PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS – May 2015
07-Str-B1 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:
The skin friction that develops between the soil and the pile for soft clay is almost equal to the undrained strength of the clay; however, in stiff clay it is much less than the undrained strength? Give reasons.

(Value: 7 marks)

Question 2:
A continuous strip footing is suggested for sand as a foundation. Will its bearing capacity be the same or change during the design life period of this footing. If it changes; how and why does it change? Provide a detailed explanation.

(Value: 7 marks)

Question 3:
In many scenarios, "The magnitude of earth pressure depends upon the relative movement of an earth retaining structure". Explain this statement and illustrate with a suitable example how passive earth pressure is generated.

(Value: 7 marks)

Question 4:
You have been assigned a job as a geotechnical engineer for the design of foundations for a ten story five star hotel in a sandy soil deposit. The ground water table is shallow (i.e. at a depth of 2 m). How do you proceed with a site investigation plan for this project? What are the key properties that you would like to determine from these investigation studies for the design of pile foundations.

(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)**

Calculate the ultimate bearing capacity of a square footing of 1.5 m size resting on the surface of a sand stratum, which lies 1.5 m below natural ground level. The footing details along with groundwater table conditions are shown in the **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, c' = 2 kPa and ϕ' = 40 degrees. Use the general bearing capacity equation. State clearly your assumptions for solving this problem.

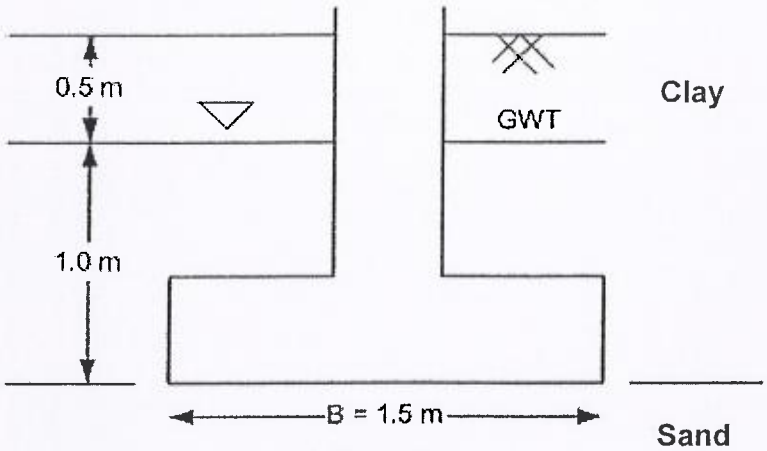

Figure 1

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

Compute the load carrying capacity of a 16 pile group (i.e. 4 x 4) made up of 12 m long cylindrical piles of 500 mm diameter in soft clay of average undrained strength of 50 kPa. Make any suitable assumptions necessary, providing justifications. Also, comment on what other criteria should be considered for the design of this pile group.

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?

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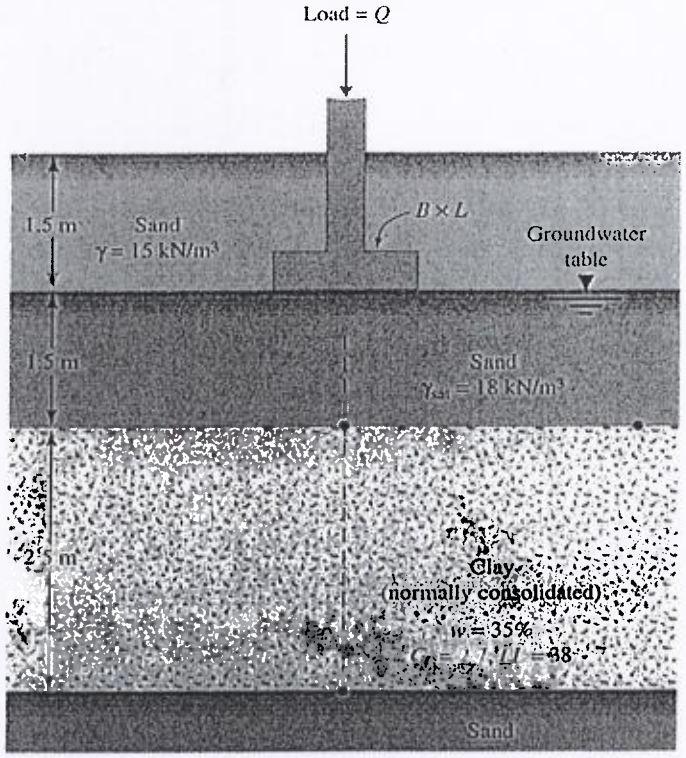

