DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Civil Engineering and Geosciences

Soil Mechanics I

CT1091

BSc EXAMINATION 2012

FOURTH PERIOD

DATE: 27 June 2012 TIME: 09.00 – 12.00

Answer ALL Questions
(Note that the questions carry unequal marks)

Other instructions
Write your name and student number on each answer sheet

Clearly identify the answer in the answer box

1) At a particular location the ground is made up of a number of layers. The ground level is at NAP -3.5 m. Nearby in a borehole the water level is found to be at NAP -4.5 m. The topsoil is a layer of peat 3 m thick, with a dry volumetric weight $\gamma_{d,peat}$ = 9 kN/m^3 and a saturated volumetric weight γ_{peat} = 11 kN/m^3. The capillary rise in this layer is 0.5m. Below this layer, from NAP -6.5 m, is a 7 m thick clay layer with $\gamma_{d,clay}$ = 16.5 kN/m^3 and γ_{clay} = 17.5 kN/m^3. Below NAP -13.5 m a layer of sand is found with γ_{sand} = 20 kN/m^3. A monitoring well in this layer gives a water level of NAP -0.5 m.

    a. Calculate and draw, based on the above information, the evolution of total stresses, effective stresses and pore water pressures in the different layers. [**10 marks**]

A railway is be constructed at this location; therefore a wide embankment 4.5 m high is planned. This consists of sand with a dry volumetric weight of γ_d = 18 kN/m^3. It is known that the clay layer has C_p =20 and the peat layer has C_p = 10.

    b. Divide the clay layer into two equal thickness sub-layers. Determine the total stresses and effective stresses at the centre of each of these sub-layers before and after the embankment has been constructed, assuming that the clay is fully consolidated. [**7 marks**]

    c. Calculate the final compression of the clay layer based on the previously calculated stresses. [**8 marks**]

    d. Calculate the total settlement of the ground surface, assuming the sand does not deform. [**5 marks**]

2) A saturated soil sample of 450 g is sampled using a sample tube of 50 mm diameter and 200 mm length. Calculate the following properties of the soil:

   a. Determine the density (in kg/m^3). [**2 marks**]

   b. Determine the volumetric weight (in kN/m^3). [**2 marks**]

   c. Suggest what type of soil the sample may be. [**2 marks**]

   After 2 days in an oedometer with a fixed diameter of 50 mm and an imposed load of 50 kPa, the sample length has decreased to 173 mm. The sample is then dried at 105 °C for 24 hours and the mass is found to be 383 g and the density of the solid particles is measured to be 1500 kg/m^3. Now calculate the following properties:

   d. The dry volumetric weight of the soil (in kN/m^3). [**3 marks**]

   e. The original water content. [**3 marks**]

   f. The original and new void ratio. [**4 marks**]

   g. The original and new porosity. [**4 marks**]

3) A circular polder of 2 km diameter is situated 5 m below NAP. The soil is formed of a clay layer of 15 m depth and then a sand layer of 2m depth. It is known that the water in the sand layer is connected to the water channels surrounding the polder. Therefore, the pore water pressures in the sand layer are governed by the water level in the water channels which are normally at NAP -1.75 m.

   The permeability of the clay is 3.3×10^{-8} m/s and the volumetric weight is $\gamma = 17$ kN/m^3.

   a. What volume of water must be pumped daily from the polder so that the polder remains dry? [**6 marks**]

   b. If the total pumping capacity of the installed pumps is 125 m^3/hour, how high would the water level in the surrounding water channels have to reach, so that the pumps could not maintain the polder drainage? [**6 marks**]

   c. A culvert is to be installed where the main services are to be located. What is the critical depth of the excavation for the culvert to avoid liquefaction? [**4 marks**]

   d. The culvert has external dimensions of 3.5 m depth by 2 m width and is to be installed so that the base of the culvert is at a depth of 8.5 m to the ground surface. If the culvert is made of concrete, with a volumetric weight of $\gamma_c = 25$ kN/m^3, calculate the wall thickness so that floatation will not occur. Assume that the wall, roof and floor thicknesses are equal, and that the roof of the culvert is covered by 5.0 m of the same clay to maintain the original ground level. [**4 marks**]

4) A large factory is to be constructed on a soft clay and exerts 127 kPa onto the ground via a raft foundation. The ground is made up of a soft clay layer of 5 m thickness, then a 3m sand layer (γ_{sand} = 19 kN/m^3) and finally a second clay layer of 20m resting upon an impermeable rock. The upper clay, clay 1, has a representative m_v value of $m_{v,clay1}$=0.0007 kPa^{-1} and a volumetric weight of γ_{clay1} = 16 kN/m^3; the second clay layer has $m_{v,clay2}$=0.0002 kPa^{-1} and γ_{clay2} = 17.5 kN/m^3. The permeability of the two clay layers is k_{clay1}=7.2x10^{-8} m/s and k_{clay2}=4.4x10^{-7} m/s.

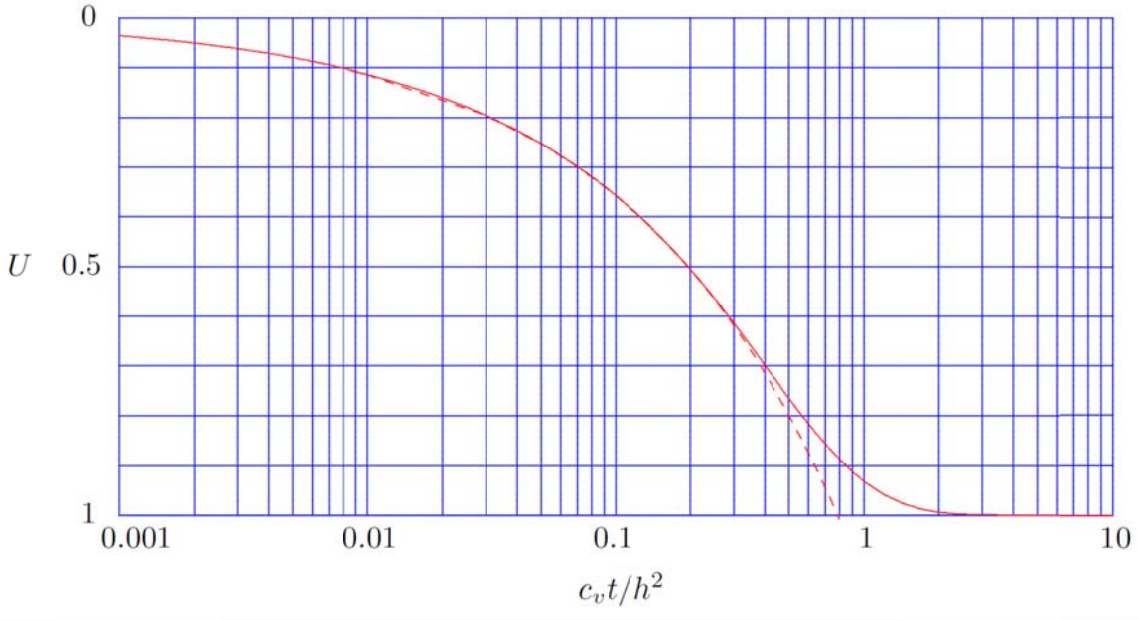
a. Calculate the consolidation coefficients for both layers. [**6 marks**]

b. Calculate the final settlement of the foundation. [**8 marks**]

c. Which clay layer will consolidate first? [**5 marks**]

d. At approximately which time will the overall consolidation be complete? [**5 marks**]

e. What is the surface settlement that would indicate 80% of the longest consolidation process to be complete? [**6 marks**]



[END OF EXAM]