

PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS – December 2014
98-CIV-B3 GEOTECHNICAL DESIGN

3 HOURS DURATION

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- 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:

List the various methods available to determine the in-situ bearing capacity of soils. Which one of the following methods listed would you recommend for reliable determination of the in-situ bearing capacity of a sandy soil? Give reasons.

(Value: 7 marks)

Question 2:

What are the appropriate shear strength parameters to be used in long-term stability analyses of slope in an expansive soil? Give your reasons why these shear strength parameters are recommended.

(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:

You have been assigned a job as a geotechnical engineer to design pile foundations for constructing a five star hotel in a clayey soil deposit. 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 is proposed to be constructed in a steep slope region which warrants construction of a retaining wall for slope stabilization in a clay soil. What are the various parameters that you have to consider in the design of this retaining wall? Justify the type of retaining wall that you propose to design? What are the various hazard scenarios that you have to consider in the design of this retaining wall?

(Value: 7 marks)

SECTION B
ANSWER ANY THREE OF THE FOLLOWING
FIVE QUESTIONS

Question 6:

(Value: 24 marks)

A 0.3 m steel H-pile is driven 10 m into a clay soil where the following conditions exist: From the ground surface to a depth of 5 m, the clay is normally consolidated, with a unit weight equal to 18 kN/m^3 and undrained cohesion equal to 50 kPa; below 5 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

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of 2. Compute the shaft capacity by assuming that the skin friction is developed on the surface of the rectangular outer perimeter (0.3 m by 0.3 m) of the pile cross-section.

Question 7:

(Value: 24 marks)

In the Table given below, the standard penetration test (SPT) results determined in the field for a sandy soil deposit are summarized. The ground water table was found to be located at a depth of 18m. Estimate the angle of internal friction, ϕ' from the provided data using an appropriate technique (**give the source where this information is obtained**) and design a shallow foundation measuring 2.0 x 3.0 m in plan and seated at a depth of 1.5 m. **Note: The design calculations should be based on the ϕ' value obtained, not on methods based on direct correlations of Bearing Capacity to Penetration Index**

Table I

Depth [m]	Soil Unit Weight [kN/m ³]	N ₆₀
2	19.0	6
4	19.0	10
6	19.0	14
8	21.5	18
10	21.4	20
12	21.4	24
14	21.4	25
16	21.4	26

Question 8:

(Value: 24 marks)

Figure 1 below shows an embankment load on a silty clay layer of soil. Determine the stress increase at points A, B, and C, located at depth of 4 m below the ground surface.

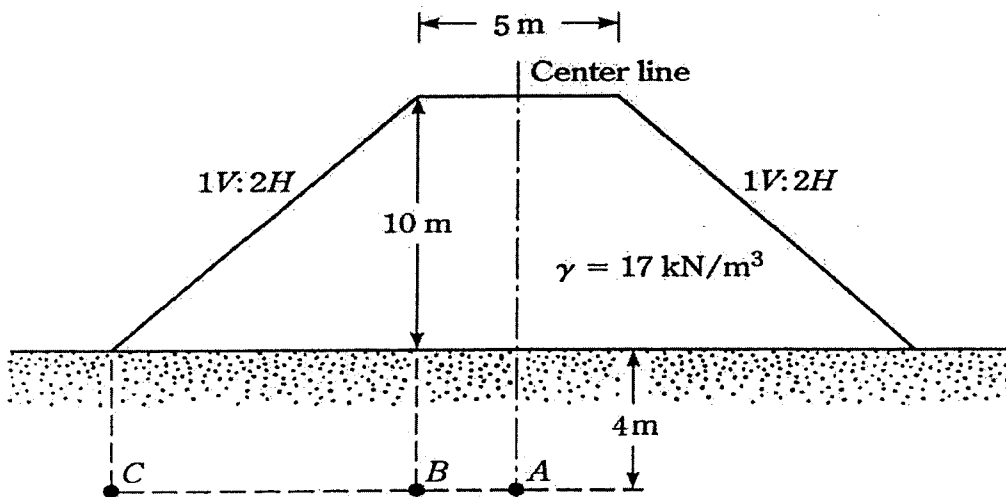


Figure 1

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Question 9:

