THE OPEN UNIVERSITY OF SRI LANKA
Department of Civil Engineering
Bachelor of Technology (Civil) - Level 6

CEX6230 – Geotechnics

FINAL EXAMINATION – 2016/2017

Time Allowed: Three (03) Hours

Date: 13-11-2017 (Monday) Time: 1330 - 1630 hrs.

Answer any five (5) questions. All questions carry equal marks.

Q1.

An elevation of an anchored flexible sheet pile wall with a smooth back, retaining the bank of a canal, is shown in Figure Q1. There is a uniformly distributed surcharge of 20 kN/m acting on the sand behind the wall. The river water level and the ground water level are 3m above the river bed level. The cohesionless sand into which the wall is driven has a bulk unit weight of 18 kN/m^3 above the water table, a submerged unit weight of 11 kN/m^3 below the water table and an angle of shearing resistance 28 degrees.

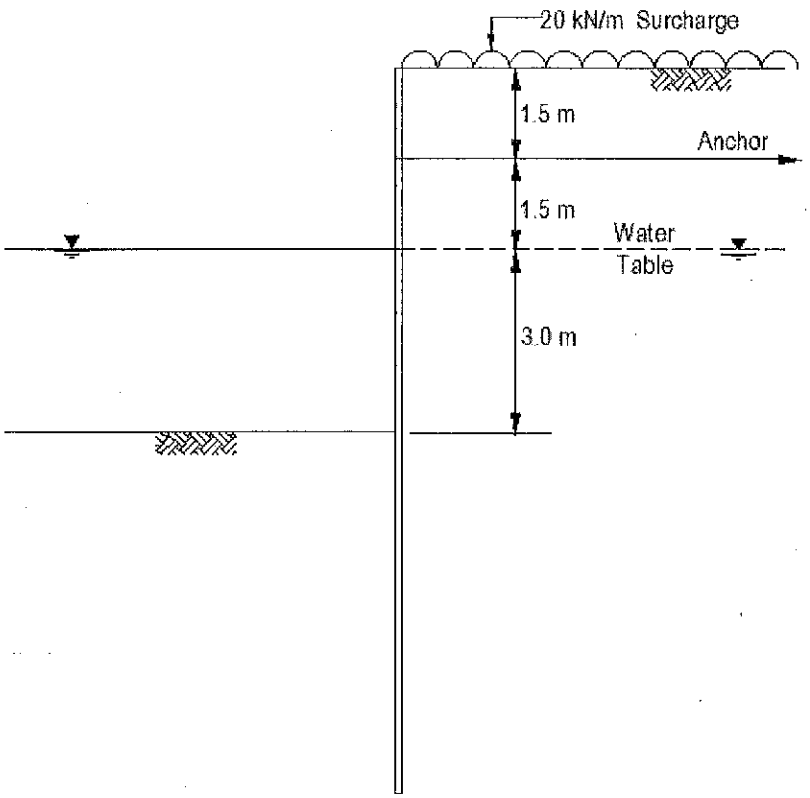

Figure Q1

(a). Evaluate the earth pressure distributions on either side of the wall. (08 marks)

(b). Determine the depth of penetration, d, required. (06 marks)

(c). Determine the force in the anchor rods if anchors are spaced at 2m centres. (06 marks)

Use free earth support method and a factor of safety of unity for all parameters.

Q2.

Direct shear test and triaxial test are two different methods of determination of shear strength of soils in the laboratory.

(a). State two advantages of direct shear test compared to triaxial test. (02 marks)

(b). State two disadvantages of direct shear test which are avoided in the triaxial test. (02 marks)

A soil sample is tested to failure in a consolidated drained triaxial loading test using a cell pressure of 200 kPa. The effective stress parameters of the soil are known to be $\varphi' = 29°$ and $c' = 0$.

