CIVL 4151
Spring 2015
Homework 8

1. The following are the results of four drained direct shear tests on undisturbed normally consolidated clay specimens, each having a diameter of 50 mm and a height of 25 mm.

Normal Force (N)	Shear Force (N)
50	18
100	35
160	56
275	99

Normal Stress (kPa)	Shear Stress (kPa)
25.5	9.2
50.9	17.8
81.5	28.5
140.1	50.4

Calculate and plot the shear stress at failure (in kPa) as a function of the normal stress (in kPa) and determine the drained friction angle for this soil. From Excel: $\phi' = \tan^{-1}(0.3569) = 19.6°$

2. If another drained direct shear test is performed on the Problem 1 soil at a normal force of 200 N, what would be the shear stress at failure? $\sigma_f = 101.8$ kPa, $\tau_f = 101.8 \tan 19.6° = 36.4$ kPa

3. Draw the Mohr circle at failure for the direct shear test in Problem 2 and determine the major and minor principal stresses at failure.

$$R = \tau_f / \cos \phi' = 36.4 / \cos 19.6 = 38.6 \text{ kPa}$$
$$\sigma_{center} = \sigma_f + R \sin \phi' = 101.8 + 38.6 \sin 19.6 = 114.7 \text{ kPa}$$
$$\sigma'_1 = \sigma_{center} - R = 114.7 - 38.6 = 76.1 \text{ kPa}$$
$$\sigma'_3 = \sigma_{center} + R = 114.7 + 38.6 = 153.3 \text{ kPa}$$

NOTE: If you use Excel to do your Mohr circle plots, you have to make sure both axes have the same scale when printed out (e.g., 200 kPa/inch), otherwise, Mohr's circle won't be a circle!

4. If you performed a consolidated-drained triaxial compression test on the Problem 1 soil at a confining pressure of 408 kPa, what would be the deviator stress at failure?

$$\sigma'_3 = 408 \text{ kPa}$$
$$\sigma'_1 = \sigma'_3 \tan^2(45° + ½ \phi') = 408 \tan^2(54.8) = 820 \text{ kPa}$$
$$\sigma'_d = \sigma'_1 - \sigma'_3 = 820 - 480 = 412 \text{ kPa}$$

5. Draw the Mohr circle at failure for the triaxial shear test in Problem 4 and determine the orientation of the failure plane through the sample with respect to the horizontal plane. $\theta = 45° + ½ \phi' = 54.8°$

6. For the specimen in Problem 4, determine the normal and shear stress on a plane inclined at 30° from the horizontal. Explain why the specimen didn't fail along that plane. The specimen didn't fail along that plane because that point is below the failure envelope.

$$\sigma'_{center} = \tfrac{1}{2}(\sigma'_1 + \sigma'_3) = \tfrac{1}{2}(408+820) = 614 \text{ kPa}$$
$$\sigma' = \sigma'_{center} + \tfrac{1}{2}\sigma'_d \cos(60°) = 614 + 206 \cos(60°) = 717 \text{ kPa}$$
$$\tau = \tfrac{1}{2}\sigma'_d \sin(60°) = 206 \sin(60°) = 178 \text{ kPa}$$

7. The following results were obtained from a consolidated-drained triaxial compression test on an overconsolidated clay soil.

Cell Pressure (kPa)	Deviator Stress (kPa)
200	700
400	855
600	1040

Draw the Mohr circles at failure and use them to determine the effective stress cohesion and effective friction angle for this soil. From Excel: $\phi' = 17.5°$, $c' = 192$ kPa