(Value: 24 marks)

A column carries a vertical downward load of 600 kN. This load is proposed to be supported on a 2.0 m deep square footing. The soil which is Normally Consolidated beneath the footing has the following properties: $\gamma = 19 \text{ kN/m}^3$, $c' = 0.5 \text{ kPa}$, $\phi' = 36^\circ$, undrained cohesion, $c_u = 150 \text{ kPa}$, undrained friction angle, $\phi_u = 0$. Sub-surface investigations show that the groundwater table is reasonably stable throughout the year at a depth of 7.0 to 8.0 m below the natural ground surface. Determine the width of the footing for the above specifications such that the short-term factor of safety is equal to 2. Use Meyerhof's general bearing capacity analysis.

Question 10:

(Value: 24 marks)

A gravity retaining wall is shown in **Figure 2**. The 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 $\delta = 2/3\phi$.

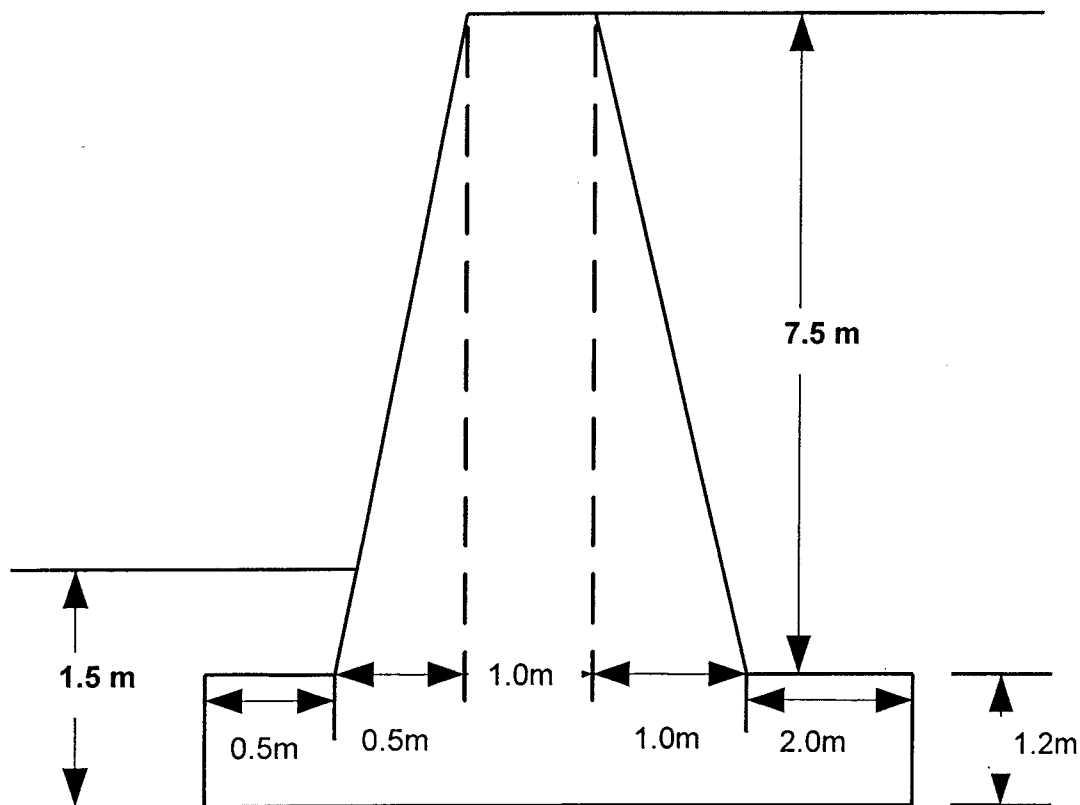


Figure 2

$\gamma = 20 \text{ kN/m}^3$
 $c' = 0 \text{ kPa}$
 $\phi' = 36^\circ$