NATIONAL EXAMINATIONS DECEMBER 2019

16-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:

Derive an expression for determining the critical height of excavation for an unsupported cut in a saturated clay for a short period. **Figure 1** below can provide some assistance for you in the derivation of this simple expression. Also, comment whether or not you need to provide any support if you excavate a cut of 8 m depth in a saturated clay, which has undrained shear strength, $c_u = 30$ kPa. **(7 marks)**

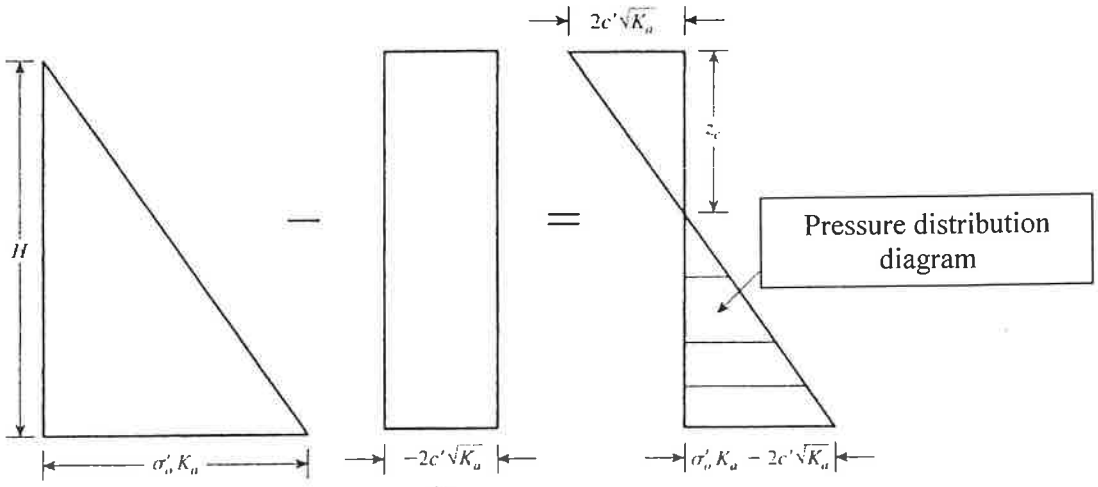

Figure 1

(Value: 7 marks)

Question 2:

Figure 2 below shows a slope that has a Factor of Safety less than 1. Suggest four different measures or techniques for improving the Factor of Safety of this slope. Discuss one of them in detail. **(Value: 7 marks)**

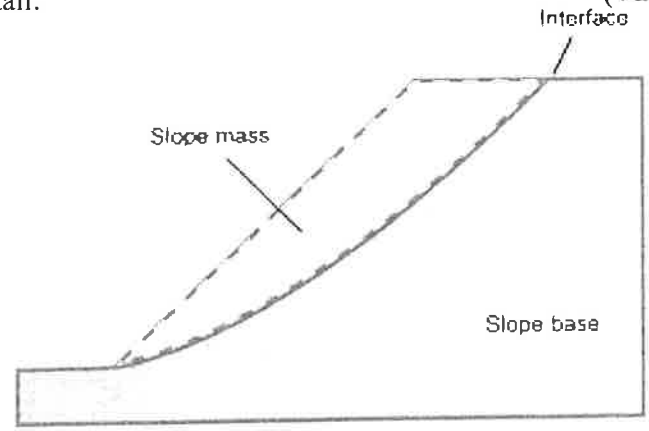

Figure 2

Question 3:
When would you recommend a foundation to be designed based on undrained shear strength parameters? How do you determine the undrained shear strength both in the laboratory and in the field? **(Value: 7 marks)**

Question 4:
A retaining wall of 6 m height is 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 an expansive clay. 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?

Hint: Supplement your answer with sketches and provide details.

(Value: 7 marks)

Question 5:
When do you prefer to use a mat foundation in comparison to either individual or combined footings or pile foundations? **(Value: 7 marks)**

SECTION B
ANSWER ANY THREE OF THE FOLLOWING FOUR QUESTIONS

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

A square footing is proposed for supporting a column load of 300 kN at a depth of 2.0 m in a normally consolidated clay. The clay has the following properties: $\gamma = 19$ kN/m^3, $c' = 0.5$ kPa, $\phi' = 28°$, undrained cohesion, $c_u = 150$ 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 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 2.5 and the width that will ensure a long-term factor of safety of 2.5. Use Meyerhof's general bearing capacity analysis. What dimensions do you recommend for the square footing?

