PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS – May 2017
16-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:

You have been assigned a job to suggest and design a suitable foundation for a condominium complex in a Toronto downtown area which has silty soil deposits. The key objective for you as a geotechnical engineer is to determine the bearing capacity and settlement behavior. **Figure 1** below shows various equipment that is available in the consulting firm that you are presently working. What equipment /tests do you suggest using for reliably estimating or determining the bearing capacity and settlement behavior for this silty soil?

Hint: You don't have to use all the equipment shown in the Figure 1 below. It is going to be a waste of time and resources of your consulting firm if you propose to use all the equipment. In addition, this does not mean that you have to use only just one of them. **Use your engineering judgment and provide your recommendations with justification.**

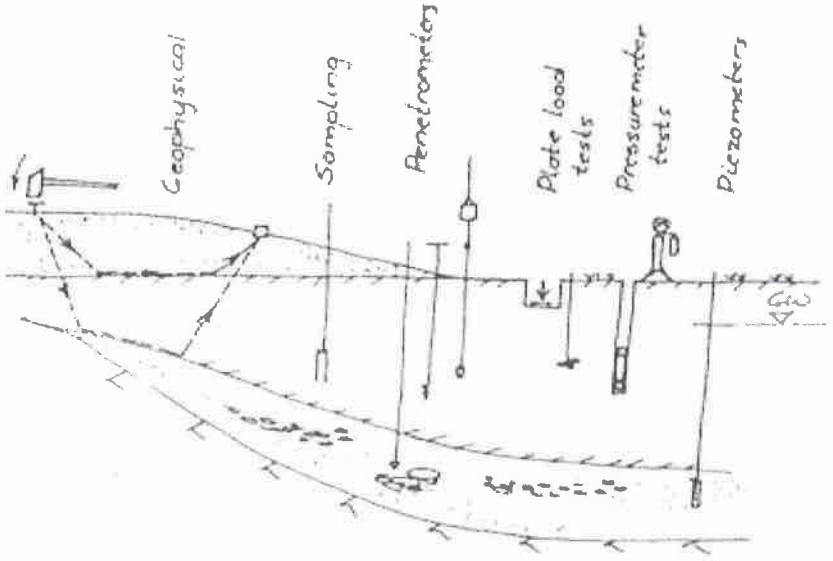

Figure 1

(Value: 7 marks)

Question 2:

Enumerate the triaxial or direct shear tests that you would suggest to be carried out for determining the shear strength parameters of the soils for the following field problems:

(i) Long term stability of a clay foundation of an embankment,
(ii) Short term stability of a footing on saturated clay
(iii) Long-term stability of a slope in fissured expansive clay.

Give your reasons for your choice of test.

(Value: 7 marks)

Question 3:
What is the need for correcting the field standard penetration test values for a sandy soil from an engineering practice point of view? What would be the governing parameter in the design of a shallow foundation in a typical dense sand: stability or settlement? Give reasons.

(Value: 7 marks)

Question 4:
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. **Hint:** Concepts related to lateral earth pressure theory will be useful in answering this question.

(Value: 7 marks)

Question 5:
When do you prefer to use CPT results in comparison to SPT results in conventional geotechnical engineering practice?

(Value: 7 marks)

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

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

Determine the design axial capacity of the pile shown in **Figure 2**, using a factor of safety of 2. Make reasonable assumptions providing justifications.

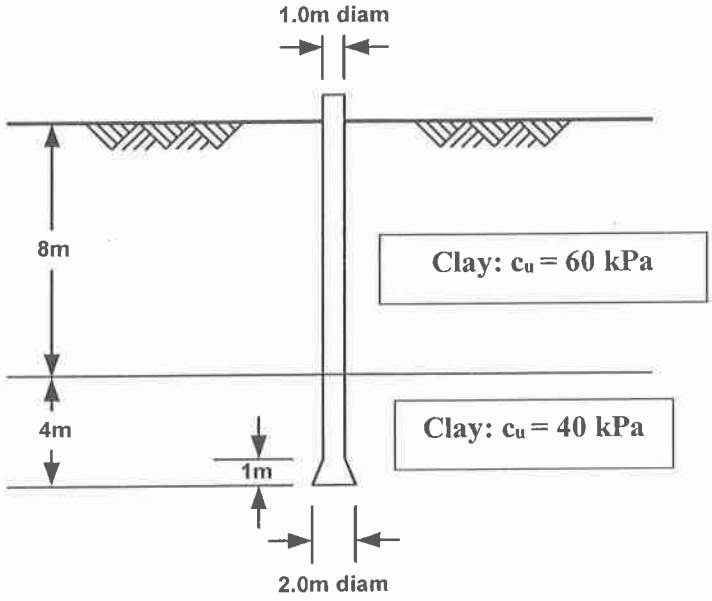

Figure 2

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

For the continuous (i.e. strip) foundation (B = 1.5m) given in **Figure 3** below.

a) Calculate the allowable bearing capacity (FS = 3) using the Terzaghi Bearing Capacity Equation. The ground water table is at a depth of 1m below the ground surface.
b) Repeat for a square foundation (i.e. B × L = 1.5m × 1.5m) using the Terzaghi Bearing Capacity Equation. The level of ground water table has dropped to 2m below the ground surface in connection with the active use of the groundwater (assume that void ratio, e and water content, w above ground water table are the same.
c) Repeat for a load inclined at an angle of 15° to the vertical using the General Bearing Capacity Equation.

