PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS – December 2013
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:
Figure 1 below shows various equipments available in the consulting firm that you are presently working for as a junior geotechnical engineer. You have been assigned a job to design a shallow foundation for a condominium complex. The key objective for you is to determine the bearing capacity and settlement behavior. The soil at the site consists of sandy soil with the ground water table located at a great depth (i.e., more than 15 m). What equipment would you use for determining the bearing capacity and settlement behavior of the sand? Also, clearly explain the limitations of the equipment that you will use for determining the bearing capacity and settlement behavior **(Hint: You don't have to use all the equipment shown in the figure or just use only one of them. Use your engineering judgment and answer this question.)**
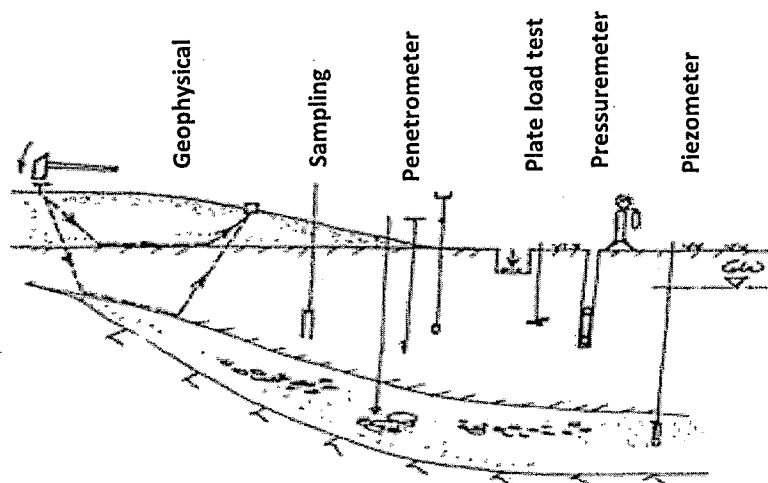

Figure 1

(Value: _7 marks_)

Question 2:
Which one of the following methods; α, β or λ methods would you recommend for estimating the short term load-carrying capacity of a single pile in soft saturated clay? What is the information that you would collect from the field or laboratory tests? Comment on the strengths and limitations of this method.

(Value: _7 marks_)

Question 3:
Figure 2 shows a failure mechanism associated with the wall movement of a retaining wall due to earth pressure. Explain this failure using the Mohr circles and Mohr-Coulomb failure envelope.
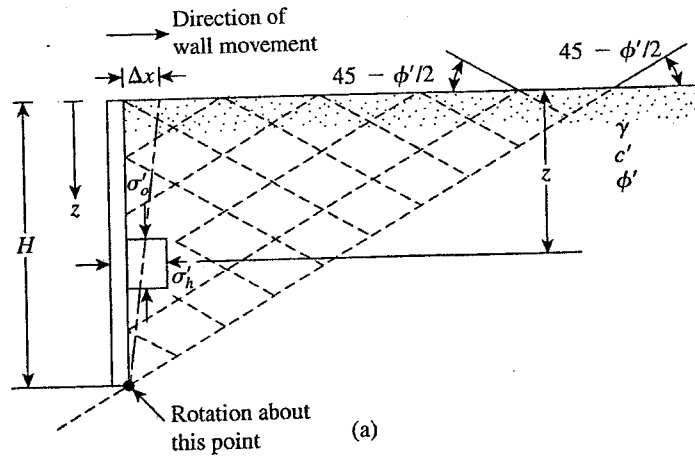
Figure 2

(Value: **7 marks**)

Question 4:

Relatively lower safety factors are recommended for long term stability of slopes. Explain the reasons associated with such a recommendation. What are the appropriate shear strength parameters and the other properties that are required in determining the long-term stability of a slope for an earthen dam constructed with a clayey type of soil? Also, what tests do you recommend to conduct to determine these parameters?

(Value: **7 marks**)

Question 5:

A retaining wall of 6 m height is proposed to be constructed in a city where favourable backfill material is not available. The only soil that is available for use as backfill material is expansive clay with a high plasticity index. What are the likely problems associated with using this clay as a backfill material instead of sand? What precautions and design measures would you suggest for designing this retaining wall?

(Value: **7 marks**)

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

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

Determine the maximum allowable bearing capacity that a square foundation (B × B = 1 m × 1 m) constructed in a coarse-grained soil can carry. The factor of safety should be greater than 3 and the permissible settlement is 25 mm. The variation of E_s (i.e. elastic modulus) with depth obtained from CPT test is shown in **Figure 3**. Use Terzaghi's bearing capacity equation and the strain influence factor method to calculate the bearing capacity and settlement, respectively. The average unit weight of the sand and internal

friction angle is 20 kN/m^3 and 36°, respectively. Also, estimate how much the bearing capacity would be reduced if the ground water table reached the surface. Comment on the expected changes in the settlement behavior.
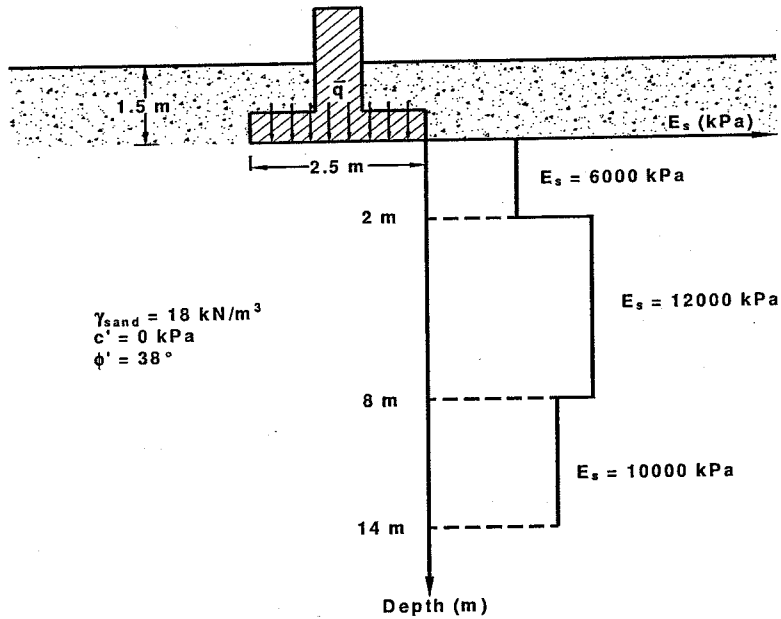

