

PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS – May 2013
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 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:

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)

Question 2:

What are the practical limitations of using the SPT results in conventional geotechnical engineering practice for the design of foundations?

(Value: 7 marks)

Question 3:

In many scenarios, α , β and λ methods are used in the estimation of the load carrying capacity of single piles; however, in many scenarios it is recommended to test at least one in 10 piles in-situ. Discuss the reasons why pile load test results are used along with empirical methods. In addition, discuss which one of the methods; α , β or λ is more reliable in estimating the long-term carrying capacity of a single pile in clay.

(Value: 7 marks)

Question 4:

Relatively higher safety factors are recommended for short term stability in comparison to 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 short-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:

“*In many scenarios, it is the settlement that is the governing parameter in the design of foundations and not the bearing capacity both for sands and clays*”. Provide your reasons to support this statement.

(Value: 7 marks)

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SECTION B
ANSWER ANY THREE OF THE FOLLOWING
FOUR QUESTIONS

Question 6:

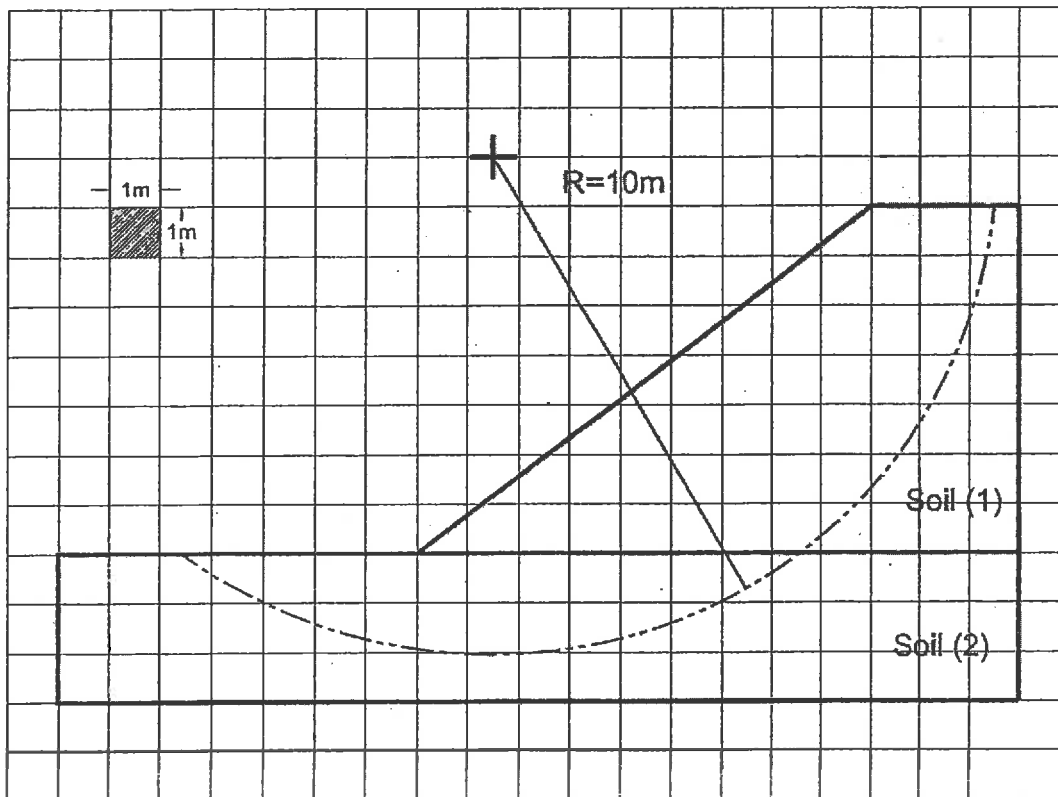
(Value: 24 marks)

Calculate the factor of safety of the slope shown in **Figure 1** using the method of slices. The soil properties are as follows:

| Soil 1 | Soil 2 |
|------------------------------|------------------------------|
| $\gamma = 20 \text{ kN/m}^3$ | $\gamma = 18 \text{ kN/m}^3$ |
| $\phi' = 30^\circ$ | $\phi' = 20^\circ$ |
| $c' = 0$ | $c' = 10 \text{ kPa}$ |

Note: Use only 3 slices

Hint: Divide the failure slip to three slices such that the first slice has only layer Soil (2); the second slice has both Soil (1) and Soil (2) layers and the third slice has only layer Soil (1).

