

The Open University of Sri Lanka  
Faculty of Engineering Technology  
Department of Civil Engineering



Study Programme : Bachelor of Science Honours in Engineering  
Name of the Examination : Final Examination  
**Course Code and Title : CVX6444 Geotechnics**  
Academic Year : 2024/25  
Date : 26<sup>th</sup> January 2026  
Time : 1330 – 1630 hours  
Duration : 3 hours

#### General instructions

1. Read all instructions carefully before answering the questions.
2. This is a **Closed Book Test**; texts or other printed material and electronic communication devices are not permitted to be kept in your possession.
3. This paper consists of **SIX (6) questions** and **SIX (6) printed pages**.
4. Answer **ALL** questions. The marks associated with each question is indicated.
5. Please remember to write your registration number in the answer script. **Do not write your name.**
6. In case of doubt, consult the supervisor or an invigilator conducting the examination.

**Question 01**

- a. Differentiate between different forms of bearing capacity failures namely, general, local, and punching shear failures paying attention to specific features of shear zone development and the load-settlement behaviour.

[6.0 Marks]

- b. A strip footing proposed as a part of the foundation for a school building is of 1.0 m width. The footing is to be founded at a depth of 0.6 m below ground surface. The groundwater table at the site is located at great depth. The subsurface profile at the site consists of a Dense Clayey Sand which is characterized by following properties given using usual notations:

$$\phi' = 30^\circ, c' = 8 \text{ kN/m}^2, \text{ and } \gamma_d = 20.5 \text{ kN/m}^3.$$

- i. Compute the ultimate load carrying capacity of the footing. Information presented in Table Q1.1 and the following equation with usual notations may be useful in performing the calculations.

$$q_u = c'N_c + qN_q + \frac{1}{2}\gamma BN_\gamma$$

**Table Q1.1: Terzaghi's Bearing Capacity Factors for general shear failure**

| $\phi'$ | $N_c$ | $N_q$ | $N_\gamma$ |
|---------|-------|-------|------------|
| 28      | 31.61 | 17.81 | 13.70      |
| 29      | 32.24 | 19.98 | 16.18      |
| 30      | 37.16 | 22.46 | 19.13      |
| 31      | 40.41 | 25.28 | 22.65      |
| 32      | 44.04 | 28.52 | 26.87      |

[6.0 Marks]

- ii. Compute the allowable bearing capacity for the footing assuming a global factor of safety of 2.5 against bearing failure.

[1.0 Marks]

- iii. Briefly explain how the calculated bearing capacity of the footing would be affected by a rise in groundwater table in the area.

[2.0 Marks]

**Question 02**

Subsurface profile at a proposed site for a multi-storey construction consists of a 5.0 m thick Medium Dense surficial layer of Sand underlain by a Very Dense Sand deposit of great depth as shown in Figure Q2.1. A pile foundation consisting of bored and cast in place concrete piles of 0.6 m diameter are considered for the project. The piles are to be terminated at a depth of 14.0 m below the existing ground surface. The groundwater table at the site is located at the interface between Medium Dense Sand and the Very Dense Sand layers. Considering a pile in axial compression, perform the following calculations. Design parameters with usual notations that may be used in performing the calculations are as given below:

Medium Dense Sand:  $\gamma = 18.0 \text{ kN/m}^3$ ,  $\phi' = 24^\circ$ ,  $K_s = 1.0$ ,  $\delta = 0.75\phi'$ ,  $N_q = 20$

Very Dense Sand:  $\gamma_{sat} = 20.5 \text{ kN/m}^3$ ,  $\phi' = 34^\circ$ ,  $K_s = 1.0$ ,  $\delta = 0.75\phi'$ ,  $N_q = 100$

The unit weight of water,  $\gamma_w$  may be taken as  $9.81 \text{ kN/m}^3$ .

