PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS – May 2014
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 FOUR questions in Section A** and any **THREE questions in Section B.**

4. **Only the first four answers submitted in Section A and the first three answers 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:
What are the limitations of the Terzaghi Bearing Capacity equation compared to the General Bearing Capacity equation?

(Value: 7 marks)

Question 2:
As a junior geotechnical engineer you were asked to determine the short term stability of a soft clay natural slope. Provide a summary of how you would proceed with the site investigation and laboratory studies to determine the said stability.

(Value: 7 marks)

Question 3:
You have been assigned another job as a junior geotechnical engineer to determine the settlement behavior of the sand on which a 10 storey five star hotel is proposed to be constructed with an underground garage. How would you proceed with the site investigation studies and other necessary tests to reliably estimate the settlement?

(Value: 7 marks)

Question 4:
The ultimate bearing capacity obtained from a plate load test is the same as that of a proposed foundation in a saturated clay regardless of size of plate (B_P) and foundation (B_F) [i.e. $(q_{ult})_P = (q_{ult})_F$]. Prove this statement using the Terzaghi bearing capacity equation given below using appropriate bearing capacity factors. State the assumptions that you made to answer this question.

$$qult = CN_c + qN_q + 0.5\gamma BN_\gamma$$

(Value: 7 marks)

Question 5:
A retaining wall of 5 m height is proposed to be constructed in a city with restricted space. Conventional retaining walls such as gravity or cantilever walls are not suitable. In such a scenario, what type of retaining wall or other structure do you recommend? Explain with a neat sketch providing some key construction/design details

(Value: 7 marks)

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

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

Check the stability of the cantilever wall shown in **Figure 1** against (a) sliding and (b) overturning. Use Rankine's theory.

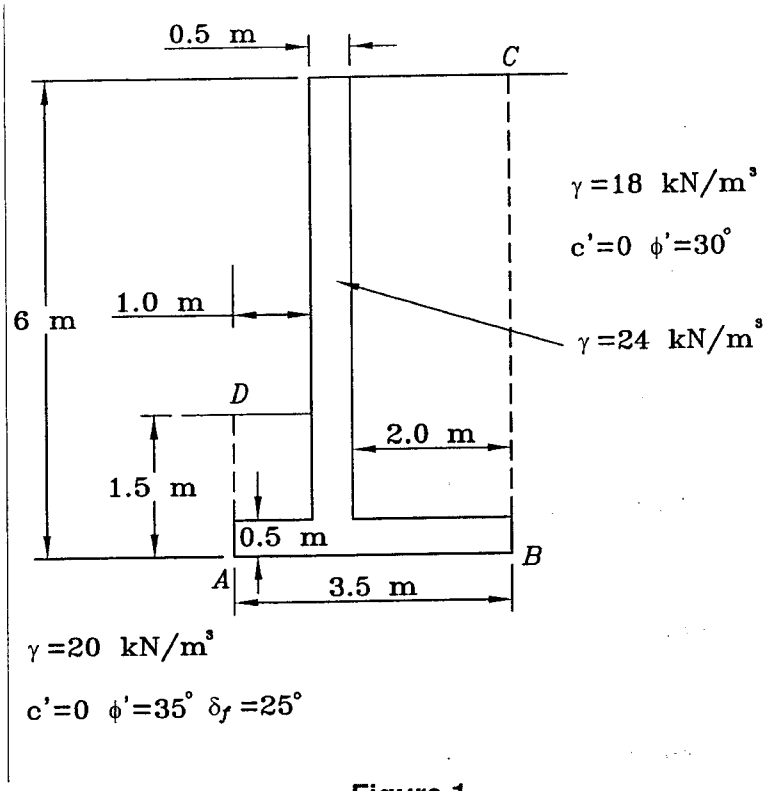

Figure 1

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

Bored cast-in-place concrete piles of 300 mm diameter are proposed to be designed as a pile group to carry a load of 1800 kN in a 12m deep 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	34
2	18.5	44
4	19	55
6	19.5	66
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 8: **(Value: 24 marks)**

Figure 2 illustrates the cross-section of a slope and a potential circular failure surface. The undrained shear strength of the soil is assumed uniform. Calculate the short-term factor of safety corresponding to the failure surface illustrated on the figure.

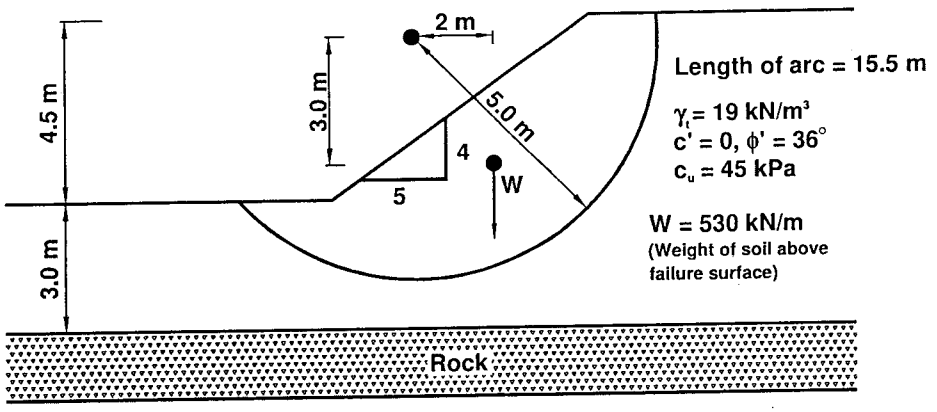

Figure 2

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

A column carries a vertical downward load of 600 kN. This load is proposed to be supported on a 2.0 m deep square footing. The soil which is normally consolidated beneath the footing has the following properties: γ = 19 kN/m^3, c' = 0.5 kPa, ϕ'= 36°, undrained cohesion, c_u = 150 kPa, undrained friction angle, ϕ_u = 0. Sub-surface investigations show that the groundwater table is reasonably stable throughout the year at a depth of 7.0 to 8.0 m below the natural ground surface. Determine the width of the footing for the above specifications such that the short-term factor of safety is equal to 2. **Use Meyerhof's general bearing capacity analysis.**