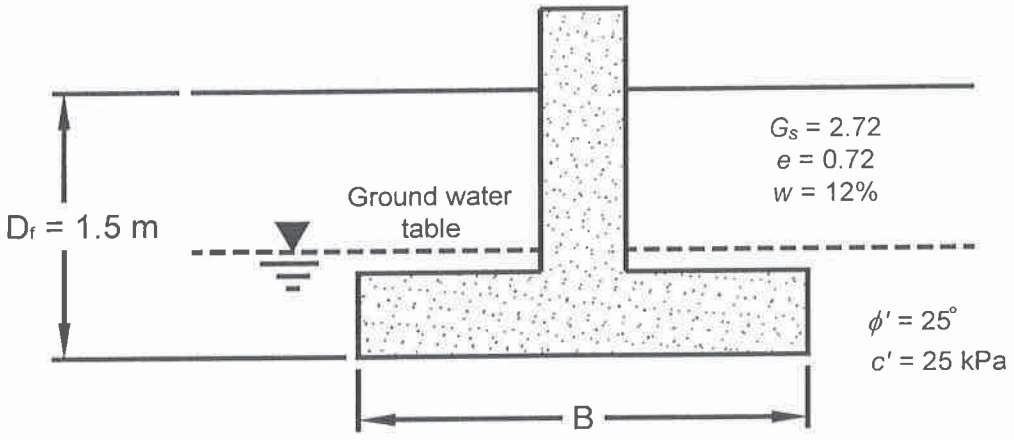

Figure 3

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

An anchored sheet pile wall is constructed by driving a line of piling into a soil (**Figure 4**) for which the saturated unit weight is 21 kN/m^3 and the characteristic shear strength parameters are c' = 10 kN/m^2 and ϕ' = 27°. Backfill is placed to a depth of 8.00 m behind the piling, the backfill having a saturated unit weight of 20 kN/m^3, unit weight of the soil above the water table of 17 kN/m^3 and characteristic shear strength parameters of c' = 0 and ϕ' = 35°. Tie rods, spaced at 2.5 m centres, are located 1.5 m below the surface of the backfill. The water level in front of the wall and the water table behind the wall are both 5.00 m below the surface of the backfill.

Determine

a. Required depth of embedment for a factor of safety of 2 with respect to gross passive resistance
b. Force in each tie rod

