**NATIONAL EXAMINATIONS – December 2018**
**16-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:**
Discuss why higher FS values are recommended for short-term stability in comparison to long-term stability of slopes ?

**(Value: 7 marks)**

**Question 2:**
Standard penetration tests (SPT) and cone penetration tests (CPT) are both used in geotechnical engineering practice. Which one of these methods is commonly used for testing sandy soils? Provide reasons.

**(Value: 7 marks)**

**Question 3:**
With a practical example explain when you would design a foundation using undrained shear strength parameters? How do you determine the undrained shear strength both in the laboratory and in the field? What are strengths and limitations of these testing techniques?

**(Value: 7 marks)**

**Question 4:**
When do you prefer to use the $\lambda$ method in comparison to the $\alpha$ or $\beta$ method for estimation of the load carrying capacity of single piles?

**(Value: 7 marks)**

**Question 5:**
Briefly explain the engineering significance of the following terms a) Active Zone in Expansive soils; and b) Negative skin friction in pile foundations

**(Value: 7 marks)**

# SECTION B
# ANSWER **ANY THREE** OF THE FOLLOWING FOUR QUESTIONS

**(Value: 24 marks)**

**Question 6:**

**Figure 1** shows a prefabricated concrete pile that is driven into a dense sand deposit. Determine the ultimate bearing capacity of the pile using two different methods.

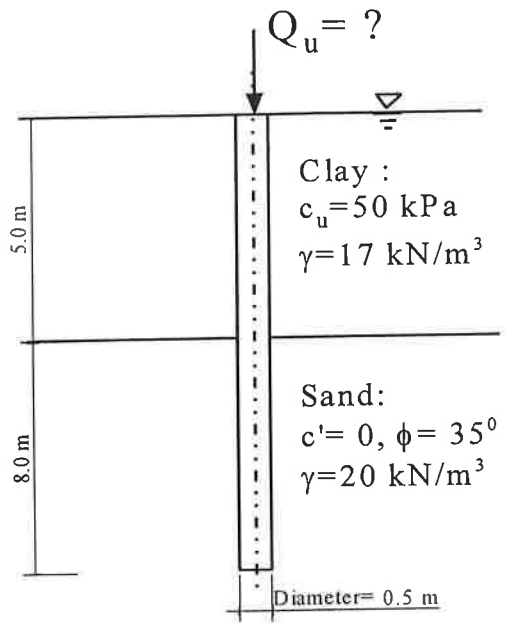


**Figure 4**

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

It is proposed to carry the load from a 5-story structure with an area of 600 $m^2$ in sand using 25 square column footings. The standard penetration test results obtained from field exploration are summarized below. (i.e., corrected $N_{60}$ results versus depth). The depth of foundation was proposed to be at 1.5 m and the tolerable settlement is 15 mm. Determine the size of the foundation.

Also, determine the bearing capacity of this foundation using Terzaghi's bearing capacity equation, if the GWT is at the natural ground level. Assume $\gamma_{sat} = 20$ kN/$m^3$.

What are the comments that you would offer to the owner as a consultant for this foundation?

**Note: If you need any additional information for solving this problem, make suitable assumptions providing justification).**

| Depth (m) | *Corrected Results of* $N_{60}$ |
|---|---|
| 1.5 | 10 |
| 3.0 | 12 |
| 4.5 | 14 |
| 6.0 | 16 |
| 7.5 | 16 |
| 10.0 | 16 |
| 12.0 | 16 |
| 14.0 | 16 |
| 16.0 | 16 |

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

A gravity retaining wall is shown in **Figure 1.** The ground water table is very deep. Calculate the factor of safety with respect to overturning and sliding. Use Coulomb's active pressure for the calculation and a soil-wall friction angle $\delta = 0.6\phi'$. 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.

