<u>NATIONAL EXAMINATIONS – May 2011</u>
<u>98-CIV-B3 GEOTECHNICAL DESIGN</u>

<u>3 HOURS DURATION</u>

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 **<u>any FOUR questions in Section A</u>** and any **<u>THREE questions in Section B.</u>**

4. **<u>Only the answers submitted to the first four questions of Section A and the first three questions of Section B will be marked.</u> Extra questions answered will not be marked.**

5. Questions will have the values shown.

6. Candidates must identify **<u>clearly the source of design charts used</u>** and where applicable the <u>source of **assumed values used**</u> 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:

Multiple choice questions:

1. The short term stability of an embankment constructed with clay can be determined using the shear strength parameters derived from:
   a. Conducting consolidated drained (CD) direct shear tests on identical specimens
   b. Conducting consolidated drained (CD) triaxial shear tests on identical specimens
   c. Conducting consolidated undrained (CU) triaxial shear tests with pore-pressure measurements during the shearing stage on identical specimens
   d. Conducting any two of the above three tests
   e. None of above tests

2. The shear strength equation proposed by Terzaghi extending the Mohr-Coulomb failure criterion, $\tau = c' + (\sigma - u_w)\tan\phi'$ is valid for:
   a. Normally consolidated clays
   b. Over consolidated clays
   c. Both for normally and over consolidated clays
   d. none of the above

3. When the total weight of the soil excavated for the foundation equals the total weight of the structure for construction, the foundation is called:
   a. Mat or raft foundation
   b. Shallow foundation
   c. Floating foundation
   d. Dancing foundation

4. Which one of the following statements is true?
   a. Allowable bearing capacity, q_a is larger than the safe bearing capacity, q_s and ultimate bearing capacity, q_u
   b. Safe bearing capacity, q_s is larger than the allowable bearing capacity, q_a and ultimate bearing capacity, q_u
   c. Ultimate bearing capacity, q_u is larger than the safe bearing capacity, q_s and allowable bearing capacity, q_a
   d. Ultimate bearing capacity, q_u is larger than the safe bearing capacity, q_s; however, safe bearing capacity is equal to the allowable bearing capacity, q_a
   e. None of the above

5. The Vane Shear test is useful to determine the in situ shear strength for
   a. Long term stability of an earthen embankment constructed with homogeneous stiff clay soils
   b. Rapid construction of an earthen embankment constructed with homogeneous clay sands and gravels

c. Slow rates of construction of an earthen embankment constructed with homogeneous soft clayey and sensitive soils
d. none of the above

6. Several parameters are listed below for increasing the load carrying capacity of a coarse-grained soil; which one of the following is more effective than the others.
   a. increase the width of the foundation
   b. decrease the depth of the foundation
   c. increase the depth of the foundation
   d. increase the thickness of the foundation
   e. by raising the ground water table to the natural ground level

7. When the ground water table depth (i.e., D_w), which was originally two times the width (i.e. 2B) of the foundation, rises to the natural ground level, the approximate bearing capacity of a shallow foundation constructed on a sandy soil;
   a. Reduces by 50%
   b. Increases by 50%
   c. Bearing capacity will be zero and quick sand conditions occur

(Value: 7 marks)

Question 2:

Plate load tests (PLT) and cone penetration tests (CPT) are both used in the determination of the bearing capacity and the settlement of soils. However, one of these techniques is more widely used in practice. Provide reasons why one of these techniques is more widely used in comparison to the other?

(Value: 7 marks)

Question 3:

What are the practical advantages of using the λ method in comparison to the α and β methods in the estimation of the load carrying capacity of single piles?

(Value: 7 marks)

Question 4:

In recent years geotextiles and geosynthetics have been increasingly used to improve the performance and also to reduce the costs associated with the construction of retaining walls on highways. Explain in your words how these objectives are achieved.

(Value: 7 marks)

Question 5:

Figure 1 and **Figure 2** show the slip planes within a soil mass near a retaining wall for active and passive states, respectively. Explain the failure mechanism for both active and passive states using the Mohr-Coulomb failure envelope.

