PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATION – December 02
98-CIV-B3 GEOTECHNICAL DESIGN

3 HOURS DURATION

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Any non-communicating calculator is permitted. This is an OPEN-BOOK exam. The candidate must indicate the type of calculator being used (i.e. write the name and model designation of the calculator, on the first inside left hand sheet of the exam workbook).

3. Answer **any two questions in Section A** and any **three questions in Section B.**

4. **Extra questions answered will not be marked.**

5. Questions will have the values shown.

6. Candidates must identify **clearly the source of design charts used** and where applicable the **source of assumed values used** in the calculations.

7. In the absence of specific information required in the formulation of problems, the candidate is expected to exercise sound engineering judgment.

8. Figures follow the text of the exam.

SECTION A
ANSWER ANY **TWO** QUESTIONS

1. (a) Geotechnical engineering problems can be divided into two broad categories of *stability* and *deformation*. What does this statement mean? Identify two examples when each or both these conditions dominate.

(Value: 10 marks)

(b) In the ϕ equals zero concept, explain why a frictional material such as soil appears to behave as if it were purely frictionless. How do we apply the ϕ equals zero concepts to foundation problems? Give examples.

(Value: 10 marks)

2. (a) "The magnitude of earth pressure depends upon the relative movement of an earth retaining structure". Explain and illustrate with suitable examples.

(Value: 10 marks)

(b) The following is a quote from a Foundation Manual: "In determining the load distribution in a pile extending through layers of weaker soils to a very competent stratum, such as a dense gravel, resistance should be assumed mobilized in this stratum, only". Explain the reasoning behind or the justification for this statement.

(Value: 10 marks)

3. (a) Discuss the reasons for excavations losing strength with time and embankments gaining strength with time.

(Value: 10 marks)

(b) Suggest a suitable type of foundation that you would recommend for the following cases:
(i) for a TV tower that is 50 m in height
(ii) for an industrial structure (housing dynamic loading equipment) that has to be constructed on a loose sand deposit extending to a 20 m depth.
State specific reasons for your recommendation, in both cases

(Value: 10 marks)

SECTION B
ANSWER ANY THREE OF THE FOLLOWING FOUR QUESTIONS

4. Design a suitable shallow square foundation system for an industrial structure. A structural load of 500 kN acts on each column. The soil properties are given below:

Organic silt layer 0.15 m, $C_u = 15$ kPa
Total density, $\rho = 1.80$ Mg/m^3

Sand layer extends down to 15 m. The total density, $\rho = 1.92$ Mg/m^3
Average N value is equal to 18.

The natural ground water level is found to be at a depth of 20 m. The proposed foundation is to be placed at a depth of 3m. Tolerable settlement for this foundation is 20 mm. Determine the allowable load and the ultimate bearing capacity, q_{ult}, for the foundation?

(Value: 20 marks)

5. A square footing shown in **Figure Q.5** is designed for carrying a load of 400 kN. The soil properties are given below:
Swelling index, $C_s = 0.06$, Compression index, $C_c = 0.25$, Average initial void ratio $e_o = 1.19$
Using the 2:1 approximation for stress increase with depth, compute the consolidation settlement in the clay caused by the footing. Consider the footing width = 2m and clay layer thickness = 3m.

(Value: 20 marks)

6. A gravity retaining wall is shown in **Figure Q.6.** Calculate the factor of safety with respect to overturning. Use Coulomb's active pressure for the calculation and a soil-wall friction angle $\delta = 2/3\phi$.

(Value: 20 marks)

7. Calculate the theoretical value of the depth of embedment, D, for the anchored sheet pile shown in **Figure Q.7.** Also, draw the pressure distribution diagram and determine the anchor force per unit length. Use the free support method.

(Value: 20 marks)

