INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: FN/AN Time: 2 hours Full Marks: 60 Department: Civil Engineering
No. of students: 5 (B. Tech Hons), 8 (M. Tech), 1 (Research Scholar) Mid Autumn Semester Examination, 2012-2013
Subject No.: CE31406, CE60123 Subject Name: Ground Improvement
Fourth year B. Tech (H), M. Tech (Geotechnical Engineering), Ph.D

Instructions: This question paper has one page. Answer all questions. State all assumptions. Maximum marks carried by a question are listed near the right margin within square brackets

1. Select the correct options for the following and explain the reason for your choice.

   ii. A correct sequence for cation exchange could be [4]

   A. $Al^{3+} > K^+ > NH_4^+$ B. $Ca^{2+} > Mg^{2+} > Na^+$ C. $Mg^{2+} > Ca^{2+} > Na^+$ D. $Na^+ > K^+ > NH_4^+$

   iii. Treatment of a fine-grained soil with a pozzolanic material is likely to lead to [4]

   A. a decreased swell pressure
   B. increased plasticity index
   C. increased hydraulic conductivity
   D. increased sensitivity

   iv. Higher valence cation substituting a lower valence species in a clay mineral would likely to make the clay exhibit [4]

   A. Greater sensitivity
   B. Greater ductility
   C. Smaller swell pressure
   D. Lower compressibility

   v. Double layer thickness in a clayey soil is likely to increase with [4]

   A. cation exchange
   B. increased soil acidity
   C. decreased clay particle surface charge density
   D. decreased groundwater salinity

2. i. Discuss the relative advantages and limitations of vacuum preloading and preloading with PVDs. [5]

   ii. A 1-m thick layer of saturated clayey silt, normally consolidated under an effective vertical stress of 100 kPa, was characterized with a compression index of 0.3. In a proposed construction project, the layer will be subjected to a vertical stress increment of 50 kPa. Find the constrained modulus assuming the void ratio before application of the stress increment to be 1. [5]

   iii. A 10-m thick layer of saturated, normally consolidated clayey silt (C_c = 0.36, c_v = 0.005 m^2/d, γ = 16 kN/m^3, natural moisture content of 50%, specific gravity of soil solids of 2.7) is found underneath a 1-m thick layer of silty sand (γ = 18 kN/m^3) at surface. The water table occurs at ground surface. The clayey silty is underlain by dense sand. Estimate the settlement of silty clay under a 3-m high preload fill (γ = 19 kN/m^3) placed over a 50-m square area and maintained over 30 days. [10]

3. A 45-kPa surcharge will be placed over a circular area of 30-m square area at a site underlain by 2-m thick clayey silt (OCR = 5, $c_v = 1\times10^{-2}$ cm^2/s, $C_c/(1+e_0)$ = 0.25, $C_r/(1+e_0)$ = 0.02, γ = 17 kN/m^3, s_u = 15 kPa) over 15-m thick, soft clayey silt ($c_v = 1\times10^{-3}$ cm^2/s, $C_c/(1+e_0)$ = 0.3, γ = 16.5 kN/m^3, $s_u = 0.3\times\sigma_v'$). The soft clayey silt is, in turn, underlain by basalt bedrock. Design a group of lime columns, 0.5 m in diameter, to support the surcharge. Assume the water table to be at the ground surface. [20]

Useful formulas:

$$T_v \approx (\pi/4)\times(U/100)^2 \text{ for } U \le 60\%$$

$$T_v \approx 1.781 - 0.933\log(100-U) \text{ for } U > 60\%$$