**Figure 1**

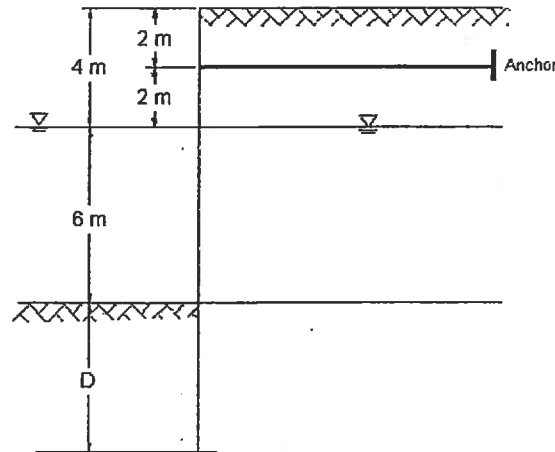
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Question 7:

(Value: 24 marks)

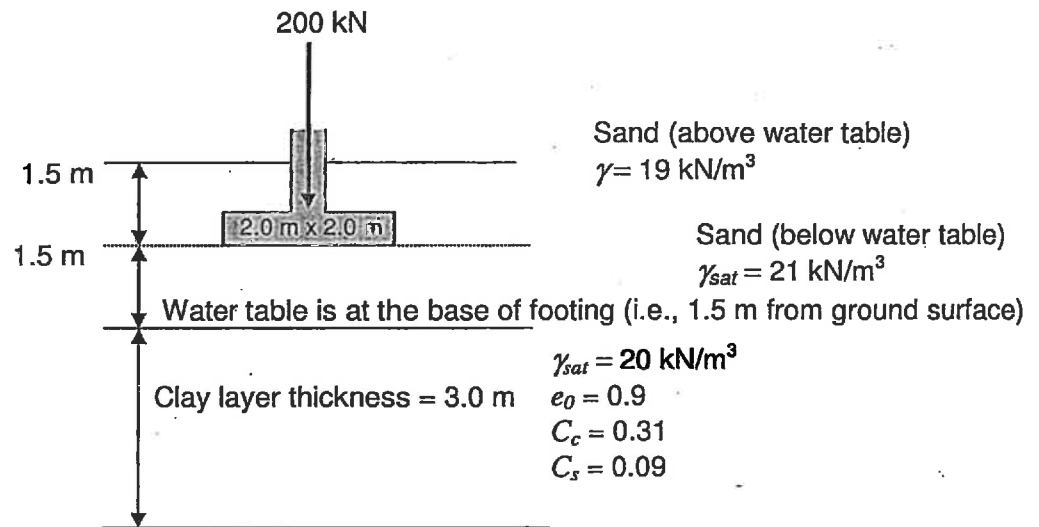
Figure 2 below shows an anchored sheet pile wall penetrating a granular soil. The unit weight of the granular soil may be assumed to be 20 kN/m^3 both above and below the ground water table and the angle of internal friction, $\phi' = 40^\circ$.

- (i) What is the theoretical depth of penetration D for free earth-support?
- (ii) Calculate the anchor force F .
- (iii) Discuss what happens, if the water table in front of the wall decreases to the dredge-line?

**Figure 2****Question 8:**

(Value: 24 marks)

A square column foundation is shown in **Figure 3** below. Determine the average increase of stress in the clay layer below the center of the foundation using the 2:1 method and estimate the average consolidation settlement of the clay layer.

**Figure 3**

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Question 9:

(Value: 24 marks)

Figure 4 below shows a retaining wall with the following properties:

| Material | γ (kN/m ³) | ϕ' (degrees) | c' (kPa) |
|----------|-------------------------------|-------------------|------------|
| Soil 1 | 20 | 36 | 5 |
| Soil 2 | 18 | 30 | 10 |
| Concrete | 24 | - | - |

