UNCONFINED COMPRESSION TEST

Aim: The purpose of this laboratory is to determine the unconfined compressive strength of a cohesive soil sample. We will measure this with the unconfined compression test, which is an unconsolidated undrained (UU or Q-type) test where the lateral confining pressure is equal to zero (atmospheric pressure) [1].

Introduction: The unconfined compression test is by far the most popular method of soil shear testing because it is one of the fastest and cheapest methods of measuring shear strength. The method is used primarily for saturated, cohesive soils recovered from thin-walled sampling tubes. The unconfined compression test is inappropriate for dry sands or crumbly clays because the materials would fall apart without some land of lateral confinement. To perform an unconfined compression test, the sample is extruded from the sampling tube. A cylindrical sample of soil is trimmed such that the ends are reasonably smooth and the length-to-diameter ratio is on the order of two. The soil sample is placed in a loading frame on a metal plate; by turning a crank, the operator raises the level of the bottom plate. The top of the soil sample is restrained by the top plate, which is attached to a calibrated proving ring. As the bottom plate is raised, an axial load is applied to the sample. The operator turns the crank at a specified rate so that there is constant strain rate. The load is gradually increased to shear the sample, and readings are taken periodically of the force applied to the sample and the resulting deformation. The loading is continued until the soil develops an obvious shearing plane or the deformations become excessive. The measured data are used to determine the strength of the soil specimen and the stress-strain characteristics. Finally, the sample is oven dried to determine its water content. The maximum load per unit area is defined as the unconfined compressive strength, qu. In the unconfined compression test, we assume that no pore water is lost from the sample during set-up or during the shearing process. A saturated sample will thus remain saturated during the test with no change in the sample volume, water content, or void ratio. More significantly, the sample is held together by an effective confining stress that results from negative pore water pressures (generated by menisci forming between particles on the sample surface). Pore pressures are not measured in an unconfined compression test; consequently, the effective stress is unknown. Hence, the undrained shear strength measured in an unconfined test is expressed in terms of the total stress [1].

Apparatus:

Compression machine (Fig. 1)

Dial Gauge

Proving Ring

Split mould

Sampling tube

Metal Plate

Moving Plate

Vernier calliper

Balance

Sampling extractor [2]

Figure 1. Unconfined compression strength Instrument Set Up [2]

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Procedure:

1. The first step in the procedure is to examine the loading frame. Turn the crank and learn how to read the load and deformation dial gages. Determine the calibration constant for the proving ring and the units of the deformation dial gauge.

2. We will be shearing the samples at a strain rate of 1% per minute. From the length of your soil sample, determine the deformation at 1% strain. Depending on the units of the vertical deformation dial gauge (usually 0.001 inches or 0.0001 inches), determine the number of dial divisions per 1 strain- Practice turning the crank at his number of dial divisions/minute. It is important that the soil sample not be sheared faster than this specified rate.

3. Measure the initial height and diameter of the soil sample with calipers. It is unlikely that the sample will be a perfect right cylinder. Therefore, it will be necessary to find the average height and diameter by taking several measurements in different places along the soil sample. The measurements should be taken by more than one member of a lab team to be sure that the calipers are read correctly. If you have any questions about how to take measurements with calipers, ask the laboratory instructor for instruction.

4. Record the weight of the soil sample and determine the total (moist) unit weight.

5. Place the soil sample in the loading frame, seat the proving ring and zero the dials.

6. During this lab you will record the load applied at specified strain values. It is recommended that readings be taken at strains of 0,0.1,0.2, 0.5, 1,2,3,4,5,6,8, 10, 12 14, 16, 18 and 20 percent. You should prerecord the vertical deformation dial readings at these strain values. With the measured initial height of sample (H0), the desired percent strain (ε) and the initial dial reading (S0), calculate the dial readings (S) as follows:

