UTEST
MATERIAL TESTING EQUIPMENT

TRIAXIAL STRESS MEASUREMENT TEST (UU-CU-CD TESTS)

Product Code

Triaxial Test Systems

Standards

ASTM D2850, D4767, D7181; AASHTO T-297;
BS 1377-7, BS 1377-8

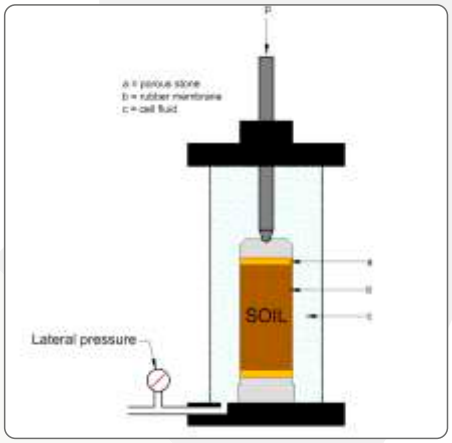
Determining the mechanical properties of soils is a very important step to design foundations, embankments and other soil structures. Building constructions, excavations, tunnelling and similar applications have several effects on the subsoil structures and these effects are successfully simulated with Triaxial Tests where the stress-strain relation of undisturbed soil specimen are investigated by subjecting the soil sample to different stress levels and drainage conditions.

The UTEST Triaxial Test System provides automated triaxial compression tests on cylindrical undisturbed and remolded soil samples. Unconsolidated undrained (UU), consolidated drained (CD) and consolidated undrained (CU) compression tests can be automatically run, controlled and reported using this apparatus.

UU Only Triaxial Test Configuration

Unconsolidated Undrained (UU) Test

For the UU test, the specimens (assumed to be saturated prior to test) are subjected to a confining fluid pressure in a triaxial chamber. Once the specimen is inside the triaxial cell, the cell pressure is increased to a predetermined value by rotating the knob of the constant pressure unit, and the specimen is brought to failure by increasing the vertical stress by applying a constant rate of axial strain. Since saturation and consolidation do not exist in this method, original structure and water content of sample is untouched. Pore and back pressures are not measured during this test and therefore the results can only be interpreted in terms of total stress over a confinement pressure (stress).



These tests are generally carried out on three specimens of the same sample subjected to different confining stresses.

Since all specimens are supposedly saturated the shear strength are similar for all tests.

The results of the test are plotted as curves of principal stres difference against strain. For conditions of maximum principal stress difference (taken as failure) Mohr circles are plotted in terms of total stress. The average undrained shear strength is recorded, and the failure (Mohr) envelope is drawn tangential to the Mohr circles in order to find the "undrained cohesion intercept" and undrained "angle of shearing resistance".

TRIAXIAL STRESS MEASUREMENT TEST (UU-CU-CD TESTS)

Consolidated Undrained (CU) Test & Consolidated Drained (CD) Test

Peak effective strength parameters (c' and ϕ') can be determined either from the results of consolidated undrained (CU) triaxial compression tests with pore pressure measurement, or from consolidated drained (CD) triaxial compression tests. The consolidated undrained/ drained triaxial compression tests are normally performed in several stages, involving the successive saturation, consolidation and shearing of each of three specimens.

Typical Configuration of Triaxial Test System for UU-CU-CD Tests

Saturation is carried out in order to ensure that the pore fluid in the specimen does not contain free air.
Saturation is normally carried out by leaving the specimens to an elevated back pressure so that the air in the pores is dissolved in water. Back pressure (which is simply an imposed pore pressure) is applied through a volume change gauge to the top of the specimen, while a cell pressure of slightly higher value is also applied.
Both cell pressure and back pressure are normally increased in increments, allowing time for equalization at each stage. The degree of saturation can be expressed in terms of Skempton's pore pressure parameter (Skempton, 1954):

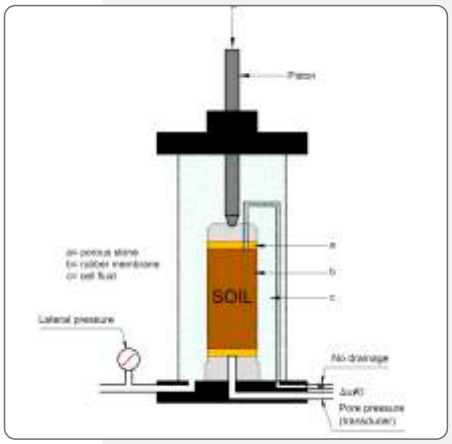
$$B = \frac{\Delta u}{\Delta \sigma_3}$$

