DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Civil Engineering and Geosciences

Soil Mechanics I

CT1091

BSc EXAMINATION 2012 - RESIT

FIFTH PERIOD

DATE: 31 August 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

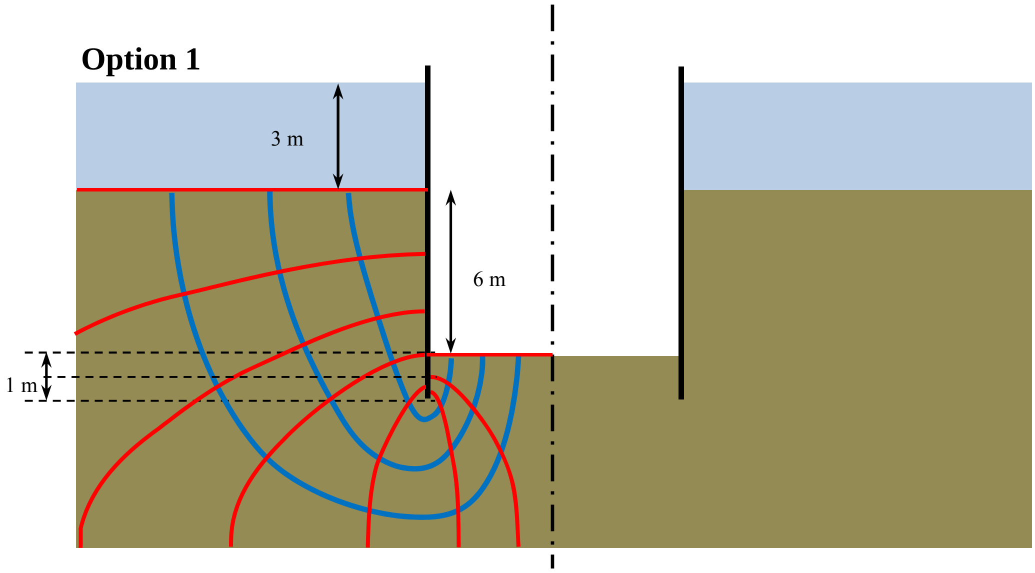
Clearly identify the answer in the answer box

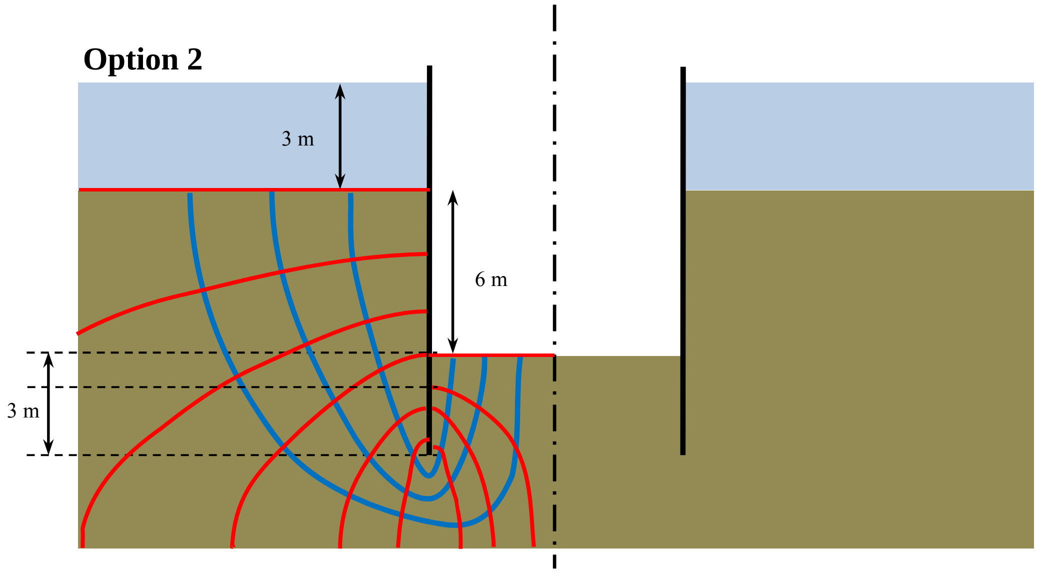
1) An excavation with sheet pile walls is being made in a river estuary for a bridge pier, in a relatively permeable sand as shown below ($k=3.7\times10^{-5}$ m/s, $\gamma=20$ kN/m^3). The river depth is 3 m and two options for the depth of the sheet pile walls are considered, with the flow nets drawn over half the domain.

   a. How many stream lines and potential lines are there in each option. [**4 marks**]

   b. Calculate the flow into the excavation for both options. [**8 marks**]

   c. Is either of the options at risk of liquefaction? [**8 marks**]





2) A borehole is sunk for a site investigation and the ground is found to be made up of a number of layers. The table below summarises the borehole log:

Start NAP (m)	Finish NAP (m)	Soil type	Saturated volumetric weight (kN/m^3)	Dry volumetric weight (kN/m^3)	Water level in soil NAP (m)	Other properties
-2.0	-12.5	Sand	20.0	18.0	-7.75	-
-12.5	-18.5	Clay	17.0	16.5	Saturated	$k = 3.4\text{x}10^{-8}$ m/s $C_p = 16$
-18.5	-35.0	Loamy-sand	19.5	18.5	Saturated	-
-35.0	-	Granite	23.0	23.0	Saturated	-

In the open borehole water is found at -8.5 m NAP, although water is first encountered in the soil at -7.75 m NAP.

