ENGINEERING TRIPOS PART IIB
ELECTRICAL AND INFORMATION SCIENCES TRIPOS PART II

Monday 28 April 2003 9 to 10.30

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.*

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

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1 Fig. 1 shows the plan of a proposed library which is to be supported on a flexible raft 10 m wide and 20 m long, with foundation level 2 m below ground level. The average bearing pressure is to be 100 kPa over the whole of the raft area. Externally the library will have large glass panels, and internally there will be light partitions. Boreholes show that the sequence of strata is as follows:

0 m - 2 m	Topsoil and mixed fill
2 m - 22 m	Firm to stiff, becoming stiff to very stiff silty clay
below 22 m	Hard limestone

The drained Young's Modulus E' increases linearly with depth from 8 MPa at 2 m below ground level to 24 MPa at the top of the limestone.

(a) Estimate the settlement of the raft at points *A, B* and *C*. [40%]

(b) Estimate the angular distortion of the raft over the lines *A-C, A-B* and *B-C*. [10%]

(c) Comment on the results of part (b) in relation to the performance of the structure. In particular, say whether you think a flexible raft is the right foundation for a structure of the type described. If you think it is likely to be unsatisfactory, suggest two different ways in which it might be improved. [25%]

(d) The owners of the nearby existing property have asked for an assurance that the new library will not cause significant additional settlement of their building. Predict the additional settlement at point *D*, and comment on the result. [25%]

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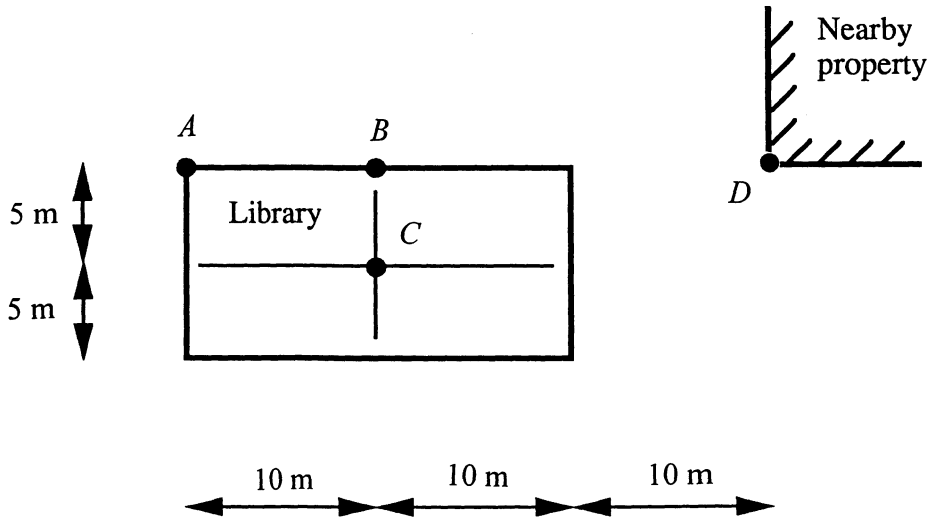

Fig. 1

2 (a) A driven precast concrete pile 0.4 m × 0.4 m in cross-section is to be designed to carry a working load of 375 kN. The factor of safety against bearing capacity failure is to be 2.5. Boreholes have given the following succession of strata:

0 m – 2 m	Fill; bulk unit weight 16 kN/m^3
2 m – 8 m	Normally consolidated clay; bulk unit weight 18 kN/m^3
below 8 m	Boulder clay; bulk unit weight 21 kN/m^3

Groundwater level is 2 m below ground level.