$$S = S_0 + (\frac{\varepsilon}{100})H_0$$

7. Readings of force (F) are taken from the proving ring dial gauge and the stress applied to the ends of the sample (01, or major principal stress) is computed as follows:

$$\sigma_1 = \frac{F}{A}$$

where A is the cross-sectional area of the sample. Because the soil sample height decreases during shear and the volume of the sample remains constant, the cross sectional area must increase. For a saturated soil that undergoes no volume change during shear (no flow of water into or out of the sample), the equivalent or average area (A) at any strain (e) is computed from the initial area (Ac) and the assumption that volume is conserved:

$$A = \frac{A_0}{1-\varepsilon}$$

8. Shear the sample at a strain rate of 1% per minute. Typically, the sample fails in one of two ways. In stiffer clays, a distinct failure plane forms. For this type of failure, it is likely that the point of failure will be

indicated by the measurement of a peak and then a decrease in load. If this is the case, continue to take four or five readings past the point of failure. (Caution: before you stop shearing the sample, be sure that the sample has failed.) A "barreling" failure is more typical for softer clays. In this type of failure, a distinct failure plane doesn't form, rather the sample bulges in the middle (Figure 2-3). The unconfined compressive strength (qu) is the maximum value σ1, which may or may not coincide with the maximum force measurement (depending on the area correction). It is also equal to the diameter of Mohr's circle as indicated in Fig. 4. The undrained shear strength (su) is typically taken as the maximum shear stress, or:

$$S_u = \frac{1}{2} q_u$$

If σ1 continues to increase up until 20 vertical strain, i.e. does not reach a maximum and then decrease, the sample has failed by "barreling". In this case, qu is defined as the value of σ1 measured at 20% strain.

9. When your lab team has completed the experiment, dismantle the loading frame and measure the water content of the soil sample. It is recommended that you reduce the data for this test during the lab period [1].
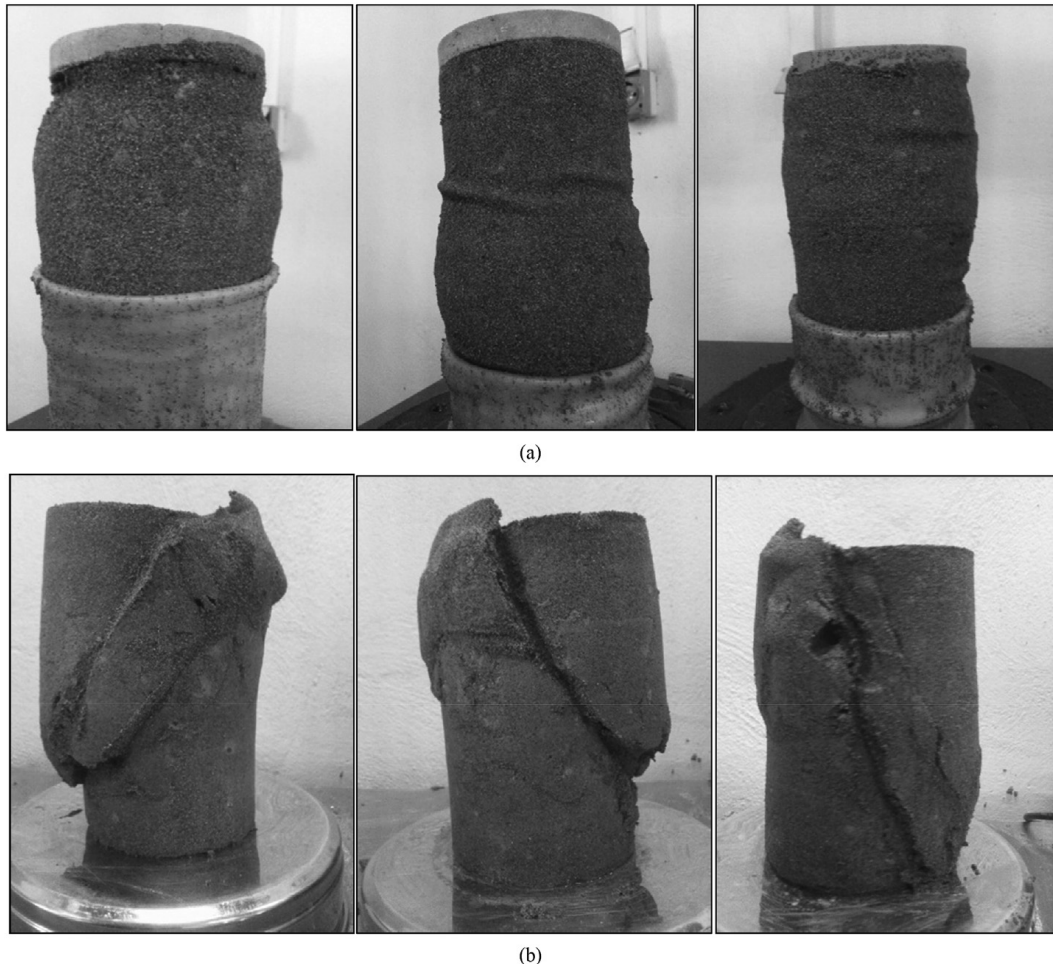