Determine the factor of safety (i) against over turning and (ii) against sliding

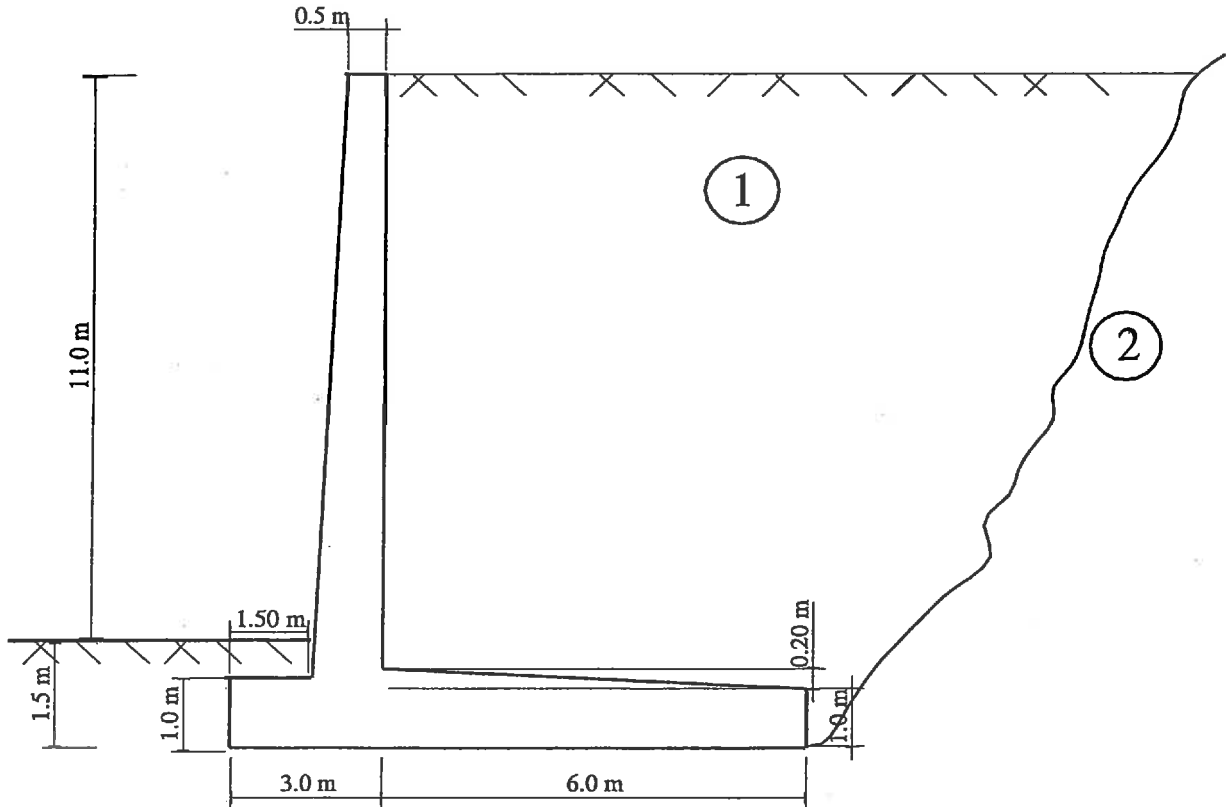


Figure 4

Question 9:

(Value: 24 marks)

A drilled pier is shown in **Figure 5**. For the pier, $L_1=5.0$ m, $L_2=2.5$ m, $D_s=1.00$ m, and $D_b= 1.8$ m.

The properties of the soil are $\gamma_c=20$ kN/m³, $c_u= 30$ kN/m², $\gamma_s= 19$ kN/m³, and $\phi' =37.5^\circ$

- Determine the net allowable point bearing capacity (FS=4). Do not reduce the friction angle of sand, ϕ' .
- Determine the skin resistance that would develop for the top 5 m (i.e., in the silty clay layer).
- Discuss the relative advantages and disadvantages of drilled piers.

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- d) What other suitable foundation would you suggest for the above soil properties on which a heavy structure has to be constructed?

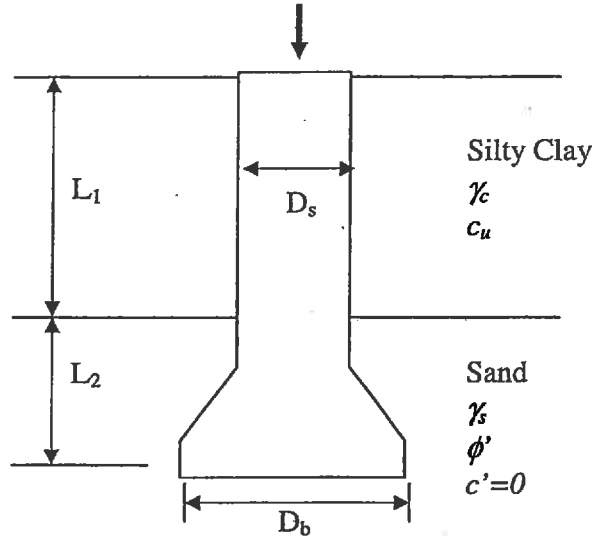


Figure 5