For the normally consolidated clay $c_u / \sigma_v' = 0.3$, where c_u is the undrained shear strength and σ_v' is the effective overburden pressure at the level considered. For the boulder clay the undrained shear strength at depth z below ground level is as follows:

z (m)	9	11	13	15	17
c_u (kPa)	50	80	120	150	200

Assume that the fill offers no support to the pile. Calculate the required length of the pile from ground level. A correlation between the adhesion factor α and c_u / σ_v' is given in Fig. 2. [50%]

(b) Suggest reasons for the large variation in the values of α used in calculating the side shearing resistance of driven piles in clay. [20%]

(c) What are the reasons for carrying out preliminary pile testing? [10%]

(d) In a recent piling project at Canary Wharf the piling was carried out using a polymer rather than piling under bentonite. Explain the advantages and disadvantages of using each material. [20%]

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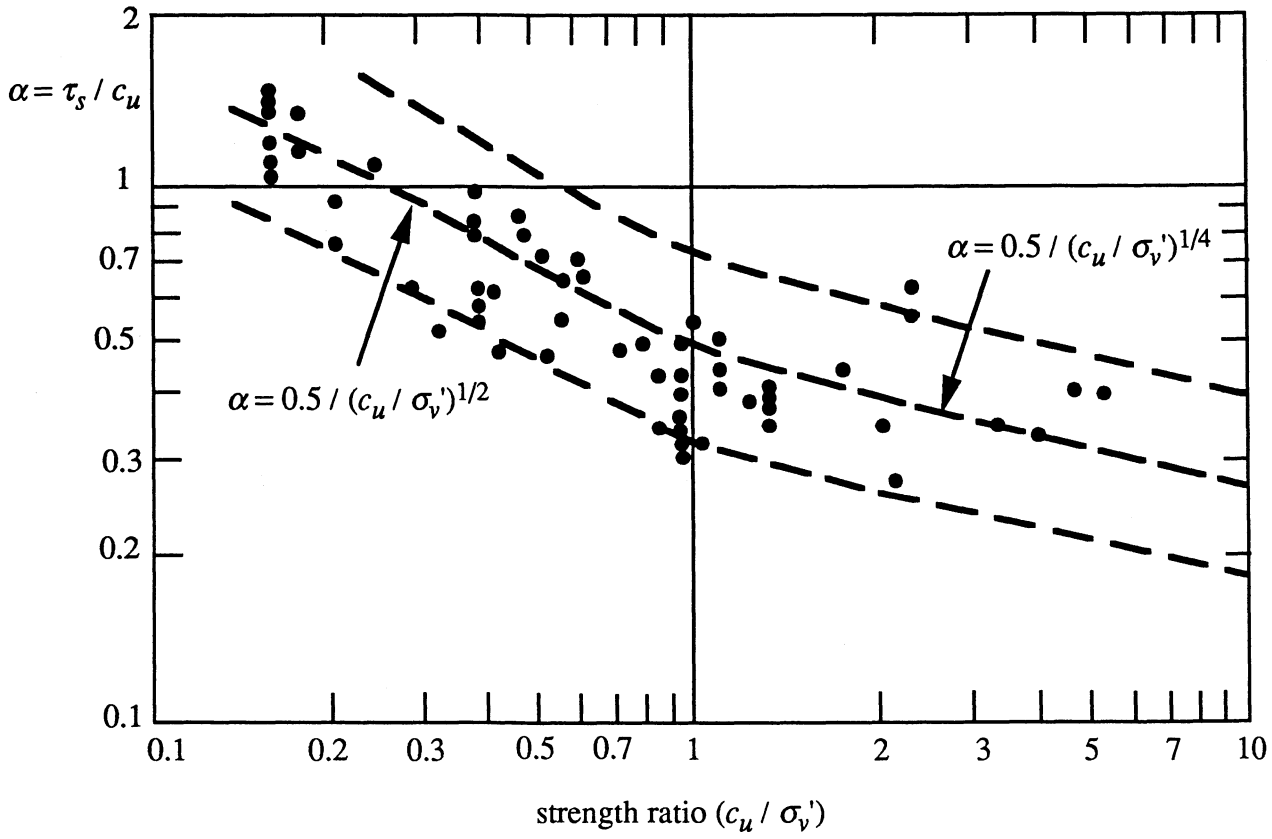

