PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS – May 2009
98-CIV-B3GEOTECHNICAL 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 FOUR questions in Section A** and any **THREE questions in Section B.**

4. **Only the answers submitted to the first four questions of Section A and the first three questions of Section B will be marked. 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 **FOUR** QUESTIONS

Question 1:
Geotechnical engineering problems can be divided into two broad categories of *stability* and *deformation*. What does this statement mean? Explain with a practical example when each of these conditions dominates.

(Value: 7 marks)

Question 2:
Suggest a suitable type of foundation that you would recommend for the following cases:

(i) for a TV transmission tower that is 40 m in height constructed on an expansive soil deposit.

(ii) For a large shopping complex with underground shopping and parking facilities on a loose sand deposit extending to a 20 m depth.

State specific reasons for your recommendation, in both cases

(Value: 7 marks)

Question 3:
Slopes that are in imminent danger of failing may be stabilized using two different approaches. Explain one of these approaches with sketches.

(Value: 7 marks)

Question 4:
Briefly explain the engineering significance of the following terms a) Active Zone in Expansive soils, and b) Negative skin friction in pile foundations.

(Value: 7 marks)

Question 5:
Geotextiles and geosynthetics have been increasingly used to improve the performance and also to reduce the costs associated with the construction of retaining walls on highways in recent years. Explain in your words how these objectives are achieved in engineering practice.

(Value: 7 marks)

SECTION B
ANSWER **ANY THREE** OF THE FOLLOWING FOUR QUESTIONS

Question 6: **(Value: 24 marks)**

Calculate the ultimate bearing capacity of a square footing of 1.5 m size resting on the surface of a cohesionless sand stratum, which lies 1.5 m below natural ground level. The footing details along with groundwater table conditions are shown on **Figure 1** below. The 1.5 m depth of soil above the foundation is clay with the following properties: γ_{total} = 17 kN/m^3, γ_{sat} = 19 kN/m^3, undrained cohesion, c_u = 50 kPa and ϕ_u = 0. The properties of the sand stratum are γ_{sat} = 20 kN/m^3 and ϕ' = 40 degrees. Use the general bearing capacity equation. State clearly your assumptions for solving this problem.

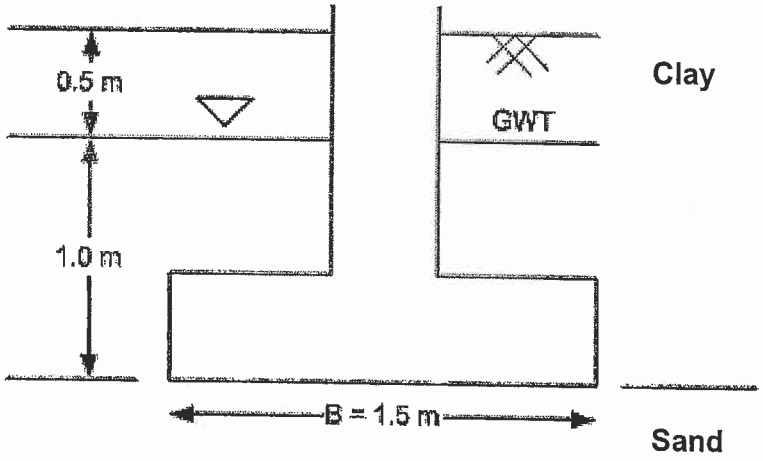

Figure 1

Question 7: **(Value: 24 marks)**

A slope is constructed with a clayey soil. The height of the slope is 12m and the slope face is inclined at a 2:1 (horizontal: vertical) ratio. The unit weight γ = 17.8 kN/m^3 of the clayey soil and the shear strength parameters were c'=20 kN/m^2 and ϕ' = 30°. Calculate the factor of safety of the slope.

a. The ground water table is well below the slope.
b. The ground water table is 5 m vertically below the ground surface and parallel to ground surface.

Question 8: **(Value: 24 marks)**

Bored piles of 250 mm diameter are proposed to be designed as a pile group to carry a load of 1000 kN on a soil deposit of clay having the following properties:

Depth (m)	Unit weight of soil (kN/m^3)	Undrained shear strength (kN/m^2)
0	18	40
2	18.5	50
4	19	60
6	19.5	70
8	20	80
10	20	90
12	20	100

If the piles are 10 m long, estimate the number of piles required in the pile group and suggest how they should be arranged. Also, determine the pile group efficiency. If the liquid limit of the clay is 40%, what will be the approximate settlement in the clay layer due to this loading. **Note: Make any suitable assumptions in solving this problem.**

Question 9: **(Value: 24 marks)**

Details of a cantilever retaining wall are shown in **Figure 2** along with the backfill properties. A uniform load of 15 kN/m^2 is applied to the soil surface behind the wall. The unit weight of the material is 23.5 kN/m^3 and the friction between the base and the foundation soil, δ' is equal to $0.75\phi'$.

Notes:

i) The soil properties of **Soil III** are the same to those of **Soil II**; and ii) Neglect passive pressure.

Determine the factor of safety (FS) against; (a) Overturning, and (b) Sliding

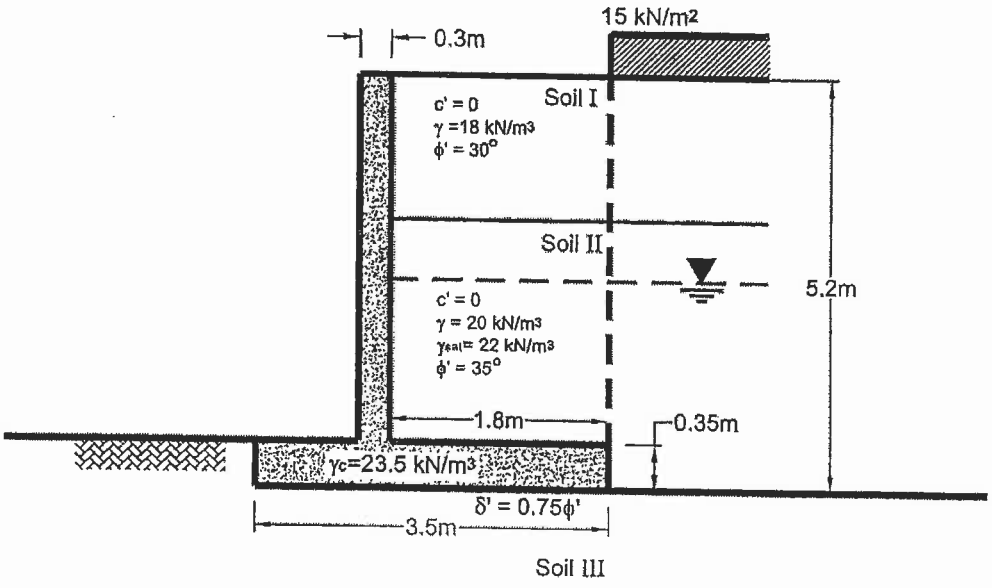

Figure 2