**PROFESSIONAL ENGINEERS ONTARIO**
**NATIONAL EXAMINATIONS – December 2008**
**98-CIV-B3 GEOTECHNICAL DESIGN**

**3 HOURS DURATION**

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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.

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# SECTION A
# ANSWER ANY **FOUR** QUESTIONS

**Question 1:**
Provide **reasons with theoretical or mathematical explanation** why a steep excavation in a clayey soil can be stable for a short period of time without any lateral support.

**(Value: 7 marks)**

**Question 2:**
What is the rationale of using Standard Penetration Test (SPT) results in the design of foundations in coarse-grained soils? What are the most common recommendations with respect to the use of SPT results in the design of foundations?

**(Value: 7 marks)**

**Question 3:**
Provide a detailed explanation why the factor of safety of slopes for long-term stability is typically lower than the factor of safety for short-term stability.

**(Value: 7 marks)**

**Question 4:**
What is the purpose of the factor $\alpha$ in the calculation of the carrying capacity of an augered cast in place pile? When do you prefer to use the $\alpha$ method in comparison to the $\beta$ and $\lambda$ methods?

**(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 along 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)**

A reinforced concrete retaining wall along with soil properties are shown in Figure 1 below. The stability of this structure which was constructed several decades ago was questioned. Check the Factor of Safety (FS) of this structure against horizontal sliding and overturning moment neglecting the passive resistance. What measures you suggest to improve the FS of this structure.

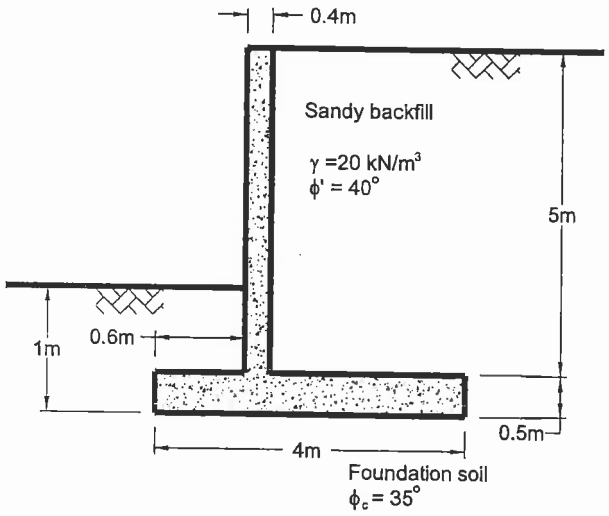


**Figure 1**

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

Figure 2 shows a 45° cut in a homogeneous clay with an undrained shear strength, $s_u$ = 50 kPa. The height of the cut is 10 m. The clay is considerably stiff below the base of the cut implying that failure is likely to occur along a slip surface through the toe of the excavation. Calculate the Factor of Safety (FS) for the slip surface shown.

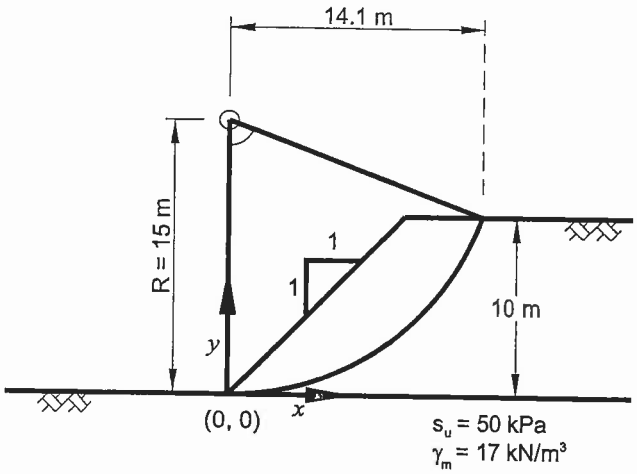


**Figure 2**

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

Bored piles of 300 mm diameter are proposed to be designed as a pile group to carry a load of 2000 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 | 70 |
| 2 | 18.5 | 80 |
| 4 | 19 | 100 |
| 6 | 19.5 | 110 |
| 8 | 20 | 110 |
| 10 | 20 | 120 |
| 12 | 20 | 120 |

If the piles are 9 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 45%, 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)**

A strip foundation on a layer of sand is shown in Figure 3 below, along with the variation of the modulus of elasticity of the soil, $E_s$. Assuming that $\gamma = 19$ $kN/m^3$ and assuming a creep time of 10 years for the correction factor $C_2$, calculate the elastic settlement of the foundation, using the Schmertmann's strain Influence Factor.

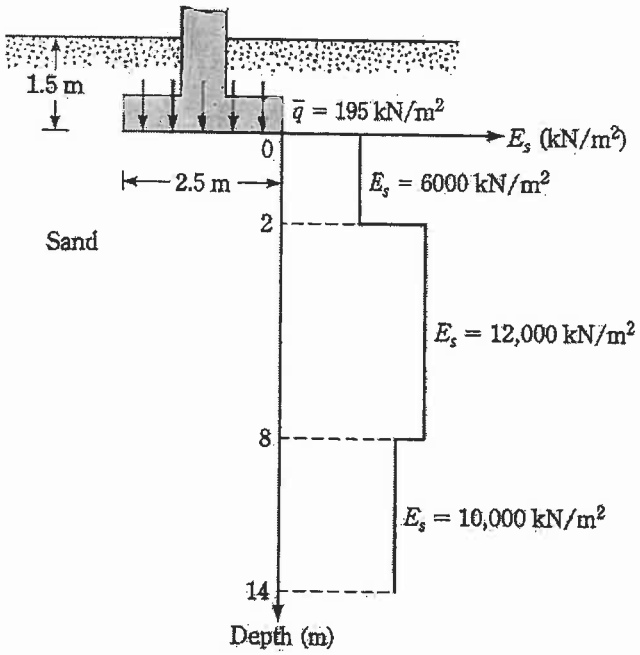
1.5 m
$\bar{q}$ = 195 kN/m²
$E_s$ (kN/m²)
0
2.5 m
$E_s$ = 6000 kN/m²
2
Sand
$E_s$ = 12,000 kN/m²
8
$E_s$ = 10,000 kN/m²
14
Depth (m)

**Figure 3**