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 wide embankment of height 3 m is to be constructed at this location, consisting of a sand with a dry volumetric weight of $\gamma_d = 18$ kN/m^3.

b. Divide the clay layer into three 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. [**7 marks**]

d. Calculate how long the clay layer will take to be fully consolidated, noting that for small stress increments m_v can be approximated by $1/(C_p\sigma_1')$. [**6 marks**]

3) A sample of soil is collected as part of a site investigation. The sample is initially weighed on site as 628 g and is collected via a sample tube of 36 mm diameter and 325 mm length. In the laboratory the sample is first dried at 110 °C for 24 hours and again weighed. The sample weight is found to be 603 g. The sample is then placed in the oven at 900 °C for another 24 hours. The remaining part of the sample is then sieved, with the volume and mass remaining on each sieve recorded in the table below.

   a. What is the volumetric weight of the original sample? [**3 marks**]

   b. Use the sieve data to determine the volume and weight of the clay, sand and silt fractions. [**5 marks**]

   c. Determine the volume percentage of peat, sand, water and air in the original sample. The density of the organic material (peat) $\rho_{s,\mathrm{peat}} = 1100 \mathrm{kg/m^3}$. [**6 marks**]

   d. What is the porosity of the original sample? [**3 marks**]

   e. Draw the grain size diagram. [**5 marks**]

   f. Find the uniformity coefficient and classify the soil. [**3 marks**]

Sieve size, μm	Volume, ml	Mass, g
1	8	21
2	32	81
63	46	141
100	41	157
200	20	84
600	11	46
2000	0	0

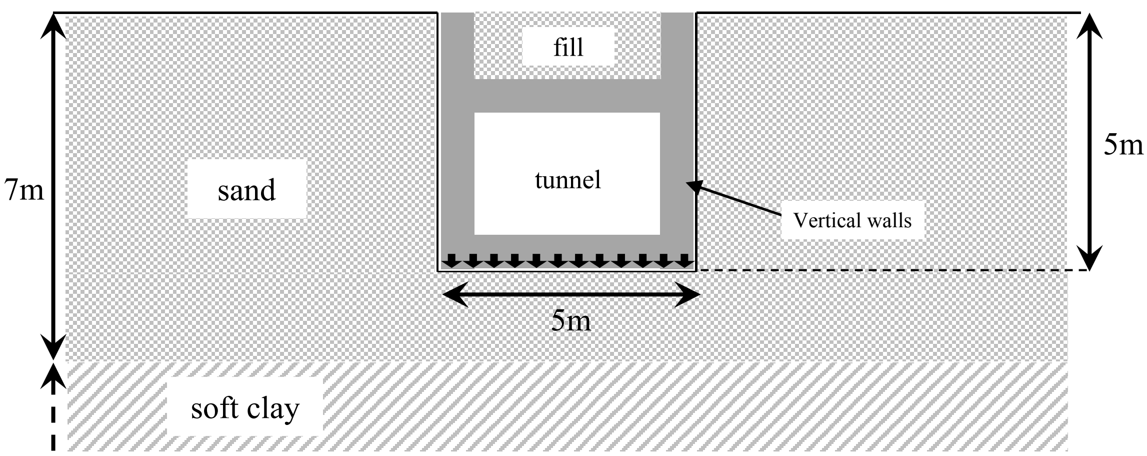
4) A cut and cover railway tunnel of 5 m width and 5 m depth is constructed with vertical retaining walls, as shown below. The tunnel, including self-weight and fill, exerts a uniform vertical stress of 60 kPa onto the underlying soil after construction. This vertical stress is indicated by the arrows in the figure below.

The vertical soil profile is made up of 7 m of sand with a volumetric weight of 18 kN/m^3, then a soft clay layer of 2 m depth with a volumetric weight of 16 kN/m^3 and C_{10} = 6, then a stiff clay layer of 14 m depth with a volumetric weight of 17 kN/m^3 and C_{10} = 17, and finally another sand layer with a volumetric weight of 18 kN/m^3. The sand layers can be assumed to be incompressible and all layers can be assumed to be saturated.

a. Sketch the initial total stress, effective stress and pore water pressure distributions as a function of depth below the ground surface prior to construction. [**5 marks**]

b. Using an appropriate elastic solution calculate the change in vertical stress at depths of 3 m, 7.5 m and 14.5 m beneath the centre-line of the tunnel due to its construction (i.e. at depths of 8 m, 12.5 m and 19.5 m relative to the original ground surface). Include the new effective stress distribution with depth on the previous sketch (assuming consolidation has been completed). [**10 marks**]

c. Calculate the final vertical deformation, using a single layer approach for the soft clay and a 2 sub-layer approach for the stiff clay. [**10 marks**]



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