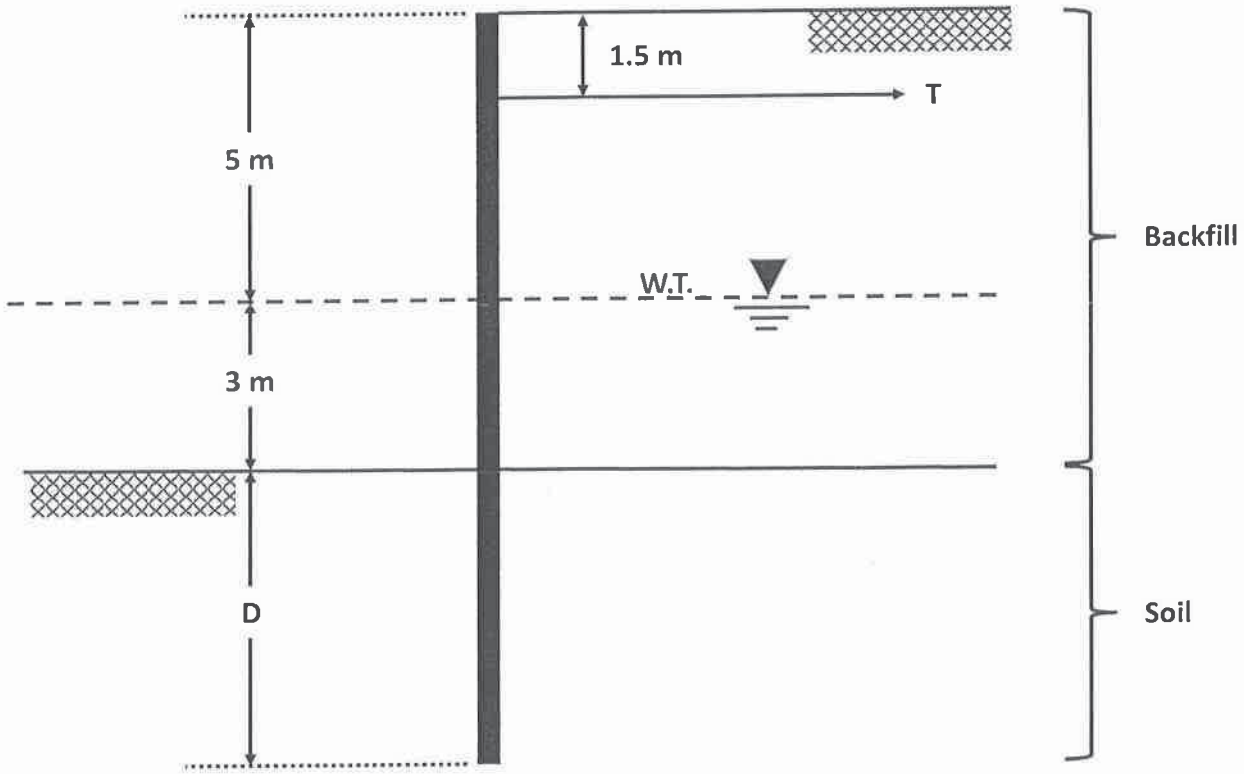

Figure 4

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

For a 4 × 4 concrete pile group (pile diameter = 406 mm) shown in **Figure 5**, determine the ultimate load capacity of the pile group considering negative skin friction. Given that L = 15 m, $\gamma_{sat(fill)}$ = 18.5 kN/m^3, ϕ'_{fill} = 35°, $\gamma_{sat(clay)}$ = 19.5 kN/m^3, ϕ'_{clay} = 20°, and H_f = 3 m. The water table coincides with the top of the sand fill. Assume that the pile group fails as individual piles (i.e. single pile failure mode).

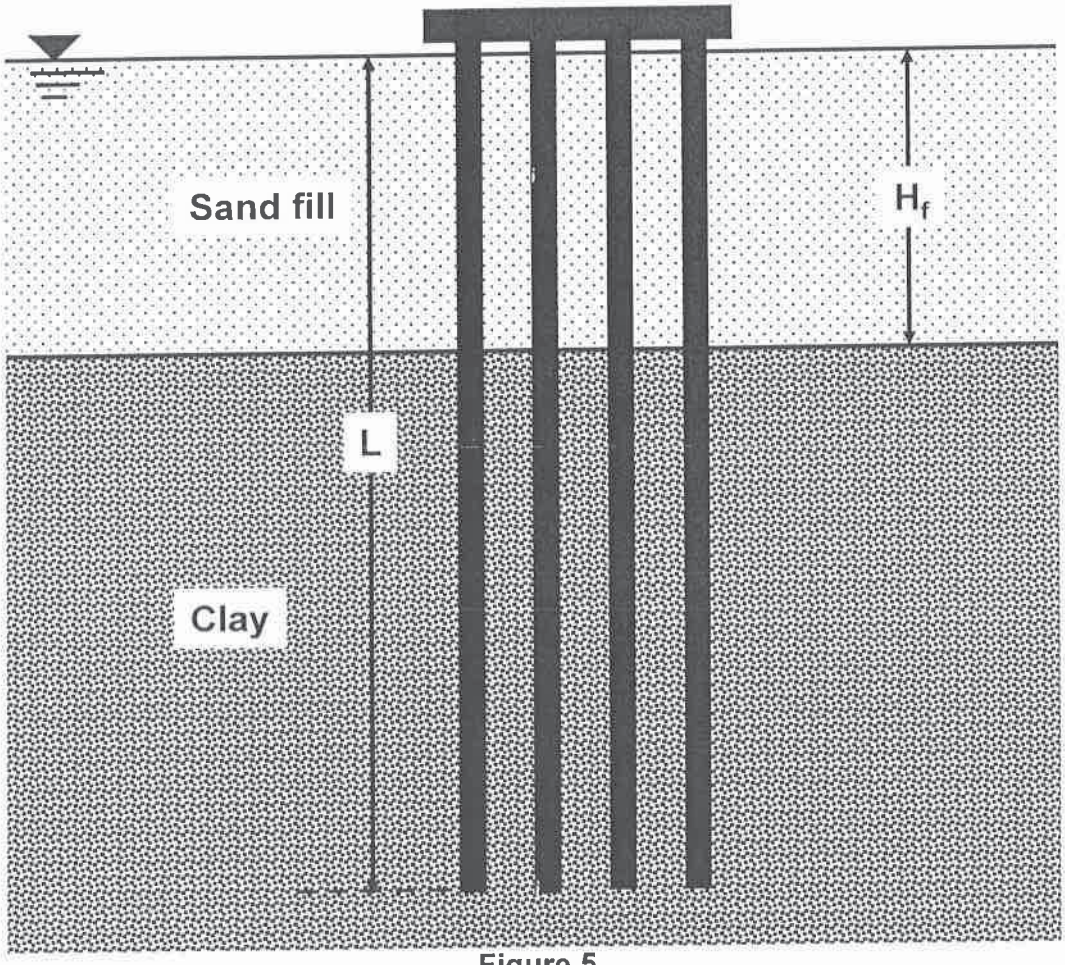

Figure 5