(c). Draw the Mohr circle corresponding to the failure condition and identify the pole. (04 Marks)

(d). Determine the inclination of the plane of failure, with respect to the direction of the major principal stress, and the magnitudes of the stresses that will act on this plane. (06 marks)

(e). What is the maximum value of shear stress that will be induced in the soil? (02 Marks)

(f). Draw the stress path followed by the soil and the failure envelope in a (p',q') plot. (04 Marks)

Q3.

An approximate flow net is drawn as shown in Figure Q3 for flow through the clayey silt base of the 37m wide weir. Coefficient of permeability of clayey silt is 1.0×10^{-3}cm/sec.

(a). Tabulate the total, pressure and elevation heads at points A, B, C and D. Take the top level of the impermeable layer (EF) as the datumn. (06 marks)

(b). Compute the rate of seepage under the weir in m^3/day per meter length of the dam. (02 marks)

(c). Calculate the approximate uplift force acting on the base of the dam per meter length of the dam. (08 marks)

(d). Explain one important reason for the provision of the cut off wall. (04 marks)

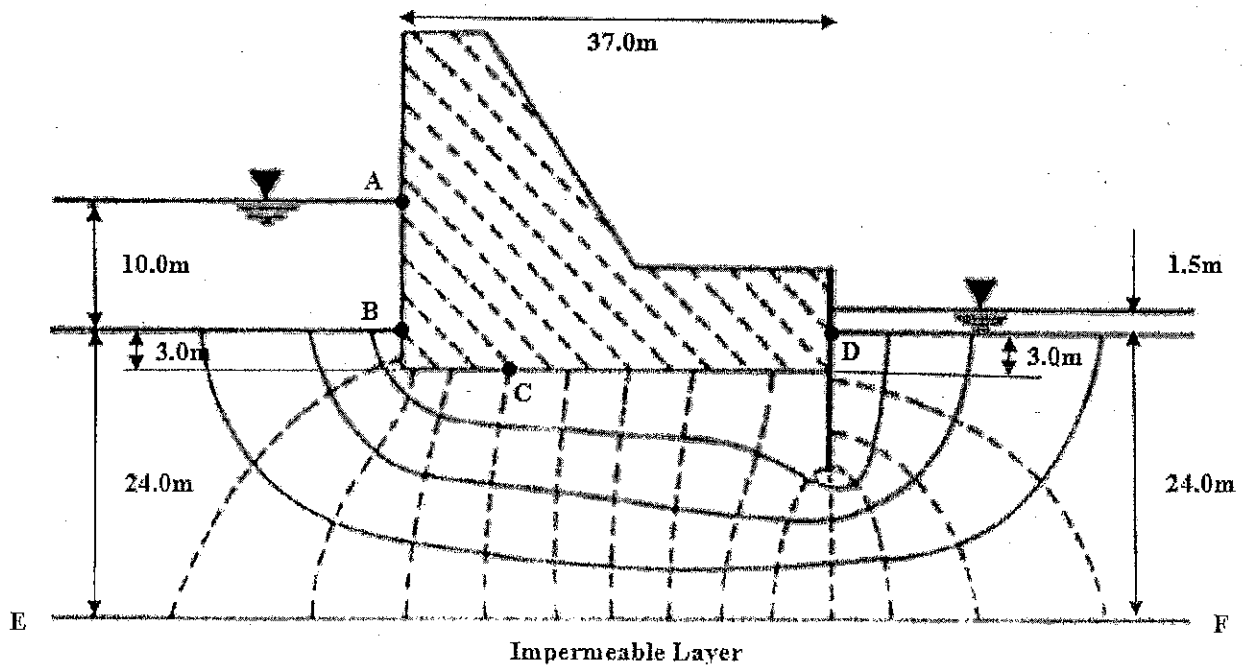

Figure Q3

Q4.

Combined footings are used more frequently nowadays to achieve a uniform pressure distribution underneath the base when constructing columns bordering to the property lines. Figure Q4 shows a trapezoidal footing used in a similar situation. Service column loads acting are 2000 kN and 1600 kN respectively as shown. Both columns are 500mm x 500mm square columns.

