00068

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	:	2023/24
Date	:	25th February 2025
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 **SEVEN (7) 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.

Q1. Isolated square pad footings of 1.2 m width are being considered as foundation units for a multistorey shopping complex. The pad footings are 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 sands of varying compactness condition. Average SPT N values of 10 and 30 are reported over the depth range from 0 to 0.6 m and from 0.6 m to 5.0 m below ground surface, respectively. Additional information that may be used in performing the calculations demanded by following sections can be obtained from Figure Q1.1.

a) Compute the allowable bearing capacity of soil as applicable to any one of the vertically and centrally loaded footings based on a limiting settlement of 25 mm.

[3.0 Marks]

b) Now, consider a pad footing that transfers a vertical column load of 200 kN at an eccentricity of 0.1 m.

i. Using usual notations, drive an expression to compute the minimum and maximum values of contact pressure beneath the footing.

[10.0 Marks]

ii. Determine if the footing can safely carry the given load without exceeding the allowable bearing capacity calculated in Section (a).

[2.0 Marks]

Q2. a) Briefly describe the construction process of a bored and cast in place concrete pile.

[6.0 Marks]

b) Subsurface profile at a proposed site for a multi-storey construction consists of a 4.0 m thick medium dense surficial layer of sand underlain by a very stiff clay deposit of great depth as shown in Figure Q2.1. A pile foundation consisting of bored and cast in place concrete piles of 1.2 m diameter are considered for the project. The piles are to be terminated at a depth of 12.0 m below the existing ground surface. The groundwater table at the site is located at the interface between sand and clay layers. Design parameters with usual notations that may be used in performing the calculations demanded by the following sections are as given below:

Medium dense sand: $\gamma = 17.0\ \text{kN/m}^3$, $\varphi' = 24^{\circ}$, $K_s = 1.0$, $\delta = 0.75\varphi'$, $N_q = 40$
Very stiff clay: $\gamma_{sat} = 20.5\ \text{kN/m}^3$, $c_u = 200\ \text{kN/m}^2$, Adhesion factor $\alpha = 0.38$

i. Determine the ultimate tip resistance for an axially loaded pile in compression.

[2.0 Marks]

ii. Determine the ultimate shaft resistance for an axially loaded pile in compression.

[6.0 Marks]

iii. Determine the ultimate load bearing capacity of a pile in compression.

[2.0 Marks]

c) Pile load testing is often recommended to verify pile capacity estimates. Briefly describe how a maintained load test is carried out to determine the load carrying capacity of a pile. Identify the measurements that are taken and how the results are obtained during a typical test. Use neatly drawn sketches to support your answer.

[8.0 Marks]

Q3. 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 kN/m^3. The soil parameters to be used in the design calculations are provided in Table Q3.1. Passive resistance that may develop due to soil fill at the toe of the wall shall be neglected, and Rankine's theory shall be assumed in performing the calculations demanded by the following sections.

a) Construct a diagram to illustrate lateral stress distribution on the wall and determine the force components that act on the wall.

[8.0 Marks]

b) Determine the factor of safety against failure by sliding at the base.

[6.0 Marks]

c) Determine the factor of safety against failure by overturning of the wall.

[3.0 Marks]

d) Briefly explain how the factor of safety against sliding at the base would be affected by seasonal rain induced elevated groundwater table behind the wall and associated seepage.

[3.0 Marks]

Q4. a) 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.

[6.0 Marks]

b) 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.

i. Compute the total and pressure heads at points A, B, C, and D. The elevations at points C and D with respect to the datum EF are 7.8 m and 2.6 m, respectively.

[6.0 Marks]

ii. Compute the discharge in m^3/day per meter length of dam. The coefficient of permeability of dam material can be taken as 5.2×10^{-7} m/s.

[4.0 Marks]

Q5. To obtain shear strength characteristics of a sand a consolidated drained triaxial compression test was conducted at an all-around cell pressure of 150 kN/m^2. The specimen failed at a deviatoric stress of 224 kN/m^2.

a) Given the sand is non-cohesive, determine the friction angle (φ') by calculation. You may sketch a typical Mohr's circle, not drawn to scale, to facilitate your calculation.

[4.0 Marks]

b) Determine the inclination of the failure plane with respect to the orientation of the major principal stress plane.

[4.0 Marks]

c) Determine the maximum shear stress induced within the specimen and the orientation of the respective plane.

[2.0 Marks]

Q6. a) Subsurface profile at a site considered for a warehouse facility development project consists of a surficial sand layer underlain by a normally consolidated clay layer. The proposed foundation as shown in Figure Q6.1 applies a net stress increment of 150 kN/m^2 at the base of the foundation. The groundwater table at the site is located at the interface between the sand and clay layers. The unit weight of water (γ_w) may be taken as 9.81 kN/m^3.

i. Compute the vertical effective stress at mid depth of the clay layer prior to the construction.

