DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Civil Engineering and Geosciences

Soil Mechanics

CTB2310

BSc EXAMINATION 2014

FOURTH PERIOD

DATE: 2 JULY 2014 TIME: 14.00 – 17.00

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) A site investigation has yielded a sample of soil. A sieving test was undertaken, with the amount of material remaining on each sieve presented in the table below.

   a. Draw the grain size distribution. [**8 marks**]

   b. Determine the uniformity coefficient. [**5 marks**]

   c. Classify the soil. [**3 marks**]

   d. Suggest the likely range of hydraulic conductivity for the soil. [**2 marks**]

   e. Suggest the likely in-situ dry volumetric weight of the soil. [**2 marks**]

Sieve size, µm	Mass, g
Tray	13
63	30
150	25
212	16
300	5
425	12
600	9
1180	27
2000	0

2) An oil tank of 20 m diameter and 10 m height is to be constructed on a saturated clay subsoil. The soil is found to have the following properties: $\gamma = 18\text{kN/m}^3$, $c' = 15$ kPa and $\phi' = 0°$. When the tank is full, the oil makes up approximately 99% of the structure weight. The oil has a volumetric weight of $\gamma = 9\text{kN/m}^3$.

   a. The foundation is initially designed to be constructed on the surface of the ground. Determine the factor of safety against bearing failure, assuming that for the shape factors $B=L=Ø$ (diameter). [**10 marks**]

   b. Another option is to build the tank so that the base of the tank is 2 m below ground surface. Again, determine the factor of safety against bearing failure. [**5 marks**]

   c. A horizontal wind load of 3000 kN is expected. For the option in part (b) calculate the resulting factor of safety. [**5 marks**]

3) A large factory is to be constructed including a basement and ground floor. An initial site investigation has identified two clay layers overlaying a sand layer. The first clay layer is 9 m thick and the second is 5 m thick. Saturated clay is first found in the borehole 2 m below the ground surface, but a long term monitoring well shows water at 4 m below the surface. A separate monitoring well in the sand layer shows a phreatic surface also at 4 m below the ground surface. The material properties that were determined were: $\gamma_{clay\_upper\_dry}$ = 16 kN/m^3, $\gamma_{clay\_upper\_wet}$ = 17 kN/m^3, γ_{clay_lower} = 18 kN/m^3 and γ_{sand} = 19 kN/m^3.

   a. Draw the total stresses, effective stresses and pore water pressures as a function of depth, identifying clearly the main points and soil layers. [**10 marks**]

Samples (50mm diameter, 25mm height) are tested from the two clay layers in an oedometer. The results from the upper layer clay are shown in the table below, which was tested with a 50 N pre-load.

Total load, N	Vertical displacement, mm
50	0
100	1.3
150	2
200	2.6
250	3.1
300	3.5
250	3.4
200	3.3
150	3.1
250	3.3
300	3.6
350	3.9
400	4.1

   b. Determine the C_{10} values for both the loading and unloading/reloading portions of the test (separately). [**10 marks**]

The first part of the construction is an excavation of the first 4 m of clay, so that the basement can be constructed.

   c. Calculate the final deformation at the new soil surface due to the excavation. Use a total of 4 equal layers and assume that the second clay is twice as stiff as the first clay. [**10 marks**]

4) Two CU triaxial tests have been undertaken. Initially both tests have been consolidated to 300 kPa. In the first test, the sample is directly sheared, whereas in the second test, the consolidation pressure has been reduced to 150 kPa prior to the shearing phase. At the last recorded axial stress the sample failed. Results for both tests are given in the table below.

Test 1

Axial stress, σ_1 (kPa)	Pore pressure, p (kPa)
300.0	0.0
350.0	30.0
400.0	70.0
450.0	110.0
500.0	155.0
540.0	192.0

Test 2

Axial stress, σ_1 (kPa)	Pore pressure, p (kPa)
150.0	0
175.0	10.0
200.0	30.0
225.0	60.0
250.0	105.0
267.0	143.0

a. If we know that the pore pressure parameter B after consolidation is 1.0, then determine the pore pressure parameter A at failure for both samples. [**5 marks**]

b. Draw the Mohr's effective stress circle for both tests at failure, highlighting the key features, and draw the Mohr-Coulomb failure envelope. [**8 marks**]

c. Estimate the effective strength parameters *c*' and ϕ'. [**5 marks**]

d. Draw the effective stress path (i.e. $(\sigma'_1 - \sigma'_3)/2$) versus $(\sigma'_1 + \sigma'_3)/2)$) for both tests and draw the modified failure envelope, again highlighting the key features. [**8 marks**]

e. Estimate the modified effective strength parameters *d'* and ψ'. [**4 marks**]

[END OF EXAM]