LECTURE 33

Triaxial Tests

Triaxial compression tests can be conducted on sands and clays shows a schematic diagram of the Triaxial test arrangement. Essentially, it consists of placing a soil specimen confined by a rubber membrane in a Lucite chamber. An all-round confining pressure (σ3) is applied to the specimen by means of the chamber fluid (generally water or glycerin). An added stress (Δσ) can also be applied to the specimen in the axial direction to cause failure (Δσ=Δσf at failure). Drainage from the specimen can be allowed or stopped, depending on the test condition. For clays, three main types of tests can be conducted with Triaxial equipment:

Triaxial test:

1. Consolidated-drained test (CD test)
2. Consolidated-undrianed test (CU test)
3. Unconsolidated-undrained test (UU test)

Major Principal effective stress =σ3=Δσf=σ1=σ′1

Minor Principal effective stress =σ3=Δσ′3

Changing σ3 allows several tests of this type to be conducted on various clay specimens. The shear strength parameters (c and ϕ) can now be determined by plotting Mohr's circle at failure, as shown in figure and drawing a common tangent to the Mohr's circles. This is the Mohr-Coulomb failure envelope. (Note: For normally consolidated clay, c≈0). At failure

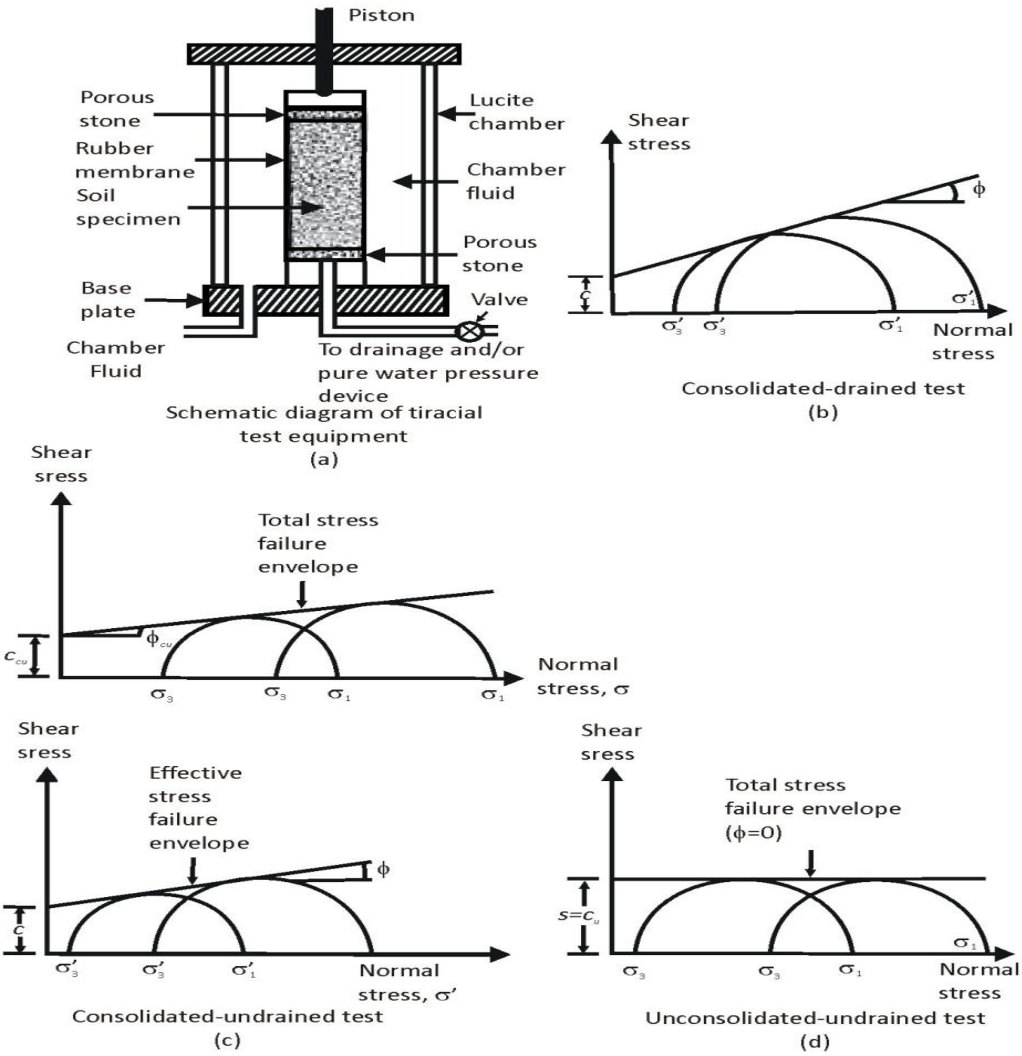
$$\sigma'_1 = \sigma'_3 \tan^2\left(45 + \frac{\phi}{2}\right) + 2c\tan\left(45 + \frac{\phi}{2}\right)$$

For consolidated-undrained tests, at failure,

Major Principal total stress =σ3=Δσf=σ1

Minor principal total stress =σ3

Major principal effective stress =(σ3+Δσf)−uf=σ′1



Minor principal effective stress $=\sigma_3 - u_f = \sigma'_3$

Changing σ_3 permits multiple tests of this type to be conducted on several soil specimens. The total stress Mohr's circles at failure can now be plotted, as shown in figure , and then a common tangent can be drawn to define the failure envelope. This total stress failure envelope is defined by the equation

$s = c_{cu} + \sigma \tan\phi_{cu}$

Where c_{cu} and ϕ_{cu} are the consolidated-undrained cohesion and angle of friction respectively (Note: $c_{cu} \approx 0$ for normally consolidated clays)

Similarly, effective stress Mohr's circles at failure can be drawn to determine the effective stress failure envelopes. They follow the relation expressed in equation .

