043

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	: 2022/2023
Date	: 15th February 2024
Time	: 09.30 -12.30 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.
3. Answer any **Five (5)** questions only. All questions carry equal marks. If you have answered more than five questions (either partly or in full), cross out the answers. Otherwise only the first five appearing in the answer book will be evaluated.
4. Answer for each question should commence on a new page.
5. This is a Closed Book Test (CBT).
6. Answers should be in clear handwriting.
7. Do not use Red colour pens.

(01)

The use of stone columns and lime columns has proved to be an economical and technically viable ground improvement technique for construction on soft soils.

i. List three (03) distinct techniques of stone column installation and describe on two (02) of these methods with clear illustrations. **(04 marks)**

ii. Describe how a lime column enhances the ground properties. **(04 marks)**

iii. Explain how stone columns contribute to mitigating the liquefaction potential of soils. **(04 marks)**

iv. List four (04) advantages and four (04) disadvantages of lime columns as a ground improvement technique. **(04 marks)**

v. Illustrate potential failure modes of group stone columns with clear sketches and brief explanations. **(04 marks)**

(02)

Ground anchors must be implemented to offer stability to a retaining wall that stands at a height of 10 m. The wall is a vertical wall. Ground anchors need to be designed for this 10 m high wall to retain granular soil characterized by an internal angle of friction, φ =28° and a unit weight of 20 kN/m^3.

i. With the use of a neat diagram show the main components of a ground anchor. **(04 marks)**

ii. Assuming that there are two anchors placed at depth of 2.5 m and 7.5 m from top of the retaining wall, and the horizontal force is shared equally by the anchor rods compute the tie back force to be resisted by each anchor. Assume at rest conditions behind the wall. **(04 marks)**

iii. Assuming that the anchor angle of inclination is 30° to the horizontal and the soldier beam location are 2.25 m apart for both upper and lower level, compute the design tie back load. **(04 marks)**

iv. Considering a safety factor of 2.5, calculate the ultimate load of the anchor. If tendons are made of steel with a yield tensile strength of 1.86 kN/mm^2, assuming 10 mm diameter strands, calculate the number of strands per anchor. **(04 marks)**

v. List four (04) different types of ground anchors. **(04 marks)**

(03)

Soil stabilization is a crucial aspect of construction and civil engineering projects. One effective method of soil stabilization is grouting and different grouting methods are employed based on the specific soil conditions and desired outcomes.

i. Compaction grouting, rock grouting and compensation grouting are three different techniques used in in geotechnical and construction applications for soil / rock improvement. Explain the key differences between these techniques providing simple sketches to illustrate each one. **(04 marks)**

ii. Describe the process of Double Fluid Jet grouting technique with the use of a neat illustration. **(04 marks)**

iii. Give four (04) different applications of Jet grouting. **(04 marks)**

iv. List the typical parameters of Jet grouting on which a particular application is decided on. **(04 marks)**

v. Discuss the advantages and disadvantages of Jet Grouting Technique. **(04 marks)**

(04)

Preload, surcharge, vacuum consolidation and electro – osmosis techniques can be used as ground treatment for fill embankments constructed over soft soils to meet the stringent total and differential settlement criteria imposed by local authority bodies.

i. Explain how the preloading mechanism help accelerate consolidation using the diagram of void ratio vs. effective stress obtained from an oedometer test. **(04 marks)**

ii. What is vacuum consolidation? How does it differ from the surcharging or preloading? **(04 marks)**

iii. Explain with an illustration, on the effectiveness of using preloading technique along with an efficient drain installation in construction of an embankment on soft clay. **(04 marks)**

iv. How does electro – osmosis help in ground improvement by consolidating the soil? **(04 marks)**

v. Give four (04) different types of electro – osmosis methods. **(04 marks)**

(05)

A road construction project needs soil to construct a road that is 4.0 m wide and 300 m long. The road needs a 0.6 m layer of soil. A borrow pit at a close location is chosen to obtain the soil for the road. The insitu unit weight of the borrow pit soil is 16 kN/m^3 and the insitu moisture content of the borrow pit soil is 8.5%. To assess the suitability of the soil a Standard Proctor compaction test was performed and the results are given in Table 1.

Table 1 : Results of Standard Proctor Compaction test

Trial No.	Volume of Proctor Compaction Mould (cm^3)	Mass of wet soil in the mould (kg)	Moisture Content (%)
1	945	1.70	7.7
2	945	1.89	11.5
3	945	2.03	14.6
4	945	1.99	17.5
5	945	1.96	19.7
6	945	1.92	21.2

Specific Gravity of soil, G_S = 2.67

i. Calculate the maximum dry density and the optimum moisture content. **(04 marks)**

ii. Plot zero air voids line on the same graph. **(04 marks)**

iii. If the road is to be compacted to the maximum dry density at the optimum moisture content, determine the total volume of the soil that needs to be hauled from the borrow pit in m^3. Assume zero wastage. **(04 marks)**

iv. It is decided to improve the properties of the road by using admixture lime. State the properties that will be enhanced by the addition of lime. **(04 marks)**

v. State three (03) disadvantages of using cement admixture for soil stabilization. **(04 marks)**

(06)

Soil Nailing is generally used to permanently or temporarily stabilize natural soil slopes and/or to stabilize over steepened slopes while maintaining their safety within acceptable limits.

i. Briefly describe the steps of the construction sequence of deep soil nailing using illustrations. **(04 marks)**

ii. Design of soil nailing is carried out by using limit state design. List six (06) limit state design considerations of a soil nail wall design. **(04 marks)**

iii. Provide a neatly labelled diagram of a soil nail with typical head plate arrangement with details of temporary and permanent facings. **(04 marks)**

iv. List four (04) advantages of soil nailing over ground anchors. **(04 marks)**

v. Give four (04) applications of Soil Nailing. **(04 marks)**

(07)

Geosynthetics are materials used in various civil engineering applications associated with earthworks such as earth reinforcement, separators between road subgrade and base layer, filtration etc.

i. Geosynthetic clay liners are popular in place of conventional clay liners in waste containment applications. Explain on how the geosynthetic clay liners are produced. **(05 marks)**

ii. Give advantages and disadvantages of geo synthetic clay liners over traditional clay liners in waste containment applications. **(05 marks)**

iii. Explain the functions of geotextiles, geo cells, geomembranes, geonets and geocomposites separately. **(05 marks)**

iv. Biodegradable geotextiles are now commonly being used in place of polymeric geotextiles. State five (05) distinctive advantages of biodegradable geotextiles over polymeric geotextiles. **(05 marks)**