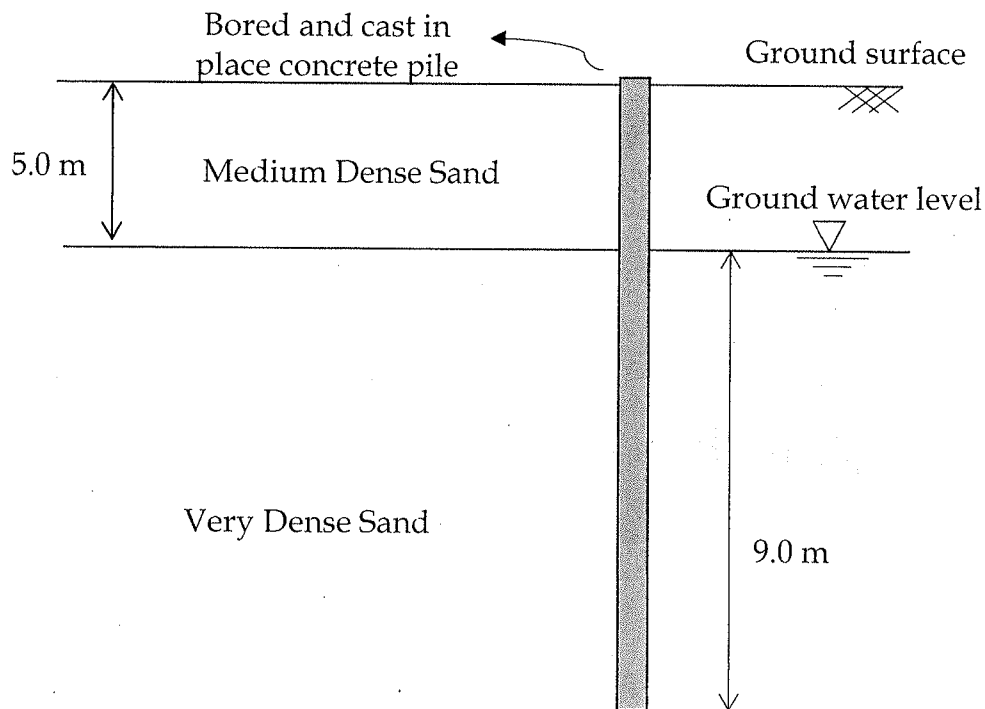


*Figure Q2.1: Subsurface profile at the proposed site*

- Determine the ultimate base resistance that develops at the pile tip.  
[5.0 Marks]
- Determine the ultimate skin resistance that develops over the pile shaft in Medium Dense Sand.  
[6.0 Marks]
- Determine the ultimate skin resistance that develops over the pile shaft in Very Dense Sand.  
[6.0 Marks]
- Determine the ultimate load carrying capacity of the axially loaded pile in compression.  
[2.0 Marks]
- Determine the allowable bearing capacity of the pile considering a global factor of safety of 2.5 against bearing failure.  
[1.0 Marks]

### Question 03

- A gravity retaining wall is proposed to stabilize a cut slope in sand as shown in Figure Q3.1. The groundwater table at the site is located well below the base of the wall. The unit weight of wall material can be taken as  $22 \text{ kN/m}^3$ .