(a). State the requirement which needs to be satisfied to achieve a uniform pressure distribution underneath the base. (04 marks)

(b). Determine the point of action of the resultant of the two column loads. (04 marks)

(c). Derive an expression in terms of dimensions A and B to ensure a uniform contact pressure of 200 kPa (neglect the weight of the base). (04 marks)

(d). Compute the dimensions A and B which satisfies the requirement stated in (a) above. (08 marks)

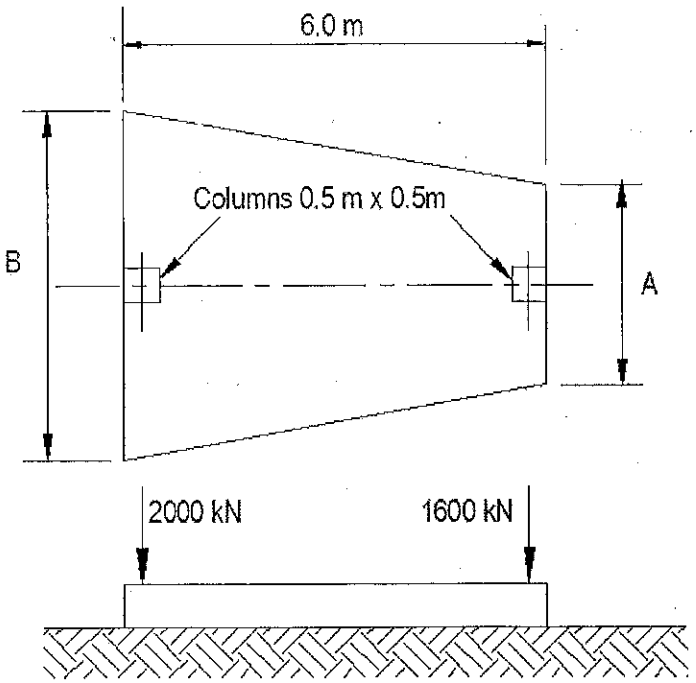

Figure Q4

Q5.

Figure Q5 shows a 10.0m x 10.0m square raft foundation constructed on a clay layer. There is a net increase in contact stress of 150 kPa due to the construction of the raft at a 2m depth.

(a). Compute the vertical effective stress at a depth of 5m from the ground level before construction of the raft foundation. (02 marks)

(b). Compute the vertical stress increment at the same level due to the construction of the raft foundation assuming a 1 horizontat to 2 verical load spread. (02 marks)

(c). Compute the consolidation settlement of the clay layer assuming the pre-consolidation preesure to be 80 kPa. (10 marks)

(d). Compute the immediate settlement if the construction was carried out under undrained conditions (Eu = 32 MN/m^2; ν = 0.50). State any assumptions made. (06 marks)