[3.0 Marks]

ii. Assuming a 2-vertical to 1-horizontal stress distribution in the subsurface, compute the increment in vertical stress at mid depth of the clay layer after the construction.

[4.0 Marks]

iii. Compute the consolidation settlement of the clay layer.

[3.0 Marks]

b) Explain how preloading can be used to control consolidation settlement of clays upon transfer of loading from structures.

[5.0 Marks]

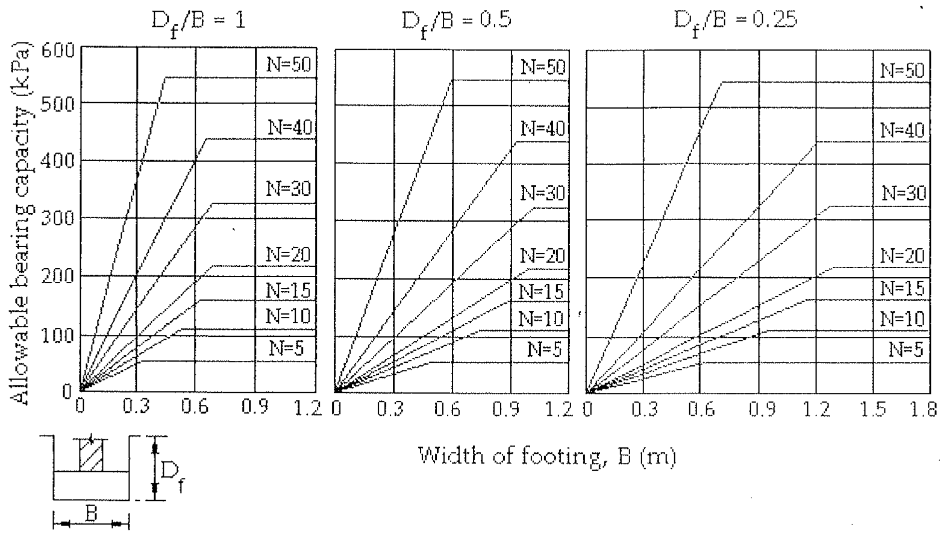

Figure Q1.1: Allowable bearing capacity for a footing in a sand stratum

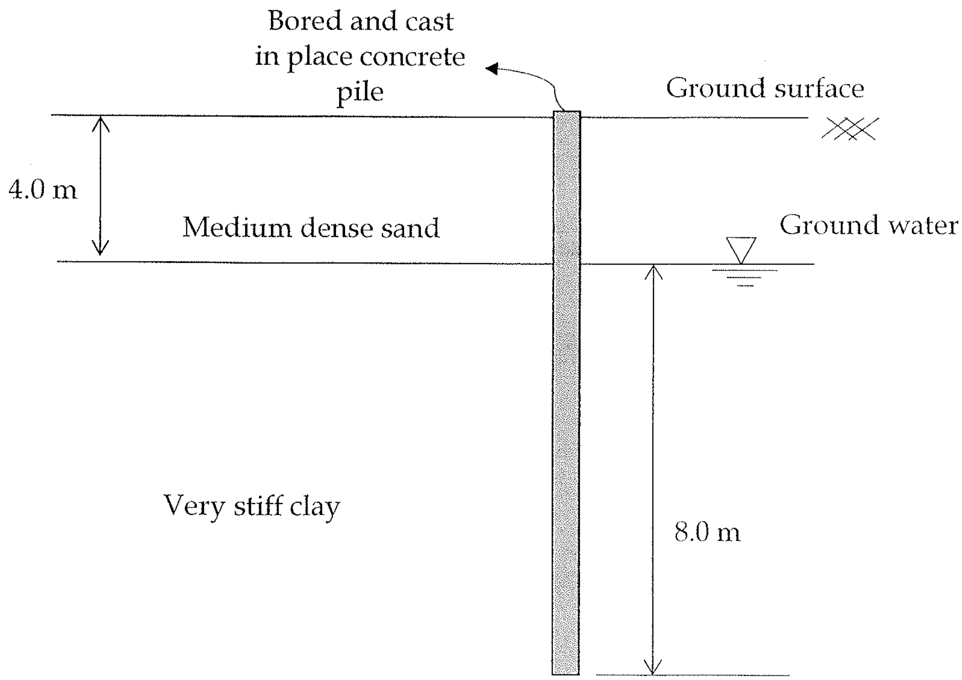

Figure Q2.1: Subsurface profile at the proposed site