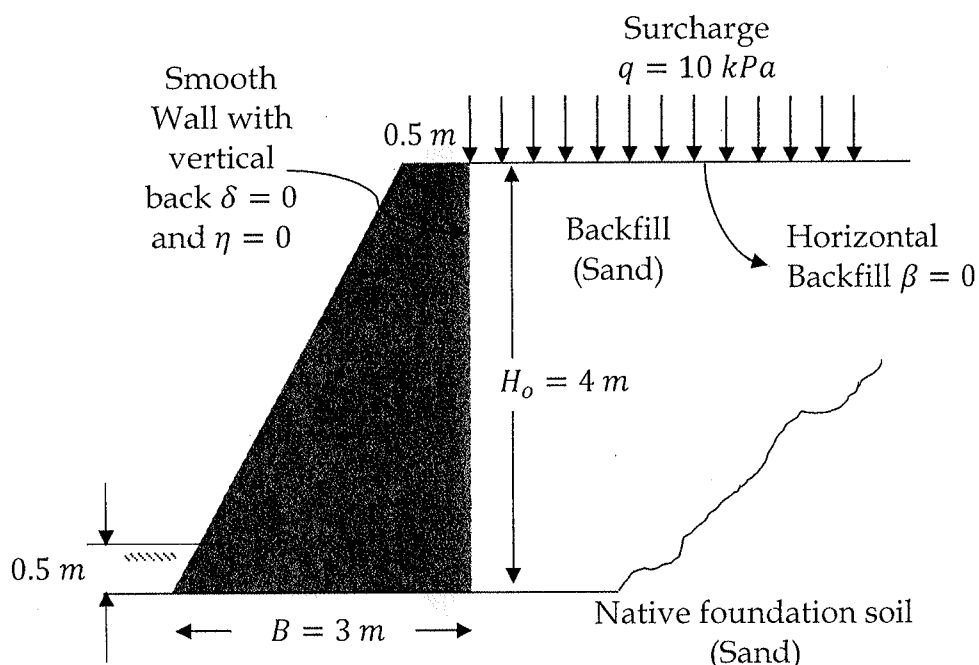


Figure Q3.1: Proposed gravity retaining wall

Perform the calculations demanded by the following sections assuming passive resistance that develop due to soil fill at the toe of the wall is negligible and Rankine's theory is applicable. The soil parameters to be used in the design calculations are provided in Table Q3.1.

Table Q3.1: Soil parameters

| Soil Properties                                                                       | Backfill (Sand) | Native foundation soil (Sand) |
|---------------------------------------------------------------------------------------|-----------------|-------------------------------|
| Dry unit weight, $\gamma_{dry}$ (kN/m <sup>3</sup> )                                  | 18              | 21.0                          |
| Friction angle, $\phi'$ (deg)                                                         | 30              | 36                            |
| Coefficient of interface friction between base of the wall and native foundation soil |                 | $\tan \phi'$                  |

- Construct a diagram to illustrate lateral stress distribution on the wall and determine the force components that act on the wall. [8.0 Marks]
  - Determine the factor of safety against failure by sliding at the base. [4.0 Marks]
  - Determine the factor of safety against failure by overturning of the wall. [5.0 Marks]
- b. Seasonal rain induced slope instabilities are very common in Sri Lanka. Explain this phenomenon using your understanding of the differences in soil behaviour between partially saturated and saturated states. [3.0 Marks]

**Question 04**

Refer to Figure Q4.1 which illustrates the flow net through a homogeneous earthen dam with a filter drain at the toe. The dam is founded on an impervious stratum. The elevations of points B, C, D, and E measured with respect to the datum AF are 10.0 m, 6.25 m, 2.75 m, and 0.0 m, respectively.

- Compute the total heads at points B, C, and E. Clearly state any assumptions that you would make. [5.0 Marks]
- Compute the pressure head at D; hence compute the seepage pore pressure at D. [5.0 Marks]
- Using a sketch, indicate where the maximum hydraulic gradient would occur in the flow regime and explain how you would compute the maximum hydraulic gradient. [4.0 Marks]
- Discuss the benefits of having a toe filter in preventing piping. [4.0 Marks]
- Given the coefficient of permeability of dam material is  $5.2 \times 10^{-7}$  m/s, compute the discharge in  $\text{m}^3/\text{day}$  per meter length of dam. [2.0 Marks]

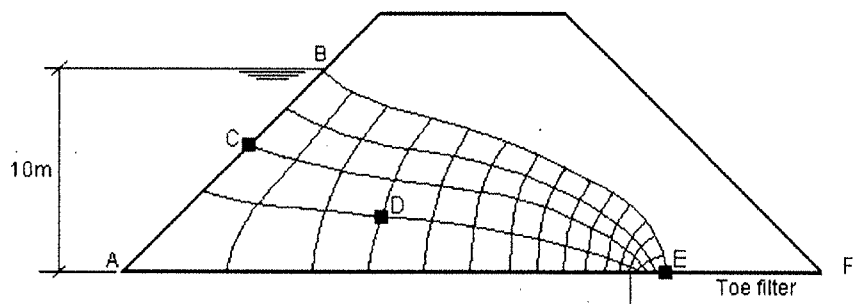


Figure Q4.1: Flow through a homogeneous dam

**Question 05**

A Direct Shear test is conducted to obtain shear strength characteristics for a sand with the application of a constant normal stress of  $70 \text{ kN/m}^2$ .

