Version GB/2

EGT3
ENGINEERING TRIPOS PART IIB

Monday 29 April 2019 14.00 to 15.40

Module 4D5

FOUNDATION ENGINEERING

*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
Engineering Data Book
Attachment: 4D5 Foundation Engineering Data Sheet (18 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.

1 Three adjacent columns in a foundation system (Fig. 1) need to carry different vertical loads: $V_A = 400\,\text{kN}$ for column A, $V_B = 250\,\text{kN}$ for column B, $V_C = 180\,\text{kN}$ for column C.

The soil profile consists of a stiff clay (PI = 42) with undrained shear strength increasing linearly with depth from 35 kPa at a depth of 1 m to a strength of 70 kPa at a depth of 8 m. The saturated unit weight of the clay is $18\,\text{kNm}^{-3}$. The water table can be assumed at the surface. The base of the foundations will be at 1 m depth.

(a) The initial design approach is to use the same size of footings to minimise the complexity of construction. Calculate the size of the footing and the bearing pressure for each footing type, assuming no interaction between the foundations. [30%]

(b) Discuss concerns relating to capacity and performance of the foundation system when the column loads are different. [10%]

(c) Explain the basic concepts behind Mobilisable Strength Design. [10%]

(d) Use Mobilisable Strength Design to size the footings to limit distortions. Testing on the clay provided a reference strain $\gamma_{M=2} = 0.0095$ and $b = 0.6$. [50%]

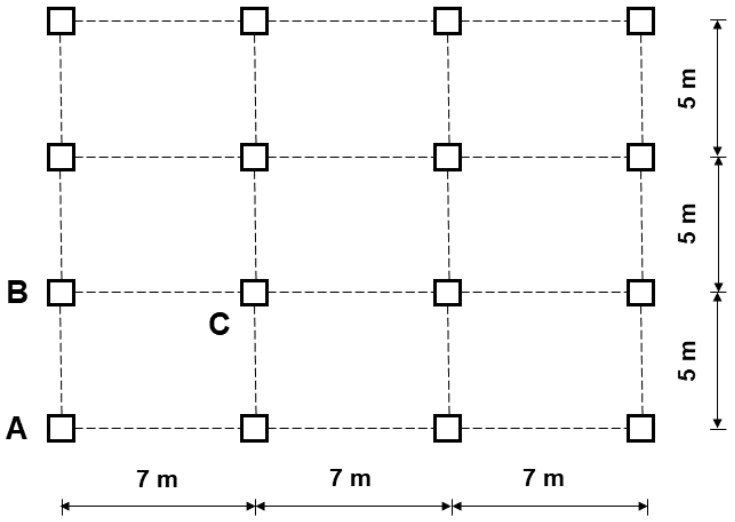

Fig. 1

2 The pile group shown in Fig. 2 is comprised of eight bored piles of diameter 0.5 m and length 10 m. The piles penetrate into a soft clay stratum whose stiffness increases linearly from 10 MPa at the surface to 20 MPa at a depth of 20 m.

(a) What would be the stiffness of a single isolated rigid pile with these dimensions loaded in vertical compression? [20%]

(b) Assuming the pile cap to be rigid and assuming all of the load to be carried by the piles, calculate the proportion of the load carried by each pile within the group. [60%]

(c) What is the settlement experienced by the pile group if it experiences a vertical load of 100 kN? [20%]

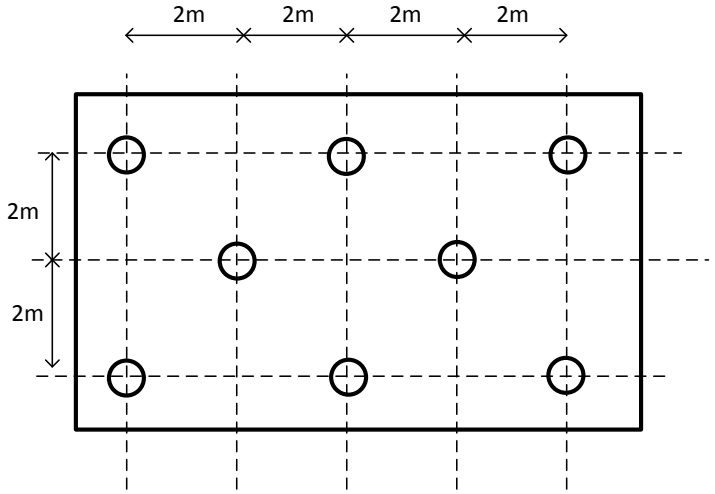

Fig. 2

3 Strip foundations with 1 m embedment are being considered for a warehouse. The unfactored vertical and horizontal structural loads are expected to be $200\,\mathrm{kNm}^{-1}$ and $80\,\mathrm{kNm}^{-1}$, respectively.

