ENGINEERING TRIPOS PART IIB

Friday 3 May 2013 2 to 3.30

Module 4D5

FOUNDATION ENGINEERING

*Answer not more than **three** questions.*

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

Attachment: Foundation Engineering Data Book (18 pages)

STATIONERY REQUIREMENTS	SPECIAL REQUIREMENTS
Single-sided script paper	Engineering Data book
	CUED approved calculator allowed

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

SKH03

1 It is required to site a number of fuel storage tanks on a coastal strip which is expected to comprise of London clay to a depth of 25 m, underlain by the dense sands and very stiff clays of the Lambeth group. The tanks are to be 20 m high and 30 m in diameter, and are to apply bearing pressures of up to 200 kPa.

The following information on the London clay can be used in preliminary assessments of the scheme. The plasticity index of the clay is about 55% and its bulk density is 21 kN m^{-3}. Its overconsolidation is consistent with the removal of 800 kPa of effective overburden. Furthermore, previously published triaxial compression tests on high-quality cores suggest that the mid-range shear stress-strain relationship for London clay fits a power curve, with an exponent b = 0.6. It is thought that the shear strain required to mobilise half the peak strength can be expressed as a function of overconsolidation ratio n, as follows:

$$\gamma_{M=2} = 0.004\, n^{0.68}$$

(a) Sketch an estimated profile within the London clay of undrained shear strength s_u and mobilisation strain $\gamma_{M=2}$. Make any required assumptions explicit in your answer. Use additional information from the Foundation Engineering data book where necessary, justifying your selections. [35%]

(b) Estimate the undrained settlement, and the ultimate fully drained settlement, of a single tank assuming it is placed on a 0.5 m thick bed of sand lying directly on the surface of the clay. [35%]

(c) Repeat the calculation in (b) but assuming that the tank is placed over a 3.5 m thick pedestal of densely compacted sand, which was constructed quickly by excavating 3 m into the clay, so that the tank base was again lifted 0.5 m above original ground level. [15%]

(d) Discuss whether there should be any concern regarding the spacing of tanks. [15%]

2 “Success in foundation engineering consists of producing the lowest-cost design that is capable of restricting the displacements of the foundation system to values which satisfy performance criteria agreed by the client.”

(a) If this proposition is accepted, discuss the apparent paradox that the great majority of foundation designs are currently produced without reference to any soil deformation parameters. What performance criteria might be appropriate for a one-storey multi-bay steel portal frame structure to house a warehouse, if all external walls have masonry infilling the frame? [40%]

(b) Discuss the pros and cons of the Limit State Design (LSD) framework for spread foundations, such as is implemented in Eurocode 7. To what extent can Ultimate Limit State (ULS) checks provide assurance of safety and robustness? To what extent can linear elastic settlement calculations carried out as Serviceability Limit State (SLS) checks provide assurance of satisfactory performance in service? [30%]

(c) Compare the role of a “partial factor” on soil strength in LSD with that of a mobilisation factor as defined in Mobilisable Strength Design (MSD). How might a designer of spread foundations allow for variability of loads and soil properties within an MSD framework? [30%]

3 Piles can be installed using either displacement or non-displacement techniques. The choice of installation method can significantly influence their final behaviour.

(a) How does the soil stress state vary during the installation and use of a driven pile in sand? [40%]

(b) How are the stress changes during installation taken into account in the API (2000) pile design procedure? [20%]

(c) Describe the geotechnical processes leading to the phenomenon of set-up for driven piles installed in clay. [20%]

(d) Discuss the advantages and disadvantages of displacement piles versus non-displacement piles. [20%]

4 (a) A 20 m long closed-ended tubular steel pile with a diameter of 0.5 m is hammer-driven into a very deep saturated sand layer with a bulk density of 20 kN m^{-3}, relative density of 70% and friction angle ϕ_{crit} of 35°. The pile-soil friction angle can be taken to be 30°. Using the API (2000) design method, calculate the vertical capacity of the pile. [20%]

(b) Assuming that a factor of safety of approximately 3 is used in design, discuss how the pile loads acting on a driven pile will be shared between the pile base and shaft both immediately after installation and under working loads. [20%]

(c) A 20 m long 0.5 m diameter bored pile is constructed in stiff clay. The strength of the clay, s_u, varies linearly from 50 kPa at the ground surface up to 250 kPa at the pile base. The shear modulus of the soil, G, can be taken to be equal to 150 s_u and its Poisson's ratio to be 0.2. Assuming the equivalent pile stiffness E_p to be 25 GPa, calculate the settlement of the pile at a vertical load of 800 kN. [25%]

(d) Pile designs are often checked against results from load tests on trial piles installed in the same conditions. Describe three types of vertical pile load test and sketch a typical graph of pile head load versus pile head settlement for each of the three tests on one graph. [35%]

END OF PAPER