- Assuming  $K_o = 0.5$ , compute the principal stresses that act on the specimen prior to application of shearing. [2.0 Marks]
- Upon application of shearing, the test reaches an ultimate shear stress of  $42 \text{ kN/m}^2$ . Given the sand is non-cohesive, determine the friction angle ( $\phi'$ ) by calculation. You may sketch a typical Mohr's circle, not drawn to scale, to facilitate your calculation. [4.0 Marks]
- Compute the principal stresses at failure. [6.0 Marks]
- Compute the orientation of the major and minor principal planes. [5.0 Marks]
- Compute the orientation of the plane on which the maximum shear stress occurs. [2.0 Marks]

**Question 06**

Subsurface profile at a low-lying site consists of a 2.0 m thick surficial sand layer underlain by an 8.0 m thick normally consolidated clay layer as shown in Figure Q6.1. A 4.0 m thick fill consisting of silty sand material at a dry unit weight of  $20 \text{ kN/m}^3$  is to be placed at the site to induce consolidation of the clay layer, that is, the site is to be preloaded. The groundwater table at the site is located at the interface between the sand and clay layers. The unit weight of water ( $\gamma_w$ ) may be taken as  $9.81 \text{ kN/m}^3$ .

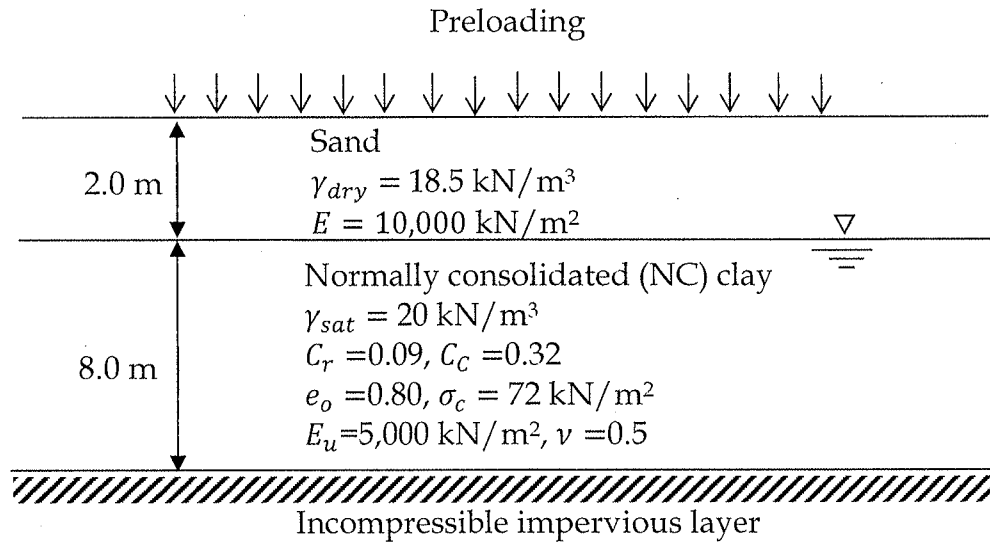


*Figure Q6.1: Subsurface profile at the site and the soil engineering parameters*

- Compute the vertical effective stress at mid depth of the clay layer prior to the placement of the preload. [2.0 Marks]
- Assuming that the preload is of infinite extent, compute the increment in vertical stress that occurs at mid depth of the clay layer after the placement of the preload. [1.0 Marks]
- Compute the consolidation settlement of the clay layer. [3.0 Marks]