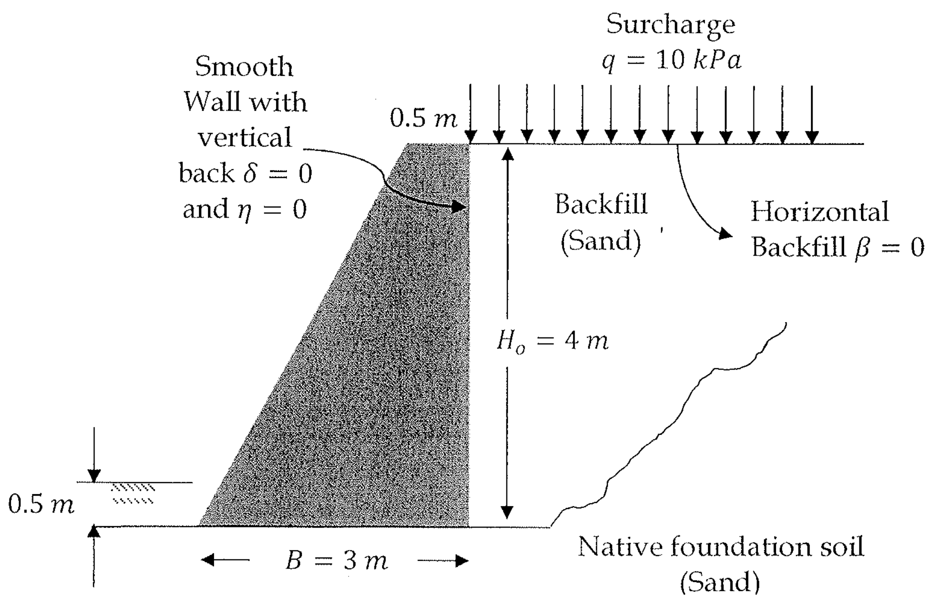

Figure Q3.1: Proposed gravity retaining wall

Table Q3.1: Soil parameters

Soil Properties	Backfill (Sand)	Native foundation soil (Sand)
Dry unit weight, γ_{dry} (kN/m^3)	18	20
Friction angle, φ' (deg)	30	32
Cohesion, c' (kN/m^2)	0	0
Coefficient of interface friction between base of the wall and native foundation soil		$\tan\varphi'$

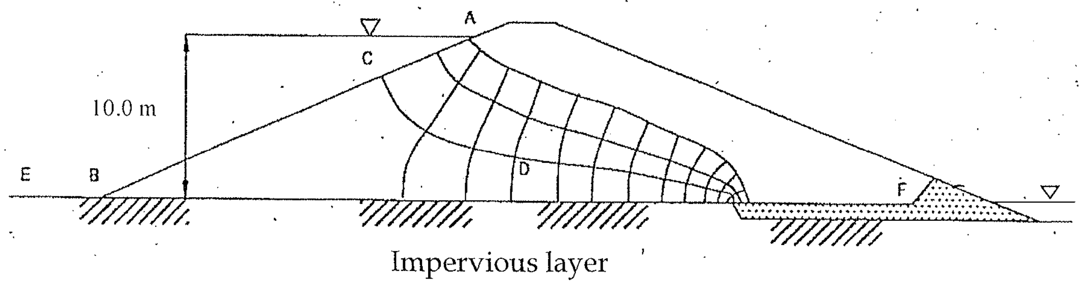

Figure Q4.1: Flow through a homogeneous dam

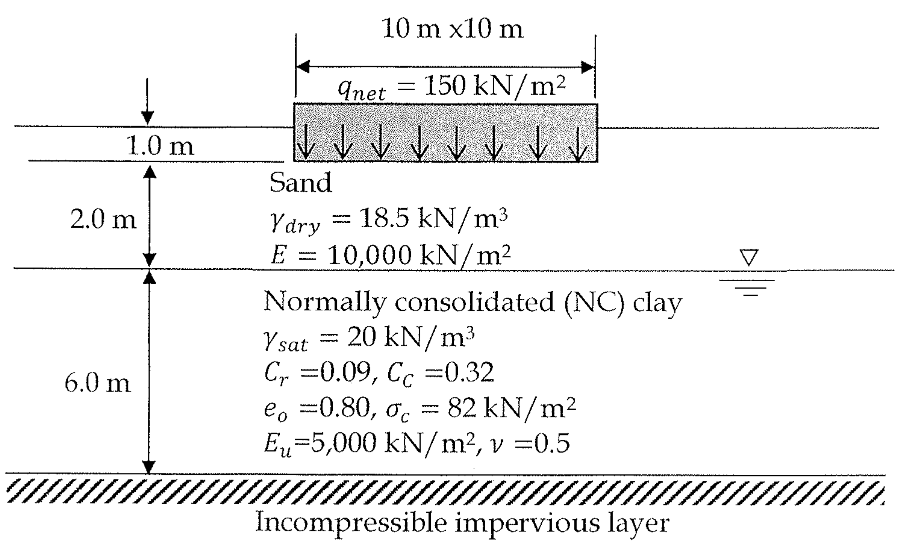

Figure Q6.1: Subsurface profile at the proposed site and the soil engineering parameters