For unconsolidated-undrained triaxial tests

Major principal total stress$=\sigma_3 = \Delta\sigma_f = \sigma_1$

Minor principal total stress $=\sigma_3$

The total stress Mohr's circle at failure can now be drawn, as shown in figure. For saturated clays, the value of $\sigma 1 - \sigma 3 = \Delta \sigma f$ is a constant, irrespective of the chamber confining pressure, $\sigma 3$.The tangent to these Mohr's circles will be a horizontal line, called the $\phi=0$ condition. The shear stress for this condition is

$$s = c_u = \frac{\Delta\sigma_f}{2}$$

Where

c_u = undrained cohesion (or undrained shear strength)

The pore pressure developed in the soil specimen during the unconsolidated-undrained triaxial test is

$$u = u_a + u_d$$

The pore pressure u_a is the contribution of the hydrostatic chamber pressure, σ_3. Hence

$$u_a = B\sigma_3$$

Where

B=Skempton′s pore pressure parameter

Similarly,the pore pressure ud is the result of added axial stress, $\Delta\sigma$, so

$ud = A\ \Delta\sigma$

Where

A=Skempton′s pore pressure parameter

However,

$\Delta\sigma = \sigma 1 - \sigma 3$

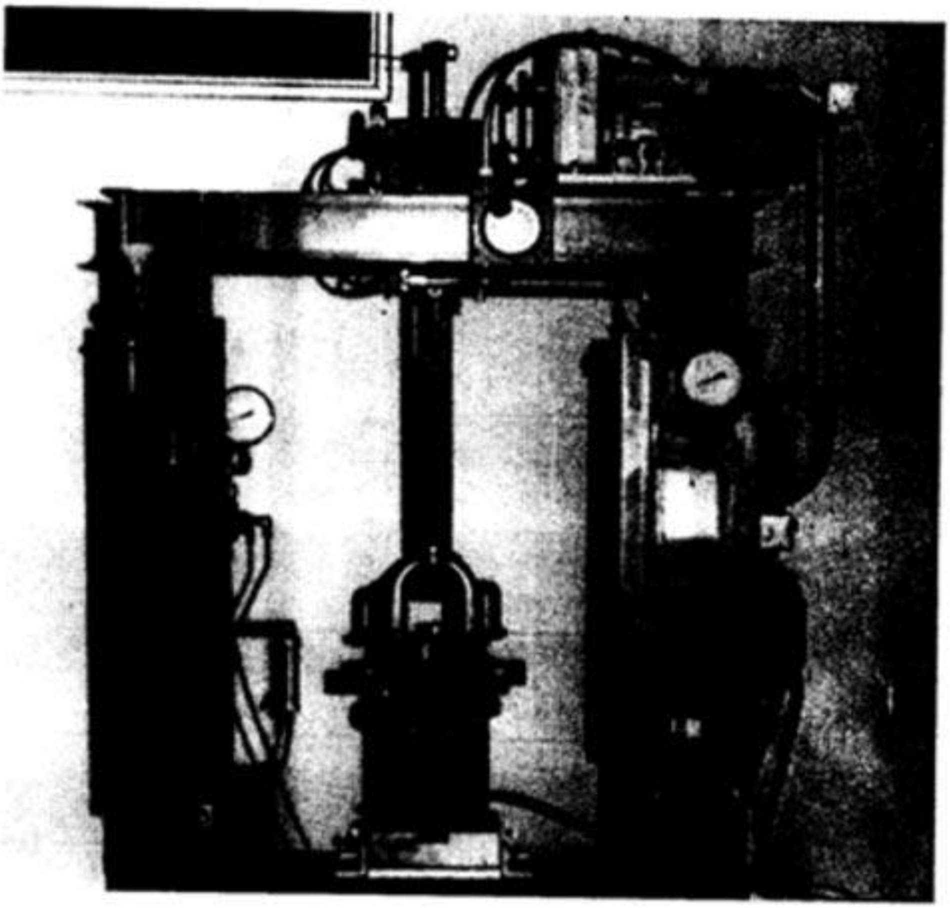
Combining equations gives

$u = ua + ud = B\sigma 3 + A\sigma 1 - \sigma 3$

The pore water pressure parameter B in soft saturated soils is 1, so

$u = \sigma 3 + A(\sigma 1 - \sigma 3)$

The value of the pore water pressure parameter A at failure will vary with the type of soil. Following is a general range of the values of A at failure for various types of clayey soil encountered in nature.



Triaxial test equipment