

PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS – May 2012
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 answers submitted to the first four questions of Section A and the first three questions 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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NATIONAL EXAMINATIONS – May 2012
07-STR-B1 – GEOTECHNICAL DESIGN

SECTION A
ANSWER ANY FOUR QUESTIONS

Question 1:

(Value: 7 marks)

1. Which one of the following statements is true?
 - a. Plate load test is commonly used to determine the bearing capacity of pile foundations
 - b. Soil samples collected using hand auger can be used only for conducting unconfined compression tests
 - c. Standard penetration test N value is defined as the average blow counts required for the last 0.3 m (12") of driving.
 - d. Field vane test results can be used for the short term stability analysis of geotechnical structures.
 - e. None of above

2. The swelling index, C_s , should be determined to estimate the
 - a. Consolidation settlement of normally consolidated clays
 - b. Consolidation settlement of overconsolidated clays
 - c. Preconsolidation pressure (i.e. past maximum effective overburden pressure)

3. When the ground water table depth (i.e. D_w) which was originally two times the width (i.e. $2B$) of a foundation sitting on the ground surface, raises 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 condition occurs.

4. Which of the following can be used to improve the stability of slopes?
 - a. Improving the shear strength of soils in the failure zone
 - b. Soil stabilization techniques
 - c. Collect and remove subsurface water effectively
 - d. All the above

5. 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 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. Raise the ground water table to the natural ground level

NATIONAL EXAMINATIONS – May 2012
07-STR-B1 – GEOTECHNICAL DESIGN

6. The pore water pressure in a saturated soft soil at a certain shearing stage can be calculated using one of the following relationships.
- $\Delta u = \Delta \sigma_3 + B \Delta(\sigma_1 - \sigma_3)$
 - $\Delta u = A \Delta \sigma_3 + (\sigma_1 - \sigma_3)$
 - $\Delta u = \Delta \sigma_3 + A(\sigma_1 - \sigma_3)$
 - $\Delta u = \Delta \sigma_3 + A \Delta(\sigma_1 - \sigma_3)$
 - $\Delta u = A \Delta \sigma_3 + B \Delta(\sigma_1 - \sigma_3)$
7. Triaxial shear tests were conducted under *CU* conditions on saturated overconsolidated clay specimens with pore-water pressure measurements. One of the statements below is valid for these tests.
- ϕ determined from total stress approach $>$ ϕ determined from effective stress approach
 - ϕ determined from total stress approach $<$ ϕ determined from effective stress approach
 - ϕ determined from total stress approach $=$ ϕ determined from effective stress approach

Question 2:

Provide justification to the statement, “*the short term bearing capacity of a footing placed on the surface of fully saturated soft clay is independent of footing size*”.

(Value: 7 marks)

Question 3:

“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:

Discuss the reasons for excavations losing strength with time and embankments gaining strength with time.

(Value: 7 marks)

Question 5:

The following is a quote from a Foundation Manual: “In determining the load distribution in a pile extending through layers of weaker soils to a very competent stratum, such as a dense gravel, resistance should be assumed mobilized in this stratum, only”. Explain the reasoning behind or the justification for this statement.

(Value: 7 marks)

NATIONAL EXAMINATIONS – May 2012
07-STR-B1 – GEOTECHNICAL DESIGN

SECTION B
ANSWER ANY THREE OF THE FOLLOWING
FOUR QUESTIONS

Question 6:

(Value: 24 marks)

Figure 1 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 considering only 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.