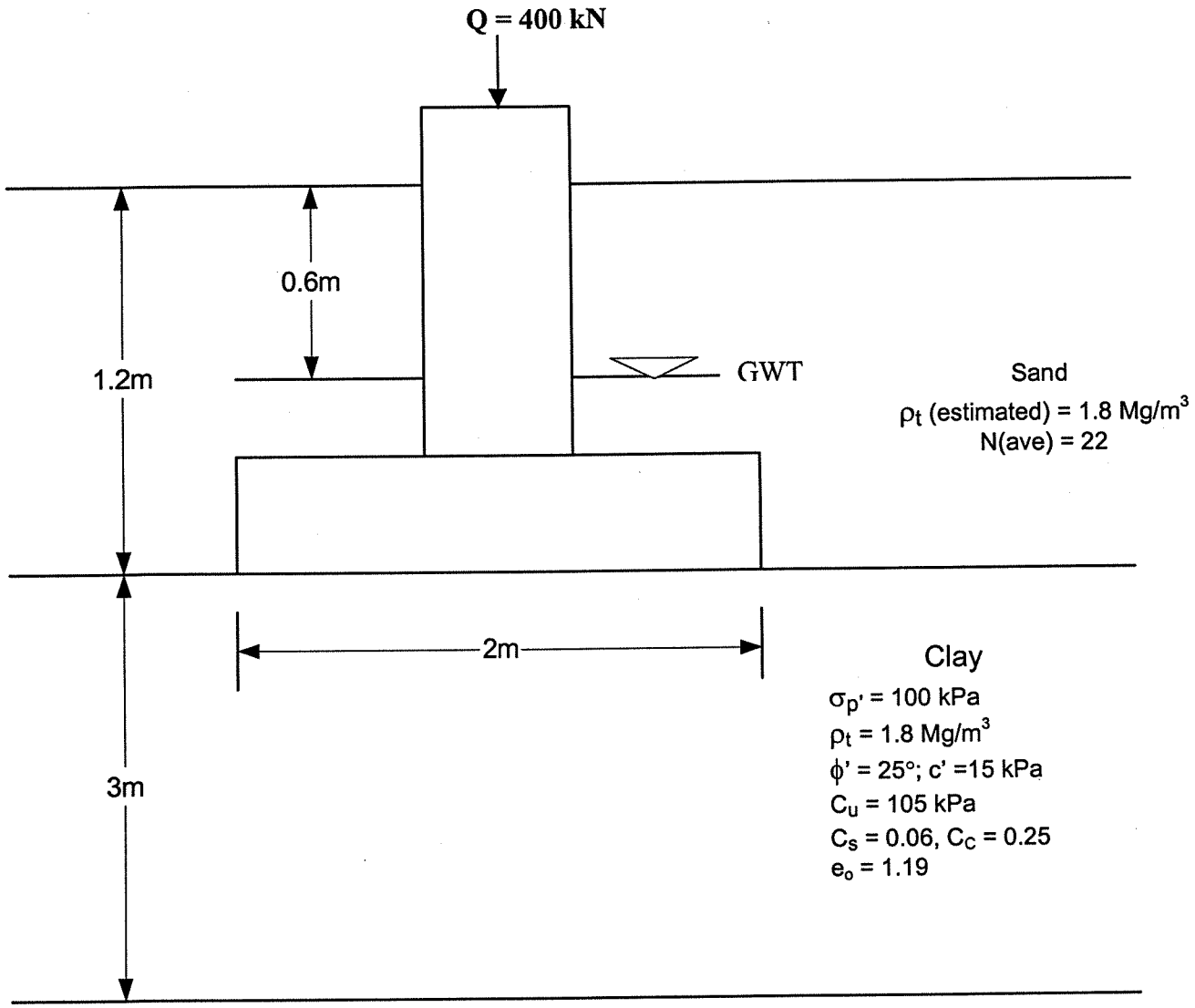
Q = 400 kN
0.6m
1.2m
GWT
Sand
ρt (estimated) = 1.8 Mg/m3
N(ave) = 22
2m
Clay
σp' = 100 kPa
ρt = 1.8 Mg/m3
ϕ' = 25°; c' =15 kPa
Cu = 105 kPa
Cs = 0.06, Cc = 0.25
eo = 1.19
3m

Figure Q.

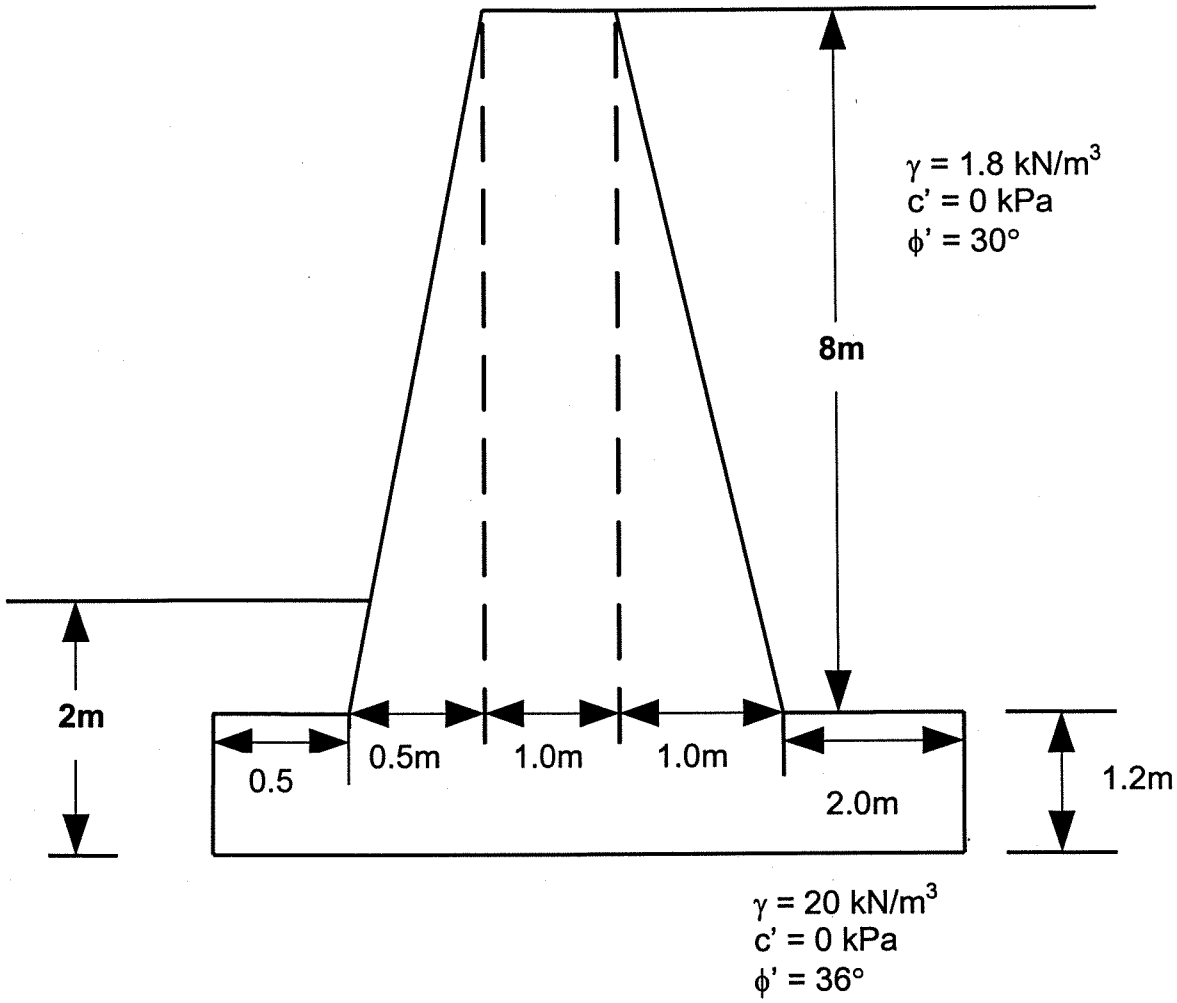
γ = 1.8 kN/m3
c' = 0 kPa
ϕ' = 30°
8m
2m
0.5
0.5m
1.0m
1.0m
2.0m
1.2m
γ = 20 kN/m3
c' = 0 kPa
ϕ' = 36°