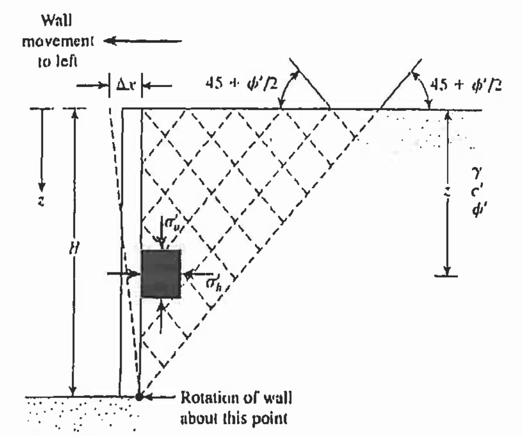

Figure 1. Rankine active earth pressure

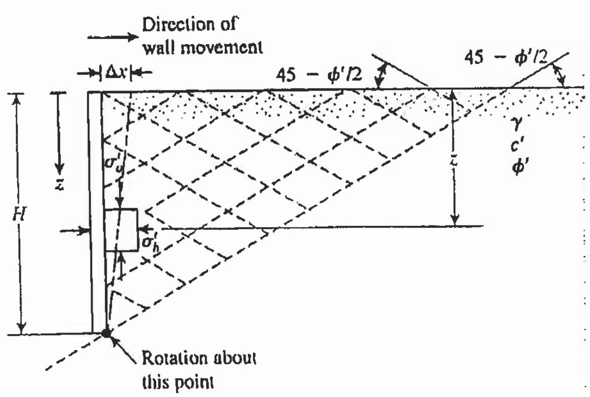

Figure 2. Rankine passive earth pressure

(Value: 7 marks)

SECTION B

ANSWER **THREE** OF THE FOLLOWING **FOUR** QUESTIONS

Question 6: (Value: 24 marks)

The cross section of a cantilever retaining wall is shown in **Figure 3**. Calculate the factors of safety with respect to overturning and sliding.

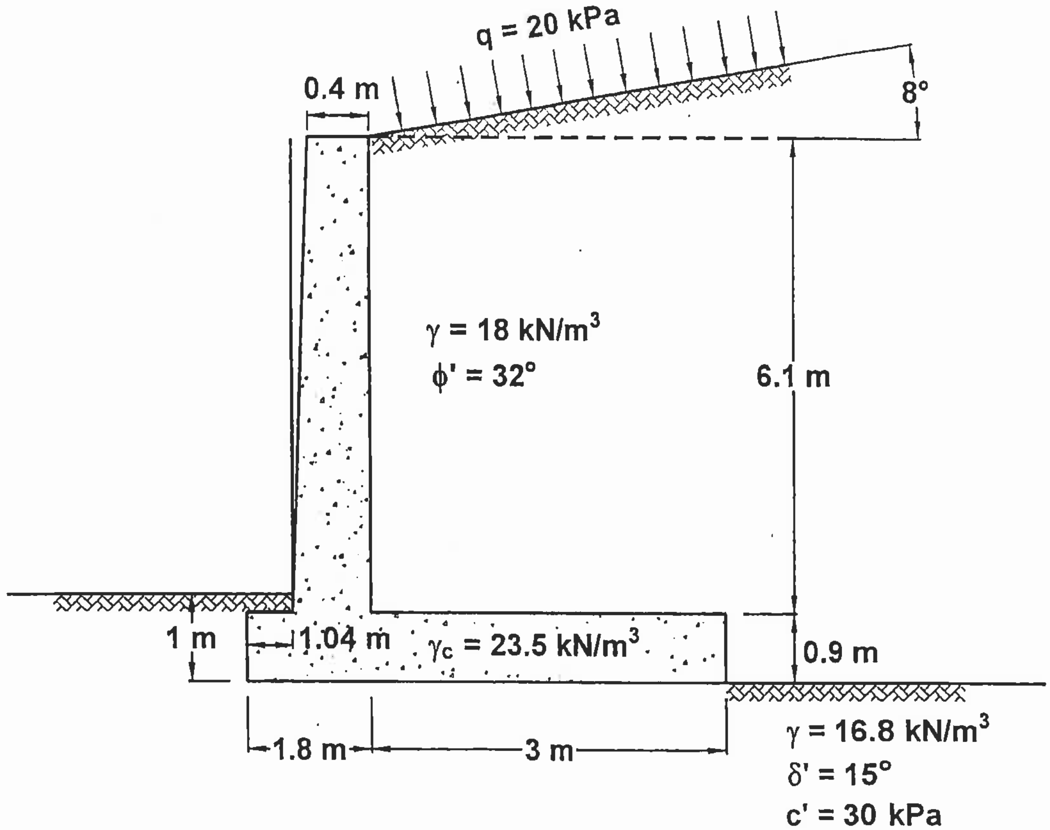

Figure 3

Question 7: (Value: 24 marks)

Determine the ultimate axial capacity of a 600 mm diameter pile installed to a depth of 18 m at the site with a profile shown in Figure 4. Note that the pile tip is in the clay layer. How much will the ultimate axial capacity increase if the pile length is increased by 3m (i.e., if the pile length is increased from 18 m to 21 m as shown in Figure 4 so that the pile tip is in the sand layer? Consider $\alpha = 1.0$ for S_u up to 50 kN/m^2; $\alpha = 0.8$ for $S_u = 80$ kN/m^2 and $\alpha = 0.6$ for $S_u = 110$; $N_q = 50$ for $\phi' = 35°$. Use earth pressure coefficient K = 1 and interface friction angle $\delta = \phi'$.