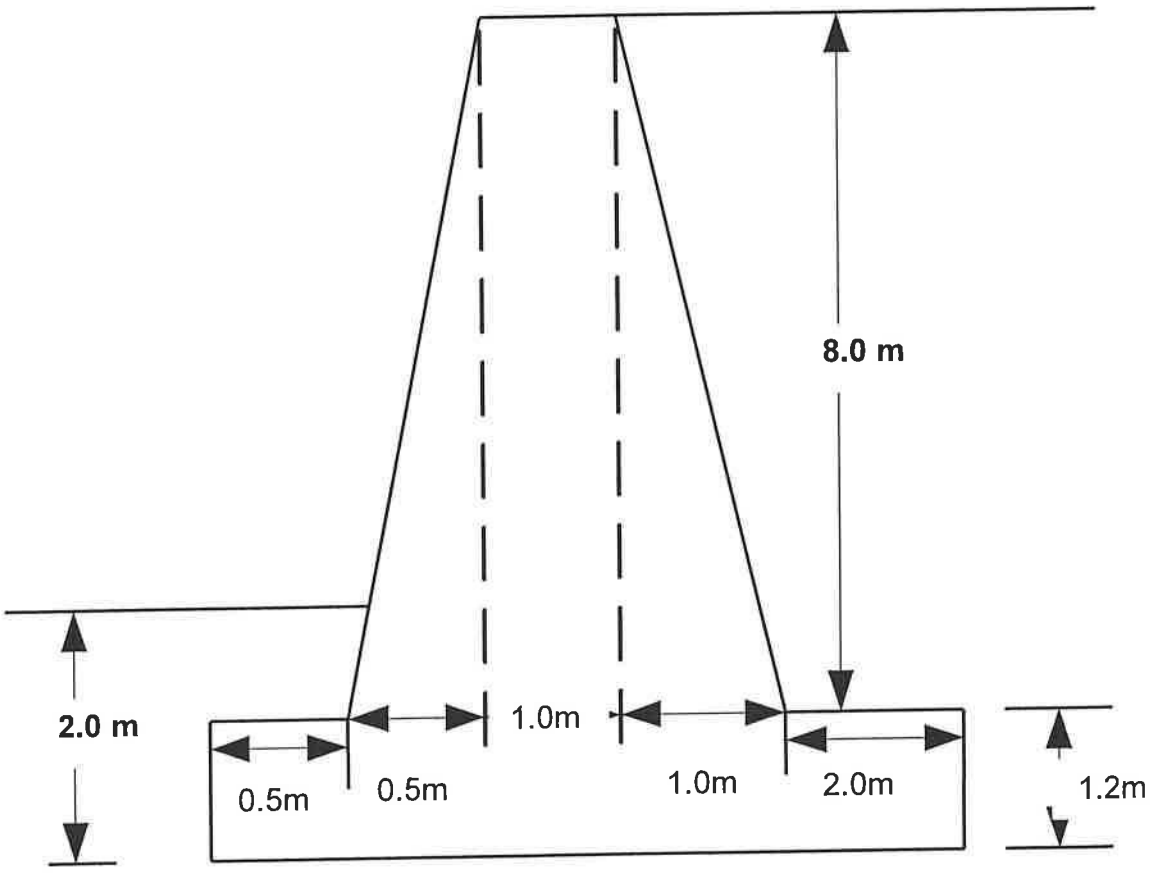


**Figure 1**

$\gamma = 20$ kN/m$^3$
$c' = 0$ kPa
$\phi' = 30°$

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

(a) The elasticity with depth in an **erratic** sandy deposit varies considerably. Representative data of Elasticity versus depth is shown below:

| Depth (m) | Data Set 1 Elasticity (kN/m$^2$) | Data Set 2 Elasticity (kN/m$^2$) | Data Set 3 Elasticity (kN/m$^2$) |
|---|---|---|---|
| 0 to 2 m | 5000 | 3000 | 8000 |
| 2 to 8 m | 10000 | 6000 | 12000 |
| 8 to 12 m | 15000 | 12000 | 20000 |
| 12 to 16m | 12000 | 8000 | 15000 |

It is proposed to construct a continuous footing with L/B > 15, on this soil that has a foundation depth equal to 2m and width equal to 2.5m. Assume $\gamma = 20$ kN/m$^3$ and creep time of 12 years for the correction factor $C_2$. Calculate the expected **maximum elastic settlement** of the foundation using the given data. Use the Schmertman strain influence factor method for calculations. The stress at the level of the foundation is equal to 100 kPa. **(Clue: You don't have to calculate the settlement for all three sets of test data; use engineering judgement and solve this problem)**

(b) The height of a retaining wall is H = 5 m. The backfill is a saturated clay with $\phi_u = 0$ and $c_u = 50$ kPa and $\gamma = 20$ kN/m$^3$ and has a horizontal surface.

i. Determine the Rankine active pressure distribution diagram behind the wall. **(You don't have to determine the resultant pressure)**

ii. Determine the depth of the tensile crack, $z_c$