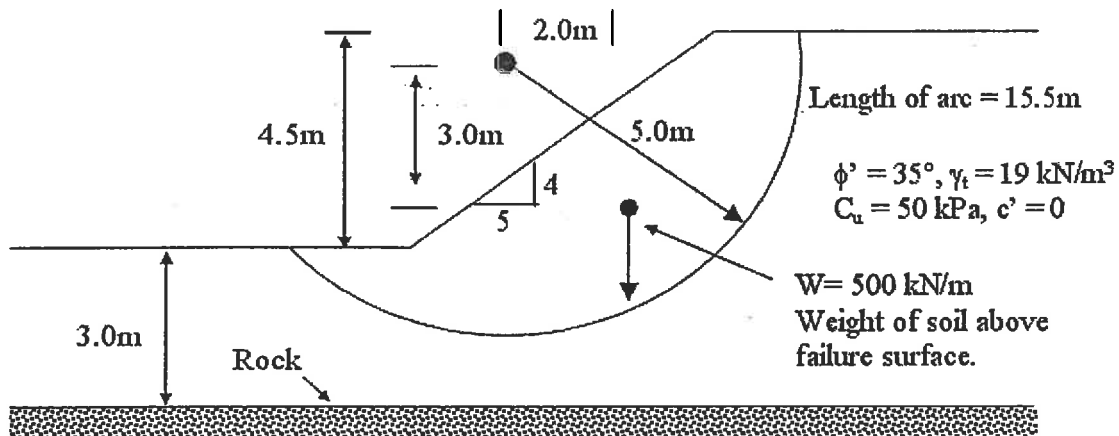


Figure 1

Question 7:

(Value: 24 marks)

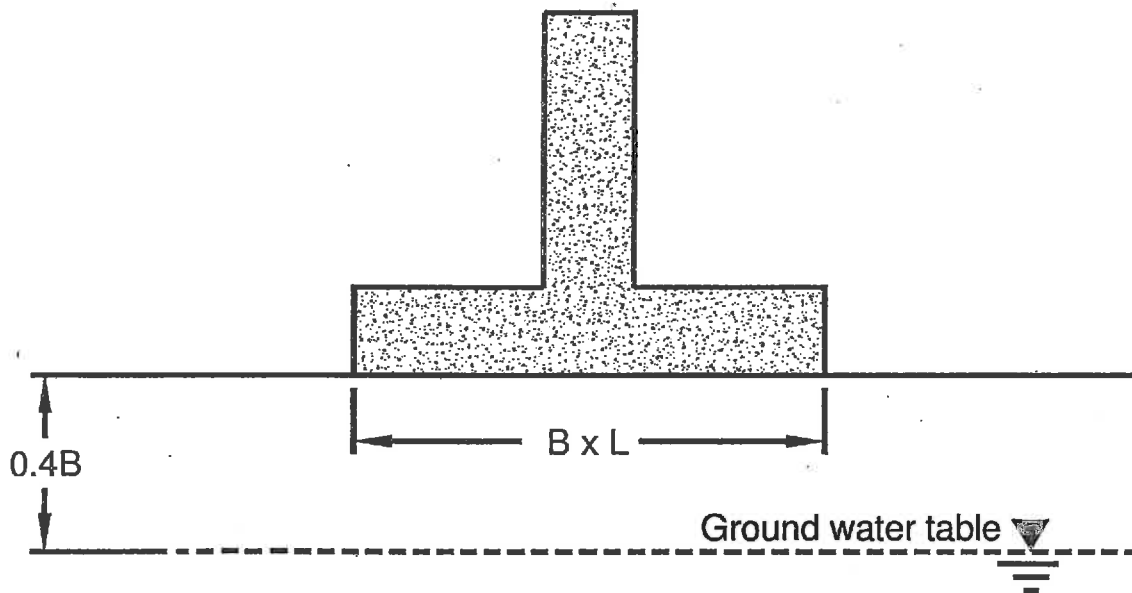
A 0.4 m steel H -pile is driven 15 m into a clay soil where the following conditions exist: From the ground surface to a depth of 10 m, the clay is normally consolidated, with a unit weight equal to 18 kN/m^3 and undrained cohesion equal to 70 kPa; below 8 m, the clay is slightly overconsolidated, with a unit weight equal to 18 kN/m^3 and undrained cohesion equal to 100 kPa. Determine the design axial capacity of this pile, using a factor of safety of 2.5. Compute the shaft capacity by assuming that the skin friction is developed on the surface of the outer perimeter (0.4 m by 0.4 m) of the pile cross-section.

NATIONAL EXAMINATIONS – May 2012
07-STR-B1 – GEOTECHNICAL DESIGN

Question 8:

(Value: 24 marks)

For a rectangular foundation (Length, $L = 3$ m) shown in **Figure 2** below, determine the width of foundation, B to carry a gross allowable load, $Q_{all} = 950$ kN (Factor of Safety, $FS = 3$). It is strongly expected that the ground water table will rise up to the natural ground surface during the rainy season.



$$\begin{aligned}G_s &= 2.7 \\e &= 0.72 \\ \phi' &= 36^\circ \\ c' &= 0 \text{ kPa}\end{aligned}$$

Figure 2

Question 9:

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, and bearing capacity. Use Rankine active earth pressure and neglect the passive pressure in your calculation.