Figure 2

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)**

A gravity retaining wall is shown in **Figure 3.** The ground water table is very deep. Calculate the factor of safety with respect to overturning. Use Coulomb's active pressure for the calculation and a soil-wall friction angle $\delta = 0.6\phi'$. Will the factor of safety increase or decrease if the ground water rises to the base of the retaining wall.

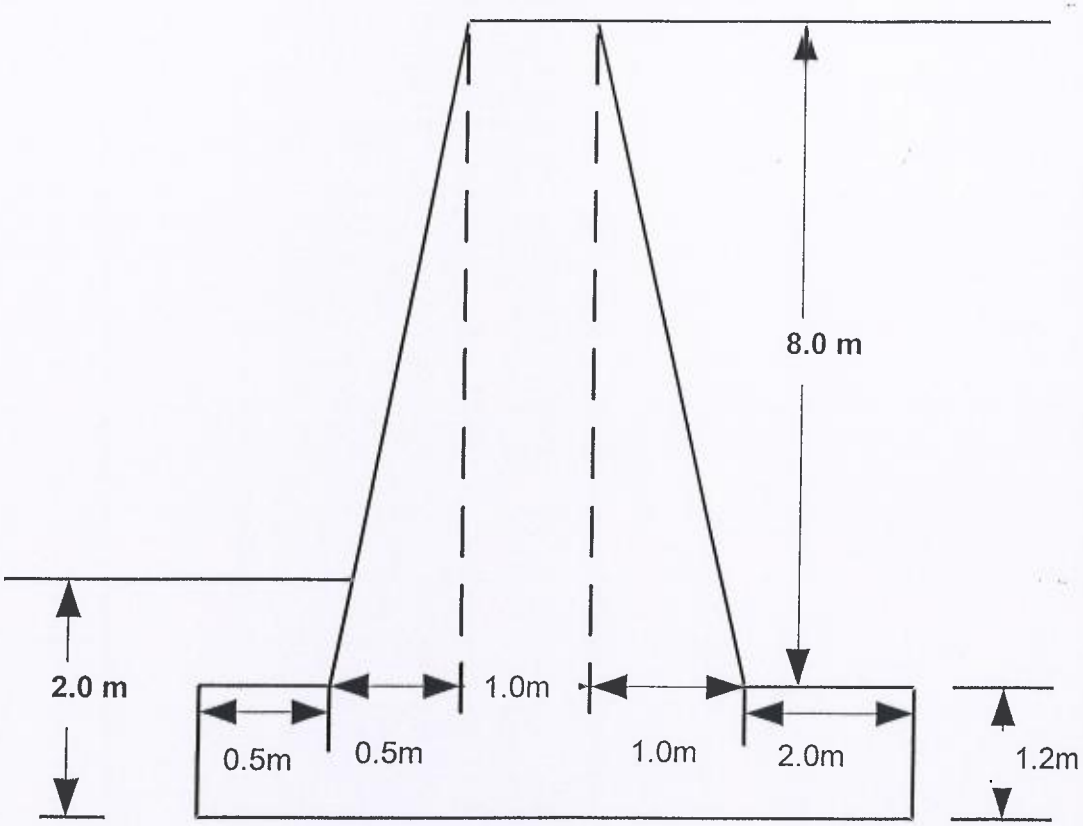

Figure 2

$\gamma = 20$ kN/m^3
$c' = 0$ kPa
$\phi' = 30°$