(a)

(b)

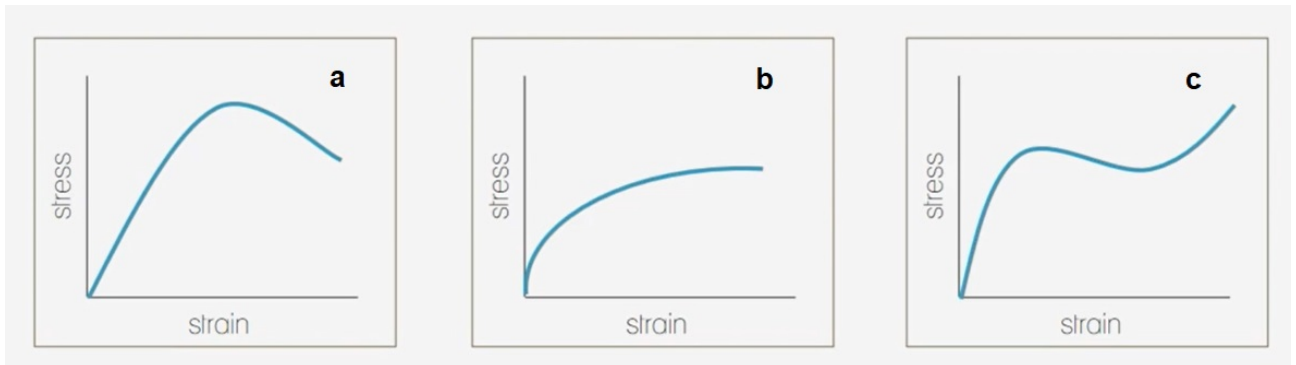Figure 2. Typical failure types; (a) barreling mode failure, (b) shear zone failure [3].

