PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS – December 2015
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.

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SECTION A
ANSWER ANY **FOUR** QUESTIONS

Question 1:
What is the rationale of using Standard Penetration Test (SPT) results in the design of foundations in coarse-grained soils? What are the recommendations of the Canadian Foundation Engineering Manual with respect to the use of SPT results in the design of foundations? **(Value: 7 marks)**

Question 2:
What is the purpose of the factor α in the calculation of the carrying capacity of an augered cast in place pile? When do you prefer to use the α method in comparison to the β and λ methods? **(Value: 7 marks)**

Question 3:
Explain the rationale of using the "ϕ equals zero" concept in the design of foundations? Give an example where you use this in engineering practice. **(Value: 7 marks)**

Question 4:
The soil profile at a site consists 5 m of highly expansive clay overlaying a very deep deposit of sand. A multi-story shopping complex is to be constructed on this site. What type of foundation do you recommend under such circumstances? Give reasons.
(Value: 7 marks)

Question 5:
A highway embankment slope is proposed to be constructed in a highly expansive soil deposit. As favourable soils are not available within close proximity, the embankment slope was also proposed to be constructed using local expansive soils. How would you go ahead with the site investigation studies with this project? More specifically, comment on how you would determine the shear strength parameters required for determining the stability of the slope. What other criteria should you consider in the design of this slope?
(Value: 7 marks)

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

Question 6: **(Value: 24 marks)**
For the cantilever retaining wall shown in **Figure 1** below, the wall dimensions are H=10m, x_1=0.5m, x_2=0.75m, x_3=1.5m, x_4=4 m, x_5= 1.2 m , D= 2.0 m, and $\alpha=10^\circ$; and the soil properties are γ_1=16.8 kN/m^3, $\phi_1=34^\circ$, γ_2=17.6 kN/m^3, $\phi_2=30^\circ$, and c_2=10 kN/m^2. Calculate the factors of safety with respect to overturning and sliding.

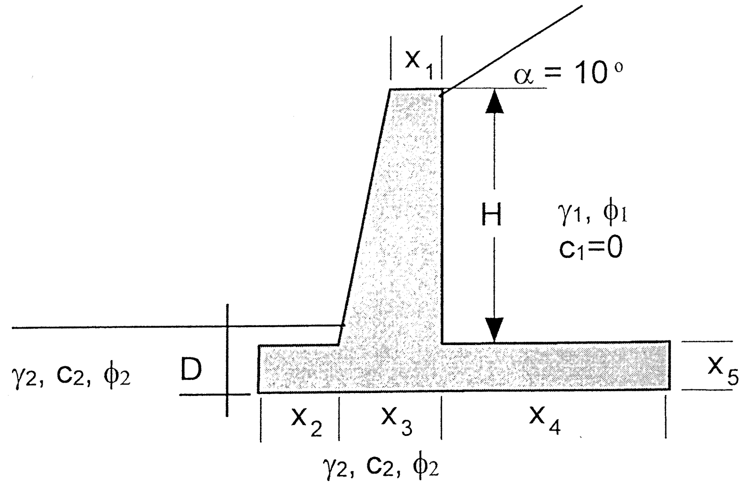

Figure 1

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

In **Table I** given below, the standard penetration test (SPT) results determined for a sandy soil deposit in the field are summarized. The ground water table was found to be located at a depth of 18m. Estimate the angle of internal friction, ϕ' from the provided data using an appropriate technique (give the source where this information is obtained) and design a shallow foundation measuring 2.5 x 2.5 m in plan. **Note: The design should be based on the angle of internal friction, ϕ', value.**

Table I

Depth [m]	Soil Unit Weight [kN/m³]	N_{60}
3	18.5	6
5	18.5	10
6	18.5	12
8	20.4	15
10	20.4	20
12	20.4	24
13.5	20.4	25
15	20.4	26

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

Determine the consolidation settlement of the footing shown in **Figure 2.** Given that B = 1.5 m, L = 2.5 m, and Q = 120 kN. Provide details of any two other methods that can be used for determining the consolidation settlement for the same problem. What additional data is necessary for the two methods you suggest?