NATIONAL EXAMINATIONS – May 2012
07-STR-B1 – GEOTECHNICAL DESIGN

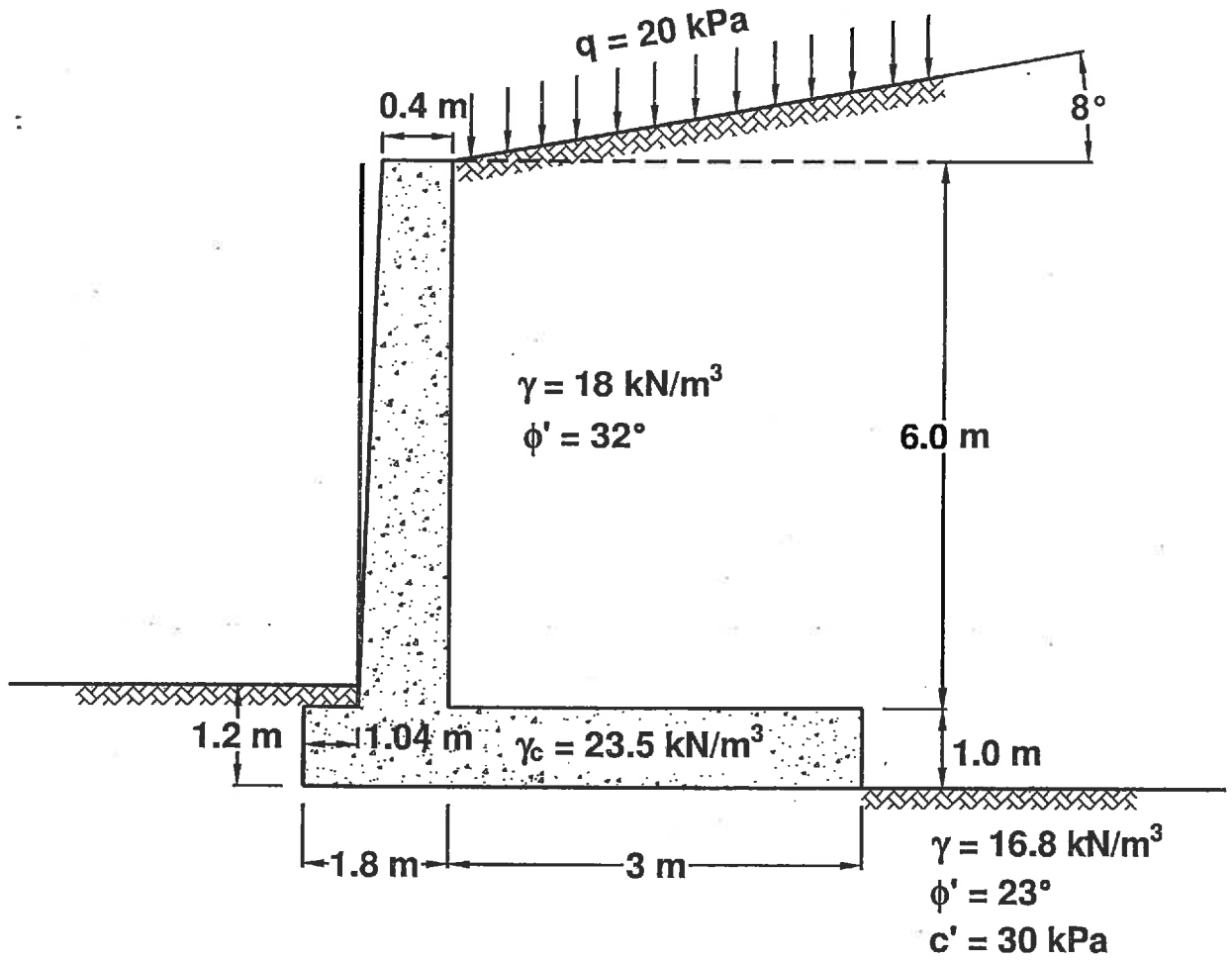


Figure 3