Figure Q.

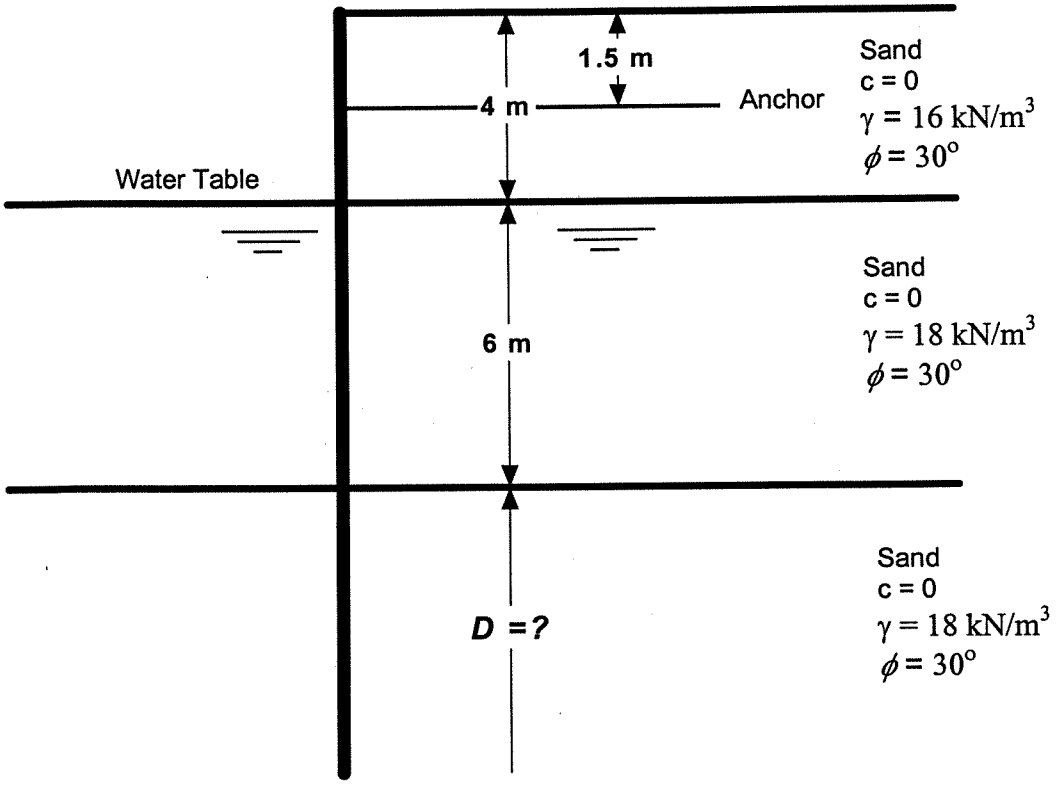
1.5 m
4 m
Anchor
Sand
c = 0
γ = 16 kN/m³
ϕ = 30°
Water Table
Sand
c = 0
γ = 18 kN/m³
ϕ = 30°
6 m
D =?
Sand
c = 0
γ = 18 kN/m³
ϕ = 30°

Figure Q. 7