Figure 3. Types of failures and their corresponding stress-strain plot, a – shearing failure, b – bulging failure, c – shearing & bulging failure [4]
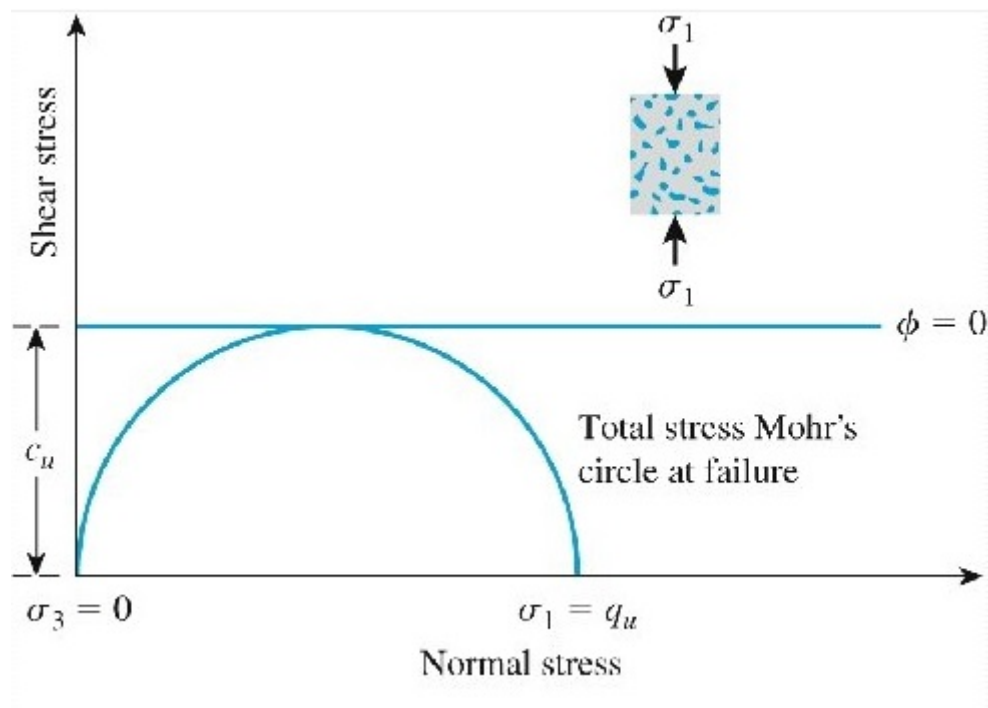

Figure 4. Mohr's Circle for the Unconfined Compression Test [5].

Test Conditions and Measurements:

Initial Weight (g) : 3912.85   Specimen Diameter (mm) : 101.33
Specimen Length (mm) : 195   Loading Speed (mm/m) : 1
Moisture of specimen (%) : 18.27
Force and deformation in length values were given in Table 1.

Table 1. Measurements and Calculations

Measurement No.	Deformation in length (ΔL)	Strain $e = \dfrac{\Delta L}{L_0}$	Corrected area $A_c = \dfrac{A_0}{1 - e}$	Normal load (kN)	Compressive stress (Kpa)
1	0.06			0.8	
2	0.1			1.0	
3	0.16			1.2	
4	0.2			1.4	
5	0.29			1.6	
6	0.37			1.8	
7	0.44			2.0	
8	0.58			2.2	
9	0.85			2.4	
10	1.30			2.6	
11	1.56			2.7	
12	1.84			2.8	
13	2.16			2.9	
14	2.51			3.0	
15	3.2			3.08	
16	4.09			3.05	
17	4.30			3.0	

Questions:

1) Calculate natural density of specimen.
2) Draw Mohr circle and show the mechanical parameters on the figure. Find cohesion value.
3) Draw the deformation plot and calculate tangent and secant elastic modulus of the related soil.

Note : Please don't forget to indicate the natural moisture (%) of specimen on answers of question 2 and 3.

Deadline for report is 19.01.2024

References:

1. Chaoyang University of Technology Department of Construction Engineering, Advanced Geotechnical Laboratory Lecture Notes.
2. KDK College of Engineering, Lecture Notes, https://www.kdkce.edu.in/pdf/unconfined%20compressive%20strength%20test..pdf , Accessed: 29.12.2021.
3. Amini, Y. and Hamidi, A., 2014. Triaxial shear behavior of a cement-treated sandegravel mixture, Journal of Rock Mechanics and Geotechnical Engineering, 1-11.
4. De La Salle University, Unconfined Compression Test (ASTM D 2166) Video, https://www.youtube.com/watch?v=eoOqcF379QU&t=205s, Accessed: 25.12.2021.
5. Yonsei University, Lecture Notes, https://slidetodoc.com/ch-12-shear-strengths-of-soil-12-7/ , Accessed: 29.12.2021.