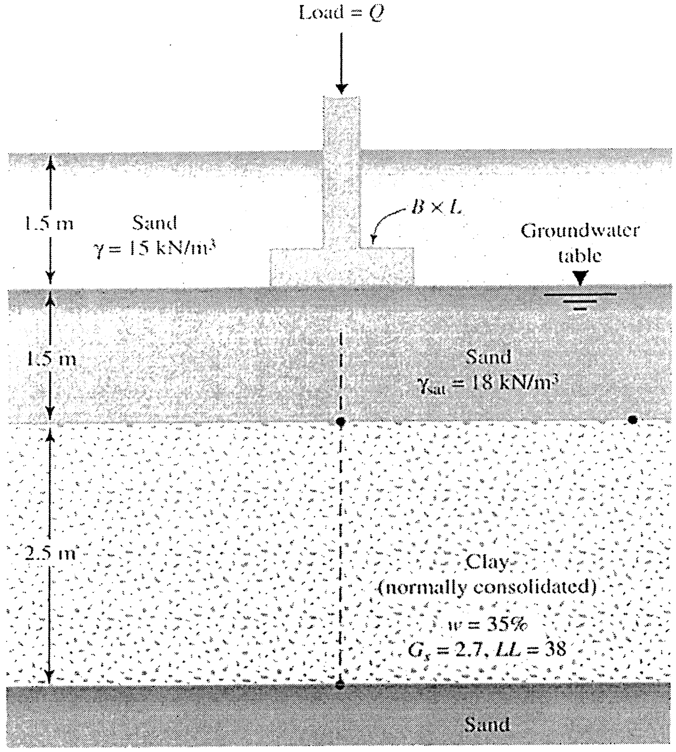

Figure 2

Note: Use $\Delta\sigma'_{av} = \dfrac{\Delta\sigma'_t + 4\sigma'_m + \Delta\sigma'_b}{6}$ for determining the average increase in the clay layer

where: $\Delta\sigma'_t$ = effective stress increase at the top of clay layer

$\Delta\sigma'_m$ = effective stress increase at the middle of clay layer

$\Delta\sigma'_b$ = effective stress increase at bottom of clay layer

Use any suitable method for finding the increase in stress $\Delta\sigma'$.

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

Figure 3 below illustrates the cross-section of a slope and a potential circular failure surface. Determine the factor of safety of the slope along the circular failure surface shown in the figure considering its short term stability. Assume the undrained shear strength value to be uniform for the soil. State whether the factor of safety of the same slope will be higher or lower if long term stability is considered. Give reasons.

Any assumptions used in solving the problem should be clearly stated in your answer book.

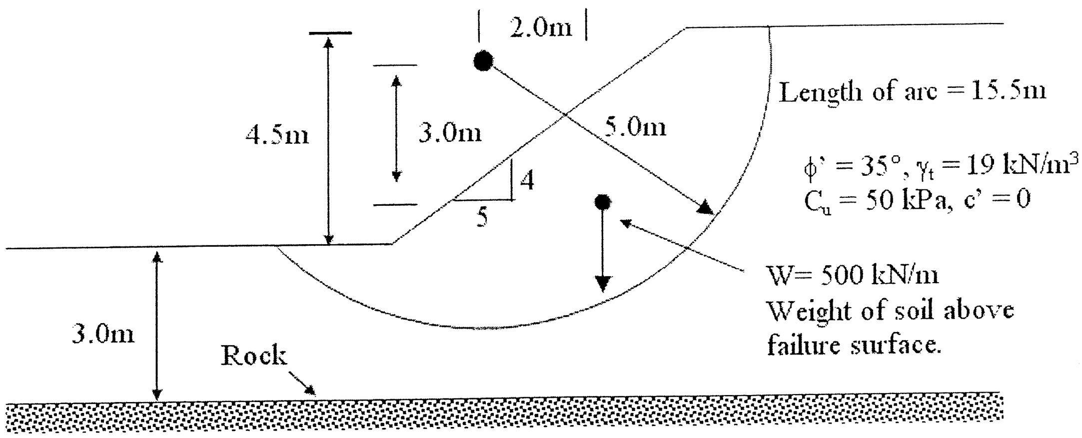
2.0m
4.5m
3.0m
5.0m
4
5
Length of arc = 15.5m
φ' = 35°, γt = 19 kN/m³
Cu = 50 kPa, c' = 0
W= 500 kN/m
Weight of soil above
failure surface.
3.0m
Rock

Figure 3