Version SKH/2

EGT2
ENGINEERING TRIPOS PART IIA

Wednesday ? April 2024 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
CUED approved calculator allowed
Attachment: 3D1 & 3D2 Geotechnical Engineering Databook (21 pages)
Engineering Data Book

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 large building is to be constructed on a 10 m thick clay layer underlain by permeable bedrock. The building is sufficiently large that the soil's compression beneath the building can be assumed to be one-dimensional. The clay's compression properties are represented by the values given for Kaolin in the databook. Site investigation reveals the water table to be at 5 m depth below the ground surface and the clay to have a saturated unit weight of 16.6 kN/m^3 which may be taken to be uniform with depth. Assume g = 10 ms^{-2}

(a) Calculate the specific volume of the clay and its preconsolidation pressure at 7.5 m below the clay surface. [25%]

(b) If 5 m of the clay is excavated to form a basement, estimate the long-term movement of the base of the excavation when consolidation is complete. [25%]

(c) After consolidation of the clay beneath the excavation ends, a building is constructed within the excavation which exerts a pressure of 600 kPa on the underlying soil. What settlement does the building suffer once consolidation is complete? [25%]

(d) If the coefficient of consolidation C_v for recompression is 1 m^2/year, estimate the times taken for 12% and 89% of this settlement to occur. [25%]

2 A sample of a silty soil is to be used to create a flood embankment alongside a river. The soil has a d_{10} particle size of 30 μm and a Standard Proctor Compaction test yielded the data given below.

w	%	2	4	6	8	10	12	14	16
ρ_{bulk}	kgm^{-3}	1783	1857	1921	1974	2009	2020	2004	1982

(a) From the compaction test data calculate the optimum moisture content for the soil and its maximum dry density. [30%]

(b) At the optimum moisture content what are the voids ratio and saturation ratio of the soil? [20%]

(c) The soil is available onsite with water contents of 4% and 14%. Comment on the benefits and disadvantages of creating the flood embankment with these two materials and suggest a strategy for the material choice for construction. [30%]

(d) Would this soil represent a good choice for construction of a flood embankment? [20%]

3 An oedometer sample from the middle a 5 m deep soft clay deposit was subjected to an effective stress increment of 50 kN m^{-2} to 100 kN m^{-2} in an oedometer. The initial sample height h_i was 15.2 mm and the settlement of the sample s with time t during this loading increment is shown in Fig. 1.

(a) Estimate values for the coefficient of consolidation c_v, the constrained elastic modulus E_0 and the permeability k for the sample using the oedometer data. [30%]

(b) Estimate the ultimate settlement of the clay layer after the application of a bearing pressure of 100 kN m^{-2} due to surcharge pre-loading with a free-draining material. [5%]

(c) Calculate bounds on the settlement of the surcharged surface and estimate the potential range of excess pore pressures at a depth of 1 m from the surface of the clay layer one year after application of the surcharge. [50%]

(d) Comment on any uncertainties associated with the analysis performed in (c). [15%]

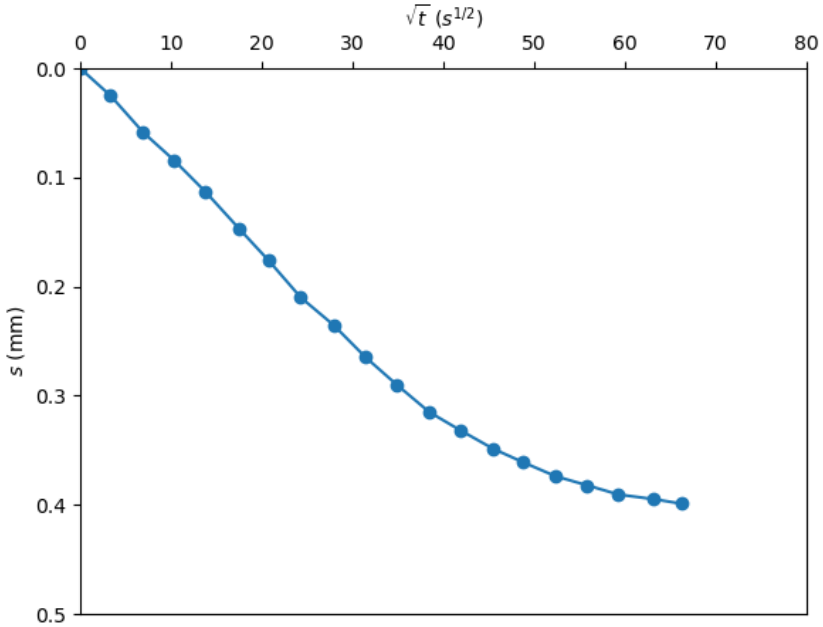

Fig. 1

4 A building is to be constructed with a footprint of 10 m by 20 m on a raft foundation embedded to a depth of 1 m. The soil the raft is to be founded in has a friction angle ϕ' of 33°, an effective unit weight γ' of 10 kN m^{-3}, Poisson's ratio ν of 0.25 and Young's modulus E of 5 MN m^{-2}.

(a) Calculate the ultimate vertical bearing capacity of the raft using Eurocode 7 shape and bearing capacity factors. [40%]

(b) Estimate the range of potential elastic settlement of the foundation on completion of construction when the building imparts a bearing pressure q of 100 kN m^{-2} on the base of the raft. Consider cases assuming that the slab is both rigid and flexible. [40%]

(c) Describe any impacts the settlements calculated in part (b) might have on the serviceability of the building. Compare the settlements calculated with acceptable limits where appropriate. [20%]

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Numerical Answers:

1)a) v = 2.44, $\sigma_{v'max}$ = 504 kPa
b) ρ = 0.184 m
c) ρ = 0.455 m
d) t_{12} = 23 days, t_{89} = 26 years

2) a) w_{opt} = 9%, ρ_{max}=1830 kgm^{-3}
b) e = 0.45, S_r = 0.53

3)a) c_v = 0.58 m^2/yr, E_0 = 1.875 MPa, k = 9.7 x 10^{-11} m/s b) ρ =0.53 m
c) ρ = 46 - 94 mm, u = 62-63 kPa

4) a) σ_{max} = 1717 kPa
b) ρ = 142 - 280 mm