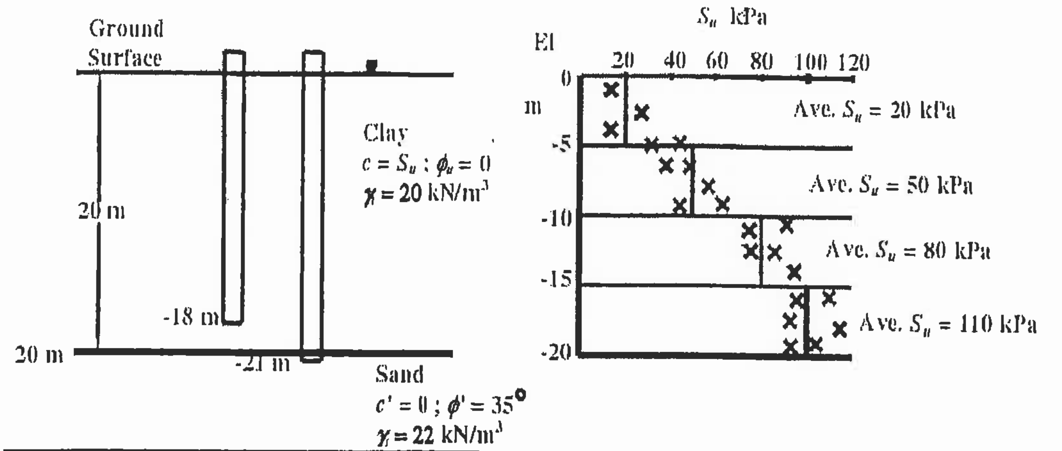

Figure 4

Question 8: **(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 5**. Use Terzaghi's equation and strain influence factor method to calculate bearing capacity and settlement, respectively. The average unit weight of the sand and the internal friction angle are 18 kN/m^3 and 35°, respectively.

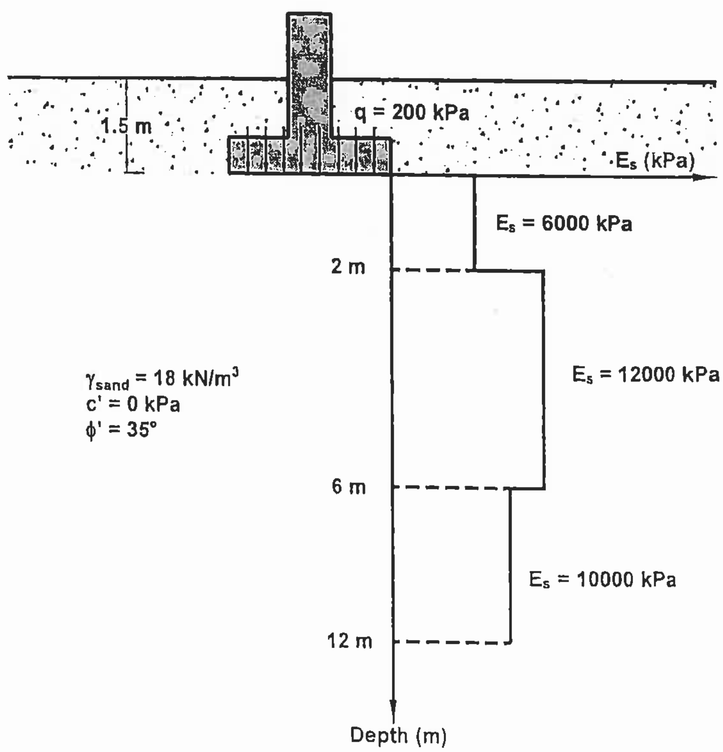

Figure 5

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

A bank of an empty canal has the soil profile shown in **Figure 6**. 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 centre of gravity. Determine the short term factor of safety for this slip surface if the canal is empty. Also, determine the short term factor of safety if the water in the canal is level with the top of the bank. *(Note: CD =tension zone depth, shown in* **Figure 6***).* Suggest two basic approaches that are commonly recommended for stabilization assuming that the slope is in imminent danger of failing.

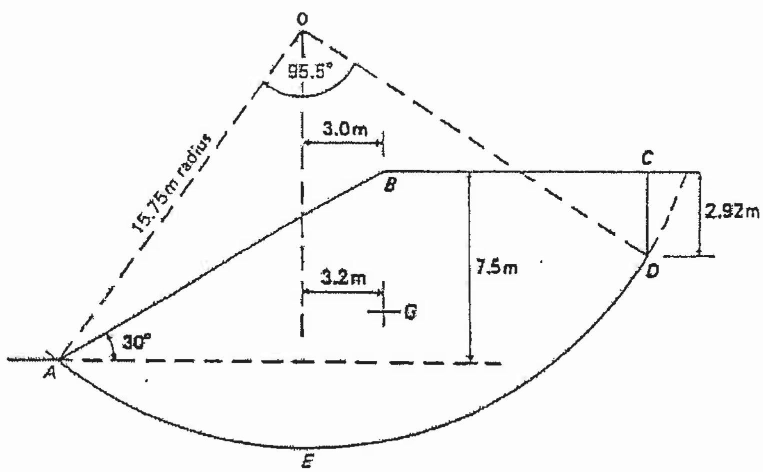

Figure 6