) Two source locations are available for this material. At location A the average water content of the soil is 17% to 18%, while at location B the water content is 8.5% to 9.5%. Which location would you select and why? [20%]

(ii) Field testing shows water contents between 11% and 12.5%, but dry densities are ranging from 2.15 kg m^{-3} to 1.85 kg m^{-3}. How can you explain this variation in compaction effectiveness? What measures will you require to be implemented to improve quality? [20%]

(c) The soil will be compacted to construct an embankment, about 3 m high. The soil profile at the site consists of 8 m of clay, overlying bedrock. The water table can be taken at the surface. The soil at the site has $\lambda = 0.25$ and $\kappa = 0.03$. A specimen taken from a depth of 4 m is overconsolidated with OCR = 2 and initial water content of 65%. Assume $G_s = 2.72$. Calculate expected settlements assuming the specimen is representative of the whole clay. [30%]

3 A temporary retaining wall with a prop at the top is to be constructed in clayey soil as shown in Fig. 4. The undrained shear strength s_u of the clay is 50 kN m^{-2} and its total unit weight is 20 kN m^{-3}. The length of the wall is 20 m. There is a need to estimate the maximum excavation depth in undrained conditions. It is assumed that the friction between the soil and the wall is zero. Use the unit weight of water as 10 kN m^{-3}.

(a) Estimate the total horizontal stress profile acting on the wall along the retained side. If a dry crack is developed between the wall and the soil, predict the depth of the crack. [10%]

(b) Estimate and plot the total horizontal stress profile acting on the soil below the excavation level when the excavation depth is (20-X) m as shown in Fig. 4. [20%]

(c) After heavy rain, the crack is filled with water and propagates further down. Evaluate the total horizontal stress profile acting on the wall at the retained side under this condition. [20%]

(d) Find the maximum excavation depth for the case in part (c). [40%]

(e) If the friction between the soil and the wall is considered, would you expect the minimum length of the wall to increase or decrease? Why? [10%]

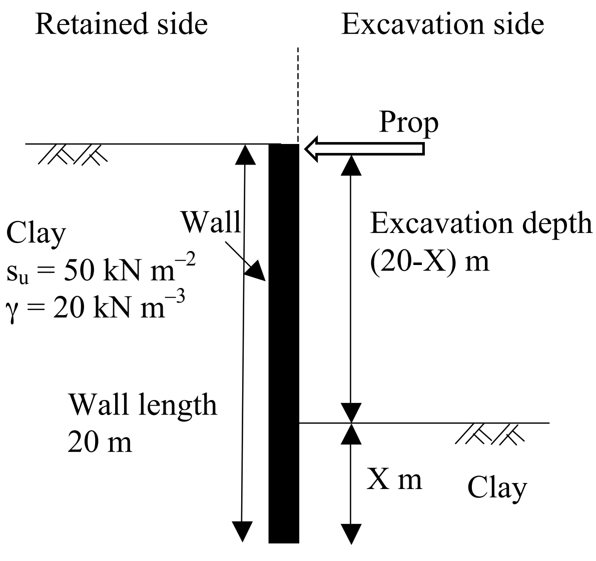

Fig. 4

4 (a) The bearing capacity of a strip foundation, which is placed on clayey soil and is subjected to combined vertical and horizontal loading, can be estimated by the following equation when the clay has a constant undrained shear strength s_u with depth.

$$\frac{V}{Bs_u} = 1 + \pi - \sin^{-1}\left(\frac{H}{Bs_u}\right) + \sqrt{1 - \left(\frac{H}{Bs_u}\right)^2}$$

where B is the foundation width, V is the vertical load and H is the horizontal load.

Using a diagram, explain how this equation is derived. There is no need to derive the equation. [25%]

(b) A strip concrete structure, 4 m high and 7 m wide, is placed under water as shown in Fig. 5. The water depth is 3 m and the structure is placed on heavily overconsolidated clay, which has an undrained shear strength of 100 kN m^{-2} and a friction angle of 28°. The unit weight of the clay is 18 kN m^{-3}, whereas that of the concrete is 23 kN m^{-3}.

