The University of Iowa
Department of Civil & Environmental Engineering
Fall Semester, 2003
53:030 Soil Mechanics
Lab Experiment No. 12:
Drained Triaxial Compression of Loose and Dense Sands

A. Objective

In this laboratory experiment, drained triaxial compression of loose and dense sands is performed to measure their stress-strain and shear strength properties. The shear strength behaviors measured in these tests can be compared/contrasted with those measured in the direct shear tests.

B. Experimental Procedure

1. Sample Preparation

a. Put vacuum grease on the base of the loading pedestal and place a sandstone endplate onto the loading pedestal. Fit a rubber membrane over the base of the loading pedestal and fasten it in place with an O-ring.

b. Assemble the 3-piece jacket for the soil specimen around the loading pedestal and fasten in place using wingnuts. Pull the rubber membrane down over the top of the jacket. Using calipers measure the inside diameter D of the jacket as well as the vertical distance H_1 from the top of the jacket down to the sandstone endplate.

c. Measure the mass M_b of a dish of dry FI-6 sand and then place the sand into the jacket until it is approximately 0.5cm from the top.

   1. For a loose sand specimen, pour the sand directly into the jacket until it reaches the appropriate level.
   2. For a dense sand specimen, pour the sand into the jacket in four lifts. After pouring in each lift, use the soil compacting tool to densify the sand as much as possible.

d. Re-measure the mass M_a of the dish containing dry FI-6 sand.

e. Measure the thickness of the lucite endcap H_2. Spread vacuum grease around the edges of the endcap and firmly press the cap into place on the sand column. Measure the distance H_3 from top of the loading cap to the top of the jacket. Pull the rubber membrane up around the lucite endcap and fasten it in place with an O-ring. Cut off the excess membrane so that the lucite endcap is easily visible.

f. Place the soil specimen into the testing machine and connect a vacuum pump to the valve draining the soil sample. With the negative pore pressure in the soil, it will now retain its shape. The jacket can thus be removed.

g. Using Table 1, compute the volume and mass of the sand specimen as well as the dry density and void ratio of the sand.

2. Application of Cell Pressure

a. Put the loading cell over the sand specimen and fasten it down onto the loading plate with wing nuts.

b. Open the air-valve at the top of the loading cell. Turn on air-pump that forces fluid into the chamber of the loading cell. When the cell is almost full, pour a small quantity of oil into the chamber from the extra valve and then close the valve. (This oil lubricates the ram during the actual test.)

c. Close the air-valve when fluid from the loading cell begins to escape and then close the valve from the supply tank to the chamber and turn off the air-pump.

d. Connect a supply hose from the pressured-controlled supply to the inflow valve of the chamber. Using a piston, manually adjust the pressure in the cell to the desired confining stress σ_3.

e. Turn on the pressure-regulator, set it at the desired σ_3, and connect it to the chamber fluid. Now that the chamber is properly pressurized, the vacuum in the soil can be released. Close the soil drainage valve leading to the vacuum, and open the alternative soil drainage valve connected to the atmosphere. This removes the vacuum from the air pore-pressure and keeps it at atmospheric pressure.

f. Remove the apparatus supporting the loading ram and make sure that the LVDTs measuring the axial load and the axial strain are properly connected.

g. Manually, adjust the machine so that the loading ram is properly seated on the soil sample.

3. Performing the Test

- Four tests will be performed on the sand as follows and the data will be shared among the lab sections:
  - Section 1: Dense Sand, $\sigma_3 = 200 kPa$
  - Section 2: Dense Sand, $\sigma_3 = 400 kPa$
  - Section 3: Loose Sand, $\sigma_3 = 200 kPa$
  - Section 4: Loose Sand, $\sigma_3 = 400 kPa$
- For each test performed:
  - Fill out the data in Table 1.
  - Select a proper loading rate for the testing machine.
  - Perform a displacement-controlled test, collecting load-displacement data until a definite peak load is achieved, and a definite residual load is also achieved.

C. Analysis

1. In the ECSS directory: /usr/ui/class/examples/cee5330/lab12 you can obtain the four data files from the four respective lab sections. Each of the four files will contain a header with the following information: The initial void ratio of the sand e_0, the initial relative density D_r, and the chamber confining stress σ_3. In addition, each file should contain two columns of data. In the first column will be the axial strain ϵ_1, and in the second column will be the increased axial stress in the soil $\Delta\sigma_1$.
2. For each test performed:
   - Plot $\Delta\sigma_1$ versus ϵ_1;
   - Determine the initial tangent elastic modulus E;
   - Determine the soil's peak axial stress increase $(\Delta\sigma_1)_{\text{max}}$;
3. From the two tests on the loose sand, estimate the respective drained friction angles ϕ_D for the loose sand and also compute the orientation θ of the failure planes during the compression tests. Do the same from the data from the two tests on the dense sand as well.

Table 1: Preliminary computations.

$H_1 =$	$M_a =$
$H_2 =$	$M_s = M_b - M_a =$
$H_3 =$	$\rho_d = \frac{M_s}{V_0} =$
Specimen height $H_0 = H_1 + H_3 - H_2 =$	$e_0 = \frac{G_s \rho_w}{\rho_d} - 1 =$
Specimen diameter $D_0 =$	$G_s = 2.66$
Specimen area $A_0 = \frac{1}{4}\pi D_0^2 =$	$e_{min} = 0.51$
Specimen volume $V_0 = A_0 H_0 =$	$e_{max} = 0.80$
$M_b =$	$D_r =$