Fig. 2

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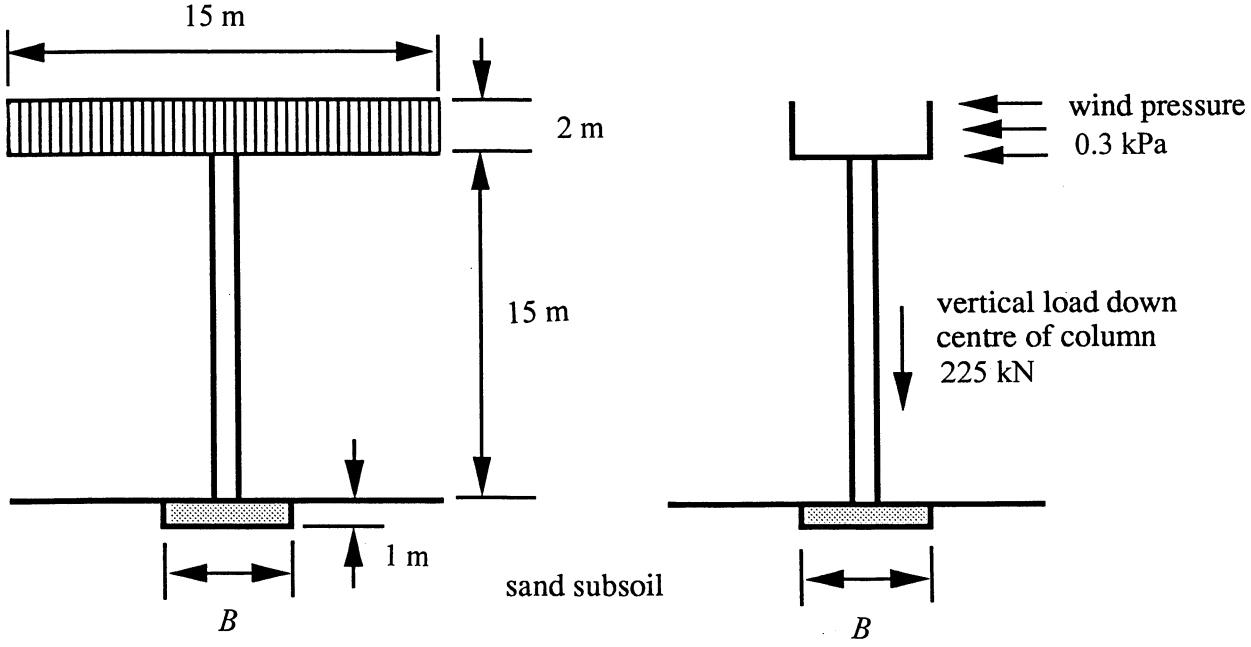
3 (a) Fig. 3 shows two elevations of the central support of a motorway footbridge. The foundation is to be a pad footing, square in plan, and it is to be designed to carry the vertical column load and the 15 m long section of the bridge indicated in Fig. 1. A horizontal wind pressure of 0.3 kPa may act on either side of the bridge, but the wind pressure on the column may be ignored. There is no horizontal force acting along the length of the bridge. The vertical working load on the footing is 225 kN. Assume that the net allowable bearing pressure on the sand subsoil is 200 kPa. Suggest a size for the pad footing. [45%]

(b) Discuss the methods available for designing a shallow footing which carries a doubly-eccentric load. [30%]

(c) The sand subsoil has an angle of friction of 30° and dry and saturated unit weights of 18 kN/m^3 and 20 kN/m^3 respectively. The groundwater level is at 2 m below ground level which is also the foundation level. Calculate the ultimate bearing capacity of the sand subsoil and hence the factor of safety against bearing capacity failure. [25%]



Elevation looking along the motorway

Elevation looking along the footbridge

Fig. 3

4 (a) A rigid vertical cylindrical pile of diameter 0.5 m and length 12.5 m carries a vertical load of 400 kN. The soil has a Poisson's ratio of 0.2 and its shear modulus G (MPa) = 0.7 z where z is the depth below the surface in metres. Calculate the pile settlement. Assume a radius of pile influence of 15 m. [25%]

(b) Four of the piles in (a) are arranged with their centres at the corner of a square of side length 1.5 m. A rigid cap is cast on the pile group. Assuming that the pile cap derives no support from the soil, calculate the settlement of the group for a central load of 1600 kN. [25%]

(c) Calculate the settlement efficiency of the pile group in (b) using two different methods and comment on your answers. [40%]

(d) How does the settlement efficiency of a pile group change when:
(i) the pile spacing is increased for the same number of piles; and
(ii) the number of piles is increased at the same spacing. [10%]

END OF PAPER