(i) A horizontal force of 350 kN m^{-1} is applied at the base of the structure as shown in Fig. 6. What is the maximum vertical load that can be applied at the centreline of the concrete structure in undrained conditions? [25%]

(ii) A vertical load is applied 2.8 m away from one edge of the structure as shown in Fig. 7. No horizontal load is applied. What is the maximum vertical load that can be applied on the concrete structure in undrained conditions? [25%]

(iii) What is the maximum vertical load that can be applied at the centreline of the structure, as shown in Fig. 8, in drained conditions? No horizontal load is applied. [25%]

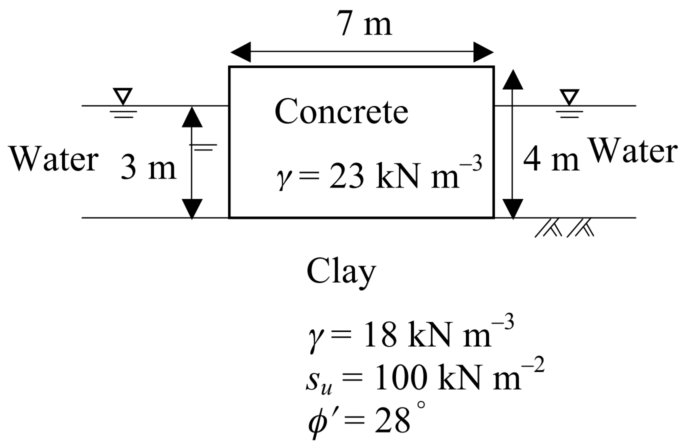

Fig. 5

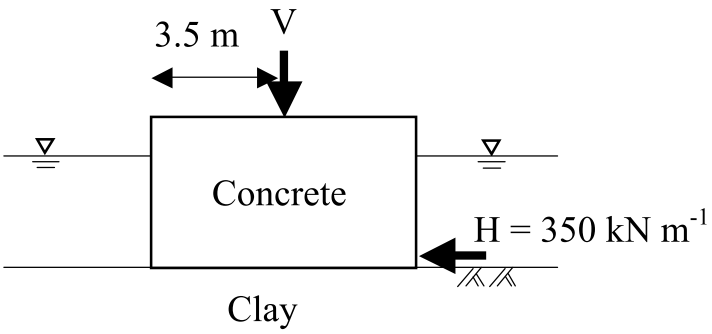

Fig. 6

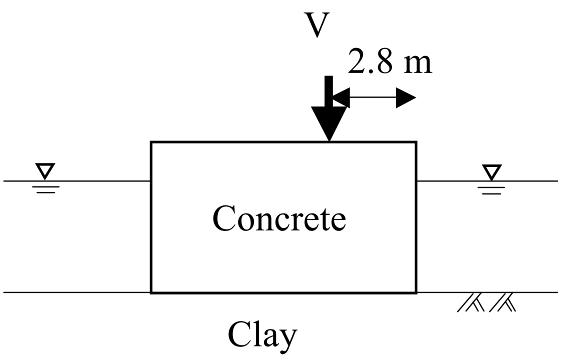

Fig. 7

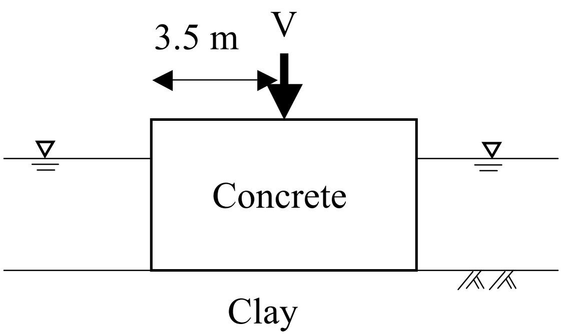

Fig. 8

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