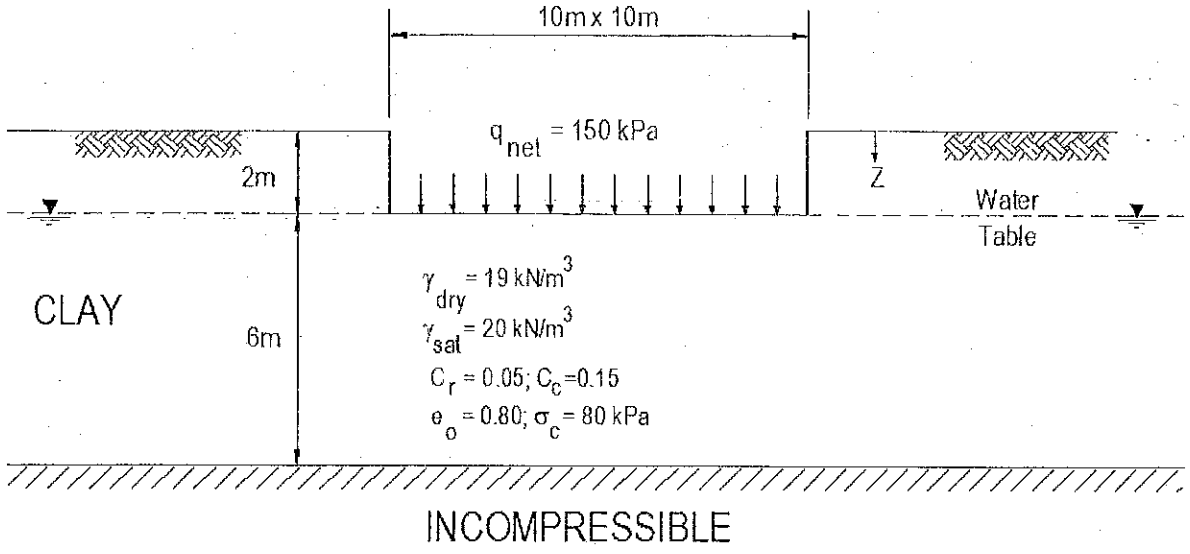

Figure Q5

Q6.

Short term and long term stability of Normally Consolidated (NC) and Over Consolidated (OC) clays subjected to loading and unloading situations in the field can be studied using stress paths.

(a). Indicate with separate sketches to illustrate situations where a soil element in the field can be subjected to a loading and unloading situation. (02 marks)

(b). Illustrate with separate (p - q) plots the undrained stress paths followed by a saturated clay sample during a laboratory triaxial loading and unloading tests. (02 marks)

(c). Draw separate (p,p'- q) plots to indicate the total and effective stress paths followed by soil in the field if the soil is a NC clay and the loading/unloading has taken place during a short span of time. Explain how you would determine whether short term or long term stability is critical based on the drawn stress paths. (08 marks)

(d). Repeat the same exercise in (c) above if the soil is a heavily OC clay. (08 marks)

Q7.

Pile foundations are deep foundations formed by long, slender, columnar elements typically made from steel or reinforced concrete.

(a). Draw a neat sketch to indicate how an applied load is carried by a bored pile and identify each component. (02 marks)

(b). Ultimate load capacity of a single pile installed in cohesive soil can be expressed as,

$$P_u = 9C_u.A_b + \sum \alpha\, C_u.A_s$$

Identify each term in the equation. (02 marks)

(c). Determine the allowable capacity of a single pile, 1.20m in diameter, 30m in length, installed in a thick deposit of clay with soil properties as given below,
Ground level to -20m; C_u = 80 kN/m^2, α = 0.60
-20m to -40m; C_u = 110 kN/m^2, α = 0.45
Use an overall factor of safety of 2.5. (06 Marks)

A group of these piles, 20 x 20 in number, is arranged in a square grid with piles at 3.6m centre to centre to support a thick raft foundation .

(d). Considering both individual and block shear failure of pile group, determine the safe carrying capacity of the pile group. Neglect the difference in weight of soil and concrete and use same factor of safety against block failure. Take the efficiency of the pile group as 0.70. (10 marks)

Q8.

(a). Explain the critical void ratio concept in relation to stress-strain behavior of sandy soils. (05 marks)

(b). What is meant by liquefaction? Discuss this phenomenon by explaining the theoretical background. (05 marks)

(c). Sketch the Mohr's Circle of stress for a soil element in the direct shear box after application of the normal stress but before application of a shear stress. Explain how its stresses are computed. (05 marks)

(d). Figure Q8 shows a natural slope with the most critical failure surface indicated with the dotted line as shown and the slope needs to be stabilized to protect a newly constructed road as shown. Propose a method to stabilize the slope without changing the slope geometry. Explain the concept behind your proposal. (05 marks)

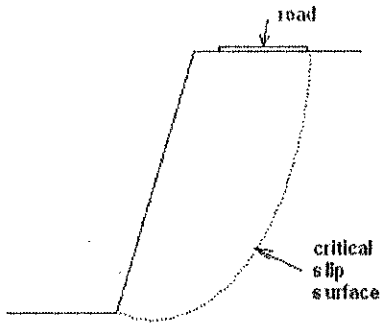

Figure Q8