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

Determine the design axial capacity of the pile shown in **Figure 3**, using a factor of safety of 2.5. Make reasonable assumptions providing justifications.

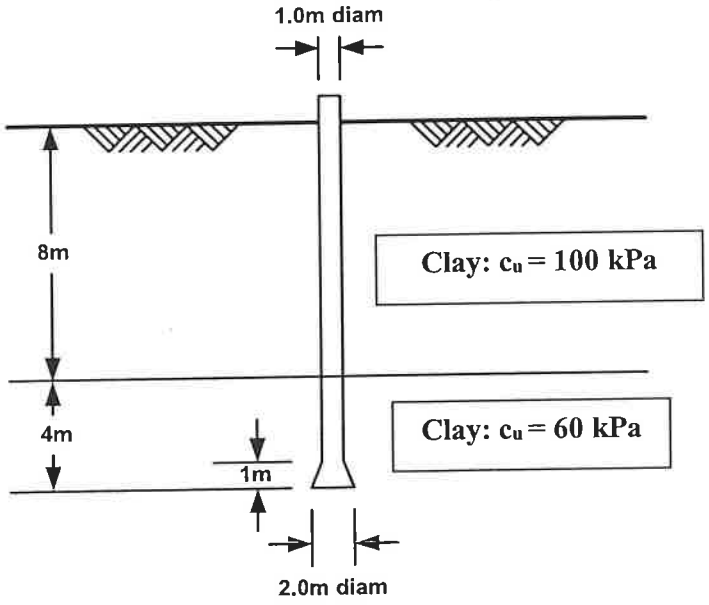

Figure 3

Question 8: **(Value: 24 marks)**

Calculate the factor of safety with respect to overturning for the gravity retaining wall shown in **Figure 4**. Use Coulomb's theory. Assume soil-wall friction angle $\delta = 0.67\ \phi'$ and the ground water table is very deep.

(i) Comment on the factor of safety value that you determined.

(ii) Comment on the factor of safety value that you would obtain for this retaining wall if Rankine's theory were used. Your comment should be based on your general understanding without making any calculations.

(iii) Suggest if it is more appropriate to use Rankine or Coulomb's method for solving this problem.

(iv) Will the factor of safety increase or decrease if the ground water rises to up to a height of 4 m in the backfill? Draw the pressure distribution diagram and explain. No calculations please!

