

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	: CVX7346 Ground Improvement Techniques
Academic Year	: 2023/2024
Date	: 06 th March 2025
Time	: 13.30 - 16.30 hours
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
 2. This question paper consists of Seven (7) questions in Four (4) pages including the design tables.
 3. Answer any **Five (5)** questions only.
 4. All questions carry equal marks.
 5. Answer for each question should commence on a new page.
 6. This is a Closed Book Test (CBT).
 7. Relevant tables / codes (if necessary) are provided in the last page of the exam paper.
 8. Answers should be in clear handwriting.
 9. Do not use Red colour pens.
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(01)

Micro Piles are typically used in limited access areas, such as low overhead clearance, and can be accessed through a typical man door. They are also useful in urban areas where there are nearby structures.

- (i) List four (04) different types of possible failure modes of Micro Piles. **(04 marks)**
- (ii) Considering the above failure modes mentioned under (01) (i), list five (05) design considerations made in the design of Micro Piles. **(05 marks)**
- (iii) Briefly explain the installation process of Micro Piles. **(05 marks)**
- (iv) List four (04) advantages and two (02) disadvantages of Micro Piles as a ground improvement technique. **(06 marks)**

(02)

An urban highway is to be retained with a Mechanically Stabilizes Earth (MSE) Wall with steel reinforcements. The design related parameters corresponding to the particular site are given in Table Q.2.1.

Table Q.2.1

Parameter	Value
Total design height (wall height 9.0 m and pavement grade 300 mm) (H)	9.3 m
Traffic surcharge	10 kN/m ²
Unit weight of retained soil (γ)	18.6 kN/m ³
Angle of internal friction (ϕ) of retaining soil	30°
Angle of internal friction (ϕ_r) of reinforced backfill soil	34°
Allowable bearing capacity	420 kPa
Pullout Resistance Factor of wall (F^*) (irrespective of the depth)	2.0
Safety Factors for External Stability	
Sliding	1.5
Bearing Capacity	1.0
Global Stability	1.3
Eccentricity	$< L_b/6$; L_b is the bottom width
Safety Factors for External Stability	
Pullout	1.5

- (i) Draw a neat diagram showing the forces acting on the proposed MSE wall. **(02 marks)**
- (ii) Assess the External Stability of the MSE wall based on the data given in Table Q.2.1. **(06 marks)**

(iii) Assuming that;

(a) Precast concrete panels of size 1.5 m x 1.5 m are used with reinforcements having a vertical spacing of 0.75 m between each and reinforcements are placed at 375 mm from top and bottom of each panel.

(b) The horizontal stress factor (α) = 1.0; irrespective of the depth.

Calculate the minimum pullout resistance required for reinforcements installed at each depth. **(08 marks)**

(iv) Calculate the number of reinforcement strips required over two panel widths for each depth considering that;

(a) Area that provide shearing resistance against pullout by a single reinforcement strip is having a width of 50 mm for the reinforcements.

and

(b) The active length, L_a , of an inextensible reinforcement is $0.3H$ (H - total design height of the wall) and it is constant throughout the entire depth of the wall.

(04 marks)

(03)

The method of Fiber Reinforcement consists of randomly mixing fibres into the soil to increase its strength properties.

(i) Briefly explain the how the properties of soil are enhanced when fibre reinforcement technique is used and describe how it affects the economy in foundation construction.

(06 marks)

(ii) Describe the effectiveness of using the fibre reinforcement technique in solving slope failure/stability problems.

(04 marks)

(iii) List four (04) advantages and four (04) disadvantages of fibre reinforcement technique.

(04 marks)

(iv) Discuss on the different types of fibres used for treatment of soil and their relative effectiveness.

(06 marks)

(04)

Blasting, also known as Explosive Compaction is initiated by systematically exploding buried explosives placed at specific locations within the soil mass.

- (i) Explain the underlying principles and the factors that affect the efficiency of the blasting as a ground improvement technique. **(05 marks)**
- (ii) Explain the blasting treatment process of soils. **(05 marks)**
- (iii) State six (06) design parameters that influence to an effective blasting process. **(04 marks)**
- (iv) Define what is 'Hopkin's Number', which is used to design the blasting treatment of soils and explain how it relates with the anticipated change in pore water pressure and settlement in the soil. **(03 marks)**
- (v) List three (03) advantages and three (03) disadvantages of blasting as a ground improvement method. **(03 marks)**

(05)

A 3.0 m high geotextile reinforced wall is to be designed to carry a storage area that applies a vertical equivalent dead load $q = 10 \text{ kN/m}^2$. The design related parameters corresponding to the particular site are given in Table Q.5.1.

Table Q.5.1

Parameter	Value
Properties of Backfill	
Unit weight of Backfill (γ)	17.2 kN/m ³
Angle of internal friction (ϕ)	34°
Cohesion (c)	0 kN/m ²
Properties of Geotextile	
Ultimate wide width tensile strength	50 kN/m ²
friction angle between geotextile and soil (δ)	24°
Site Specific Partial Safety Factors	
Installation damage	1.5
Creep	3.0
Chemical degradation	1.25
Biological degradation	1.0
Global Safety Factor	1.5

- (i) Calculate the vertical spacing between geotextiles at each depth at intervals of 0.33 m. **(04 marks)**

- (ii) Assuming that the slip surface is inclined to the horizontal at $(45 + \phi/2)$, calculate the length of the geotextiles at each depth at intervals of 0.33 m. **(08 marks)**
- (iii) Determine the exact depths of geotextile installation and corresponding total length of geotextiles required at each depth, assuming that the overlap length of the geotextiles at each depth as 1.00m. **(08 marks)**

(06)

Improvement or stabilization of soils with the use of admixtures is achieved with cementitious materials such as cement, lime, fly ash, blast furnace slag and pozzolanas.

- (i) Briefly explain the structural changes occur in the soil structure when using Cement and Lime as admixtures using illustrations. **(05 marks)**
- (ii) Discuss the effects on the duration between treatment and compaction of a given soil strata when using; (a) Cement (b) Lime and compare their advantages and disadvantages. **(05 marks)**
- (iii) Discuss the influence of properties of the parent soil for effective soil treatment with admixtures. **(05 marks)**
- (iv) Briefly discuss the applicability of Cement and Lime on different types of soils and for different field applications. **(05 marks)**

(07)

Dewatering is considered as a ground improvement technique and its most common application involves lowering groundwater levels in the vicinity of an excavation which will be used for some construction or construction related usage.

- (i) Describe in detail on the following dewatering methods with neat illustrations.
 - (a) Wellpoints. **(03 marks)**
 - (b) Eductor Wells. **(03 marks)**
- (ii) A deep well is to be employed to lower the water table by 3.0 m at a construction site, from 16.0 m MSL to 13.0 m MSL. If permeability of the soil is 1.5×10^{-3} m/s, and the well diameter is 800 mm, calculate the discharge flow rate. **(06 marks)**
- (iii) Suppose instead of a single deep well mentioned in question (07) (ii), a cluster of deep wells are employed in a triangular arrangement. If the distance between deep wells is 300 m and the well diameter is 300 mm, calculate the discharge flow rate. **(04 marks)**
- (iv) List four (04) advantages and four (04) disadvantages of dewatering as a ground improvement method. **(04 marks)**