(a) The site soil profile consists of a stiff overconsolidated silty clay with unit weight of $19.5\,\mathrm{kNm}^{-3}$. Triaxial isotropically consolidated undrained compression tests were carried out on the soil. Representative results for a specimen consolidated to 30 kPa are shown in Fig. 3. Estimate the undrained shear strength and drained strength parameters for the clay. [30%]

(b) Comment on the choices in part (a). [10%]

(c) Explain why the undrained bearing capacity of a strip foundation reduces under combined vertical and horizontal loads using sketches rather than calculations. [10%]

(d) Determine the width of the strip foundation using your strength estimate from part (a) according to the Eurocode 7 approach. [25%]

(e) Check if the foundation is still safe in long-term (drained) conditions. [25%]

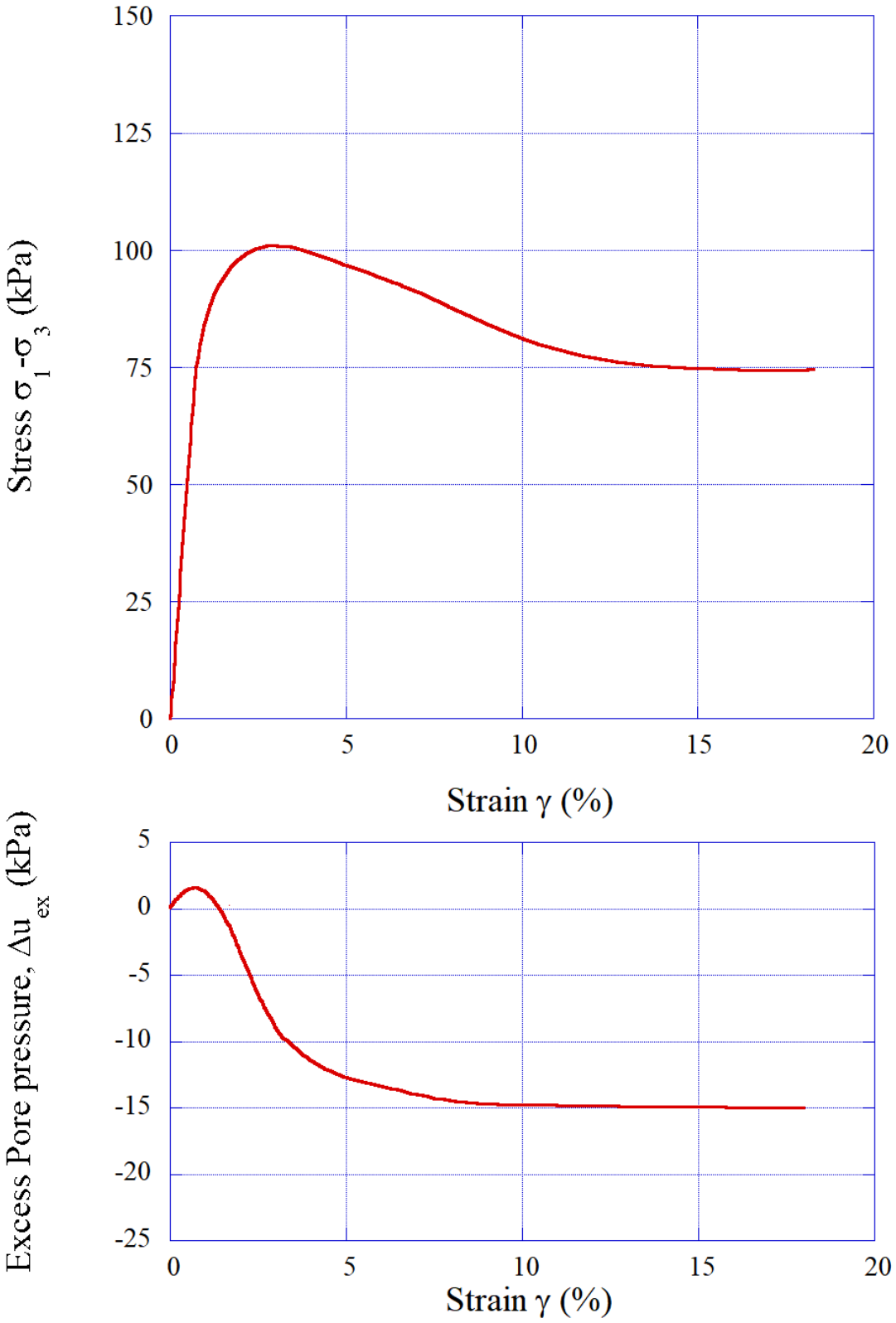

Fig. 3

(TURN OVER

4 (a) Describe how the pile installation process affects the performance of bored and driven piles. [30%]

(b) Explain how the vertical capacity of driven piles varies with length and how this is implemented within the API design code. [20%]

(c) (i) Explain why the stiffness of a pile to vertical loading does not always increase with pile length. [20%]

(ii) Calculate the vertical stiffness of a 0.5 m diameter steel tubular pile with a wall thickness of 50 mm driven to a depth of 20 m in a uniform clay layer with a soil stiffness $E = 10$ MPa. [30%]

END OF PAPER

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ANSWERS

1) a) B_A= 1.5 m, q_A=177.8 kPa; d) w_A = 24 mm

2) a) Q_s/w = 19.6 MN/m; c) w=1.8 mm

3) a) S_u= 37.5 kPa, Φ = 27 degrees; d) B=3 m;

4) d) V/w = 306 MN/m