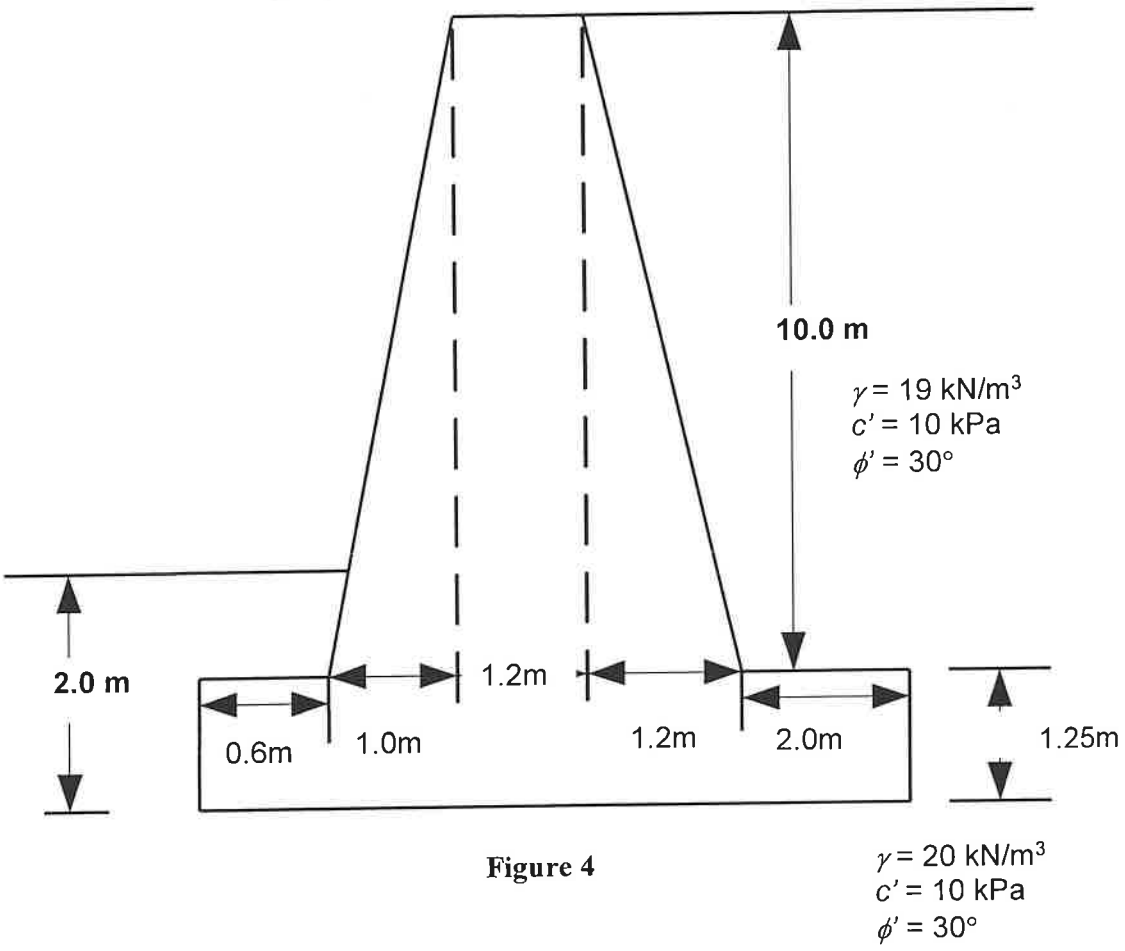

Figure 4

(Value: 24 marks)

Question 9:

Using the strain influence factor method suggested by Schmertman, determine the elastic settlement of the foundation constructed for a condominium complex. The variation of modulus of elasticity, E_s with respect to depth and other information are shown in **Figure 5**. The unit weight of soil, γ = 20 kN/m^3 and a creep time = 5 years for the correction factor C_2. It was proposed to construct 10 more storeys onto the existing condominium complex. What will be your recommendations with respect to this foundation? Would it be safe to construct another ten storeys? (*Hint's: Think about the overall stress that will increase at the base of foundation due to the construction of extra ten storeys. You may assume approximately a load of 10 kPa for each storey. In addition, it may not be a bad idea to increase the creep period too).*

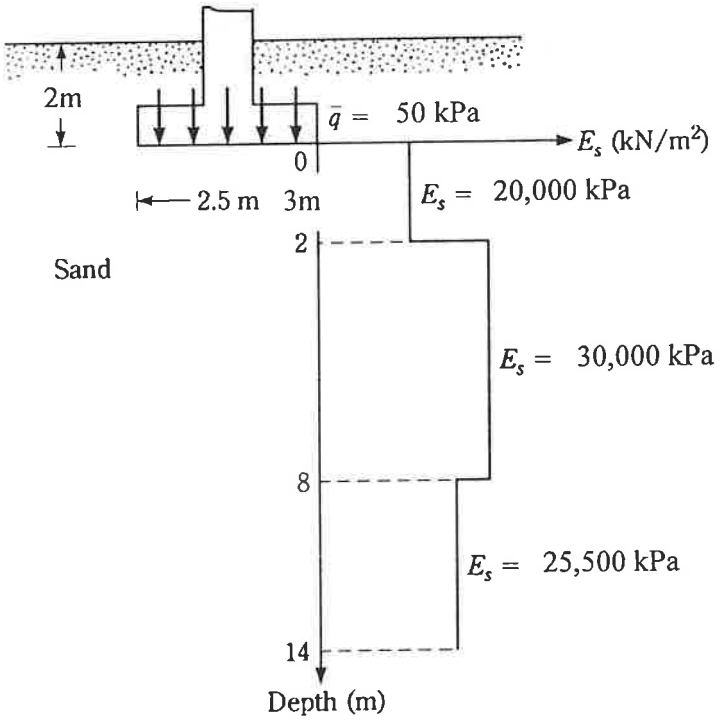
2m
$\bar{q}$ = 50 kPa
E_s (kN/m^2)
0
2.5 m
3m
E_s = 20,000 kPa
2
Sand
E_s = 30,000 kPa
8
E_s = 25,500 kPa
14
Depth (m)

Figure 5