where Δu is equal to change in pore pressure for an applied cell pressure change of Δσ3. For an ideally saturated soil B is equal to unity. It is recommended by several standard test methods that a value of B greater than, or equal to, 0.95 must be achieved before the specimen may be considered as fully saturated and the consolidation stage started. The consolidation stage of an effective stress triaxial test is carried out for two reasons. First, three specimens are tested and consolidated at three different effective pressures, in order to give specimens of different strengths which will produce widely spaced effective stress Mohr circles.
Secondly, the results of consolidation are used to determine the minimum time to failure in the shear stage.
The effective consolidation pressures (i.e. cell pressure minus back pressure) will normally be increased by a factor of two between each specimen, with the middle pressure approximating to the vertical effective stress in the ground.
When the consolidation cell pressure and back pressure are applied to the specimen, readings of volume change are made using a volume change device in the back pressure line.
Pore pressure is measured at the specimen base, with drainage to the back pressure line taking place through a porous stone covering the top of the specimen.
The coefficient of consolidation of the clay can be determined by plotting volume change as a function of the square root of time.
Theoretical considerations indicate that the first 50% of volume loss during consolidation should show as a straight line on this plot.
This straight line is extended down to cut the horizontal line representing 100% consolidation, and the time intercept at this point (termed "t_{100}" by Bishop and Henkel) can be used to obtain the coefficient of consolidation.

TRIAXIAL STRESS MEASUREMENT TEST (UU-CU-CD TESTS)

Consolidated Undrained (CU) Test:

Once consolidation is complete, the specimen is to be isolated from the back pressure and the rate of vertical movement of the compression machine platen set according to result of consolidation. During the shear stage the vertical stress is increased by the loading ram, and measurements are made at regular intervals of deformation, ram load and pore pressure. These are converted to graphs of principal stress difference $(\sigma 1 - \sigma 3)$ and pore pressure as a function of strain, and failure is normally taken as the point of maximum principal stress difference. The effective stress Mohr circles are plotted for the failure conditions of the three specimens which has been subjected to different consolidation level, and the gradient and intercept of a straight line drawn tangential to these circles defines the effective strength parameters c' and ϕ'.



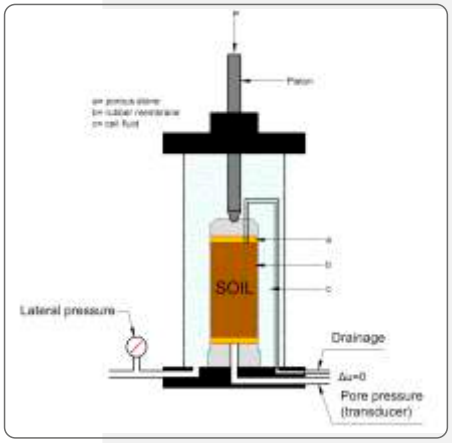
Consolidated Drained (CD) Test:

The consolidated drained triaxial compression test, with volume change measurement during shear is carried out in a similar sequence to the consolidated undrained test, but during shear the back pressure remains connected to the specimen which is loaded sufficiently slowly to avoid the development of excess pore pressures.

The shear stage of a drained triaxial test can be expected to take between 7 and 15 times longer than that of an undrained test with pore pressure measurement. Once shearing is complete, the results are presented as graphs of principal stress difference and volume change as a function of strain, and the failure Mohr circles are plotted to give the drained failure envelope defined by the parameters cd' and $\varphi d'$.

Triaxial CD-CU-UU equipment is computer controlled, test values can be transferred to computer and data processing can be made with Triaxial software on Windows operating system. All data can be used on Excel programs. The load data and axial displacement data are transfered and recorded through U-Touch Control Unit to the software.

Three pressure data (cell pressure, back pressure and pore pressure) from triaxial cell and volume change data transfered and recorded through the interface unit with 4 channel for data acquisition (UTCU-0020) to the software.



Typical configuration of system for triaxial tests (UU-CU-CD)			
Product Code	Description	UU	UU-CU-CD
UTM-0108.SMPR	Multiplex Universal Electromechanic Test Machine*	1	1
UTGM-1180	Load Cell 5 k N, S Type	1	1
UTGM-1190	Load Cell 10 kN, Pancake Type**	1	1
UTS-2400 UTS-2401	Triaxial Cell***	1	1
UTS-2405	Block with One Connection Line for Triaxial Test Cells	1	3
UTGM-1420	Pressure Transducer	1	3
UTS-2408	Oil and Water Constant Pressure System	1	2
UTS-2415	Automatic Volume Change Unit	-	1
UTCU-0020	Interface Unit with 4 Channel for Data Acquisition	-	1
USOFT-2419	Software to Perform UU Triaxial Tests	1	1
USOFT-2420	Software to Perform CU-CD Triaxial Tests	-	1
UTS-1330 and UTGP-1140	De-Airing Water Tank, 7 L. and Hose	1	1

* Supplied complete with UTGM-1210 50 kN Load Cell, UTGM-0064 50 mm linear potentiometric transducer with holder (UTM-0114 and UTAS-1060) and lower compression platen.
** May be need for 70-100 mm dia. samples with high strength.
*** Choose the suitable cell for the specimen size (UTS-2400:38-50 mm dia. samples / UTS-2401: 70-100 mm dia. samples).
For cell and cell accessories see "Triaxial Cells, Cell Accesories and Sample Preparation" page.

Optional Apparatus which should be ordered seperately for de-airing water see the page of De-Airing Water Systems".