Figure 3

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

Figure 4 shows a prefabricated concrete pile that is driven into a dense sand deposit. Determine the ultimate bearing capacity of the pile using two different methods.
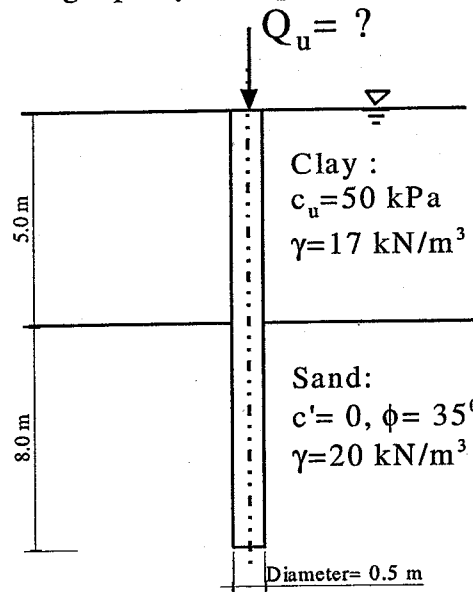

Figure 4

Question 8:   (Value: <u>24 marks</u>)

The cross section of a cantilever retaining wall is shown in **Figure 5**. Calculate the factors of safety with respect to overturning and sliding. The backfill material used is sand.

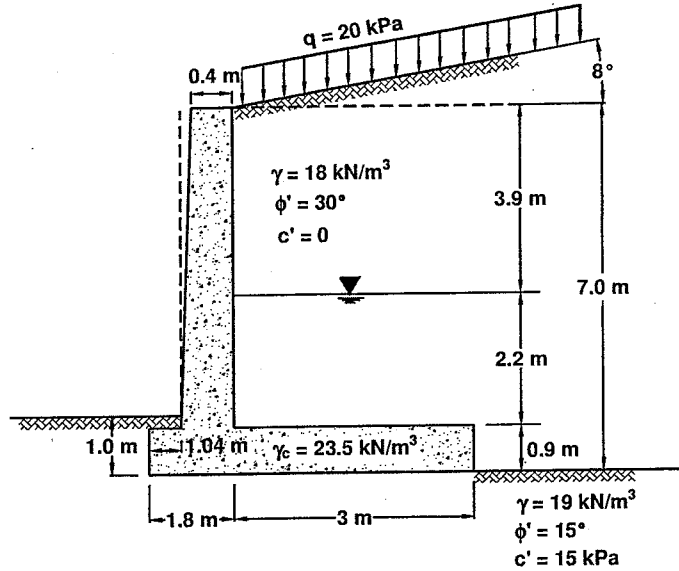Note: Make suitable assumptions to calculate the required density values.

$q = 20$ kPa

0.4 m

8°

$\gamma = 18$ kN/m^3
$\phi' = 30°$
$c' = 0$

3.9 m

7.0 m

2.2 m

1.0 m   1.04 m $\gamma_c = 23.5$ kN/m^3 0.9 m

1.8 m   3 m

$\gamma = 19$ kN/m^3
$\phi' = 15°$
$c' = 15$ kPa

Figure 5

Question 9:   (Value: <u>24 marks</u>)

An empty bank of a canal has the profile shown below. The canal has been cut into homogeneous saturated clay with a unit weight of 20 kN/m^3. The undrained shear strength of the clay is 30 kN/m^2. For the trial slip circle shown the area of ABCDE is 155 m^2 and G is its centroid. Find the factor of safety for this slip surface if the canal is empty. How would the factor of safety be affected if the water in the canal is level with the top of the bank? (**Note: CD =tension zone depth, shown in Figure 6 below**).
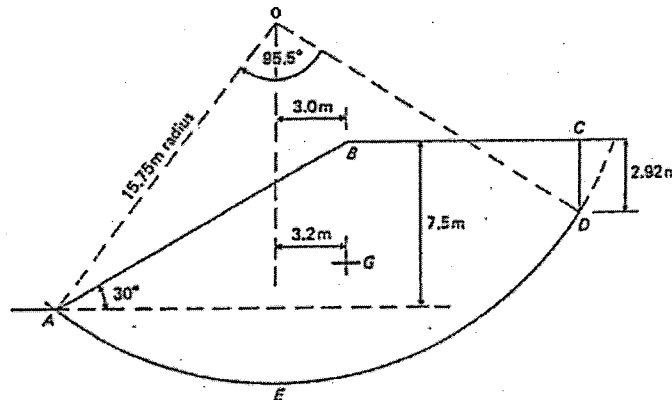

o

95.5°

15.75m radius

3.0m

C

B

2.92m

3.2m

7.5m

D

G

30°

A

E

Figure 6