INDIAN INSTITUTE OF TECHNOLOGY GANDHINAGAR
Department of Civil Engineering
Soil Mechanics Laboratory

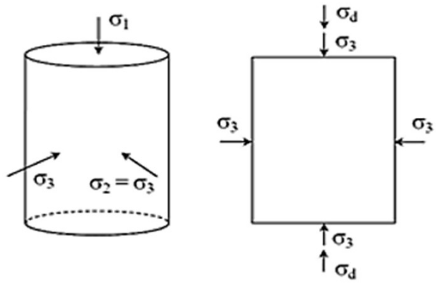
UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION (UU) TEST

(IS 2720-Part 11-1993) Reaffirmed-2002

CONCEPT:

Unconsolidated Undrained (UU) triaxial test provides undrained stress-strain response of a cylindrical soil specimen under triaxial compression loading without consolidating the specimen. It also provides the undrained shear strength parameters by performing the tests on different confining pressures. Initially, a confining pressure (σ_3) is applied through water around the specimen in triaxial cell. Drainage valve is closed throughout the test, which does not allow the consolidation of the specimen. The specimen is then subjected to shearing by applying the constant rate of deformation under undrained compression loading conditions. Excess pore water pressure is not measured during shearing; hence the shear strength parameters are analyzed in total stress conditions only.

Initial state of stress is hydrostatic with all three principal stresses same as applied confining pressure (σ_3). The vertical stress acts as major principal stress (σ_1) during shearing, while the confining pressure (σ_3) acts in other two principal directions of cylindrical specimen. The intermediate principal and minor principal stresses are equal to each other. Deviatoric stress (σ_d) is the difference of σ_1 ($\sigma_1 = \sigma_d + \sigma_3$) and σ_3, acting on specimen while its shear deformation**.**



NEED AND SCOPE:

Unconsolidated undrained triaxial test is quick test as compared to consolidated undrained (CU) and consolidated drained (CD) triaxial test. UU test can be performed on any type of soil to determine its shear strength parameters under undrained condition i.e., cohesion (c_u) and angle of internal friction (φ_u). These undrained shear strength parameters are useful in determination of bearing capacity of soil, stability analysis of highway embankments, earthen embankments etc. One of the critical conditions for stability of any slope occurs immediately after construction, which represents the undrained condition. In such conditions, undrained shear strength parameters should be used for stability analysis.

APPARATUS REQUIRED

1) Loading frame capable of generating constant rate of movement
2) Proving ring (Capacity ranging from 1 kN to 50 kN)
3) Bottom platen of required diameter made with Perspex glass (diameter of the plate is selected according to the diameter of the sample)
4) Top cap of required diameter made with Perspex glass with a circular groove to accommodate the plunger of triaxial cell
5) Dial gauge (0.01 mm accuracy)

6) Hardened Steel ball
7) Triaxial cell, in which using water hydrostatic pressure can be applied to the specimen and having a central plunger that can be connected to proving ring to measure the vertical load/pressure. The cell (made of Perspex) is usually designed with a non-ferrous metal top and base connected by tension rods.
8) Bottom base plate with a pedestal of diameter similar to the diameter of specimen and valve arrangements to apply cell pressure
9) Air-water interface system (Cylinder filled with water and a balloon inside it which applies air pressure to the water filled in cylinder)
10) Air Compressor
11) Constant pressure system with regulators, valves and pressure meter to control the cell pressure
12) De-aeration tank
13) Latex rubber membrane
14) Rubber O-rings
15) Membrane Stretcher (An open-ended cylindrical section former, required inside diameter fitted with a small rubber tube on its side)

SPECIMEN PREPARATION AND DEFORMATION RATE:

The UU triaxial test can be performed on undisturbed soil samples, wherever the undisturbed sample (UDS) collection is possible. When UDS sample collection is not possible or the UDS sample shows cracks while extraction, reconstituted specimens can be prepared. The samples can be reconstituted at in-situ density and moisture content. The UU triaxial test is commonly conducted on specimen size of 38 mm diameter and 76 mm height. The loading frame is used to provide a constant rate of deformation to the specimen commonly 0.4 mm/min for fine soils and 0.6 mm/min for coarse soil.

PROCEDURE:

1. Place the bottom platen on the pedestal of base plate of triaxial cell, then place the specimen on bottom platen.
2. Place the top cap on the specimen.
3. Seal the specimen arrangement properly with the latex rubber membrane and rubber O-rings using the membrane stretcher.
4. Place the cell such that it must be properly set up and uniformly clamped down to prevent leakage of pressured water during the test.
5. Move down the plunger and set up it on the circular groove of the top cap. Place a steel ball on the top of plunger.
6. Adjust the center line of the specimen such that the proving ring, the steel ball, plunger and specimen are in the same line.
7. Fill the cell with the water with bleed valve open. Close the bleed valve tightly after filling the cell with water.
8. The air water interface is then regulated using valves and regulator of constant pressure system, and the pressure is applied to water with the balloon in interface system. This pressure is applied through water to the cell.

9. Open the valve that connects pressure to the cell to apply the required cell pressure. (For example, 50 kPa, 100 kPa and 150 kPa or 100kPa, 200 kPa and 300 kPa as per the depth where the sample is brought and the application requirements.)
10. The pressure gauge must be watched during the test and any necessary adjustments must be made to keep the pressure constant.
11. A small deformation is applied to the system until the underside of the hemispherical seating of the proving ring, through which the loading is applied, just touches the steel ball on cell piston. This procedure is called the docking of triaxial system.
12. After docking fix a dial gauge to measure the vertical compression of the specimen.
13. Adjust the gear position on the load frame to give suitable rate of deformation.
14. Start applying the load and record the readings of the proving ring and compression dial for every 25 divisions in compression dial gauge.
15. Continue loading till failure or 20% axial strain (whichever is reached earlier) (IS-2720-PART-10-1991), and then take the picture of the failure pattern of the specimen.

OBSERVATION & RECORDING:

At particular intervals of strain, dial gauge readings and the corresponding proving ring readings are taken, and the corresponding load is determined using proving ring constant. The experiment is stopped either at failure or at the 20% axial strain.

Data Sheet for Triaxial Test (UU)

Sample No :
Length of specimen : cm
Diameter of specimen : cm
Initial area of specimen (A_0) : cm^2
Initial Volume : cc
Dry density : g/cc
Moisture Content : %
Deformation rate : mm/minute
Proving ring constant: : N
Strain dial least count : mm

Cell pressure kPa (σ_3)	Dial gauge reading (divisions)	Deformation mm (divisions*least count)	Strain (%), ε = (deformation/ht. of specimen*100)	Proving ring reading (divisions)	Load taken (kN) (divisions*proving ring constant)	Corrected area (m^2) = $A_0/\{1-(\varepsilon/100)\}$	Deviator Stress, (σ_d) kPa (= (load taken/corrected area)
	25						
	50						
	75						
	100						
	125						
	150						
	175						
	200						
	225						
	250						
	275						
	300						
	325						
	350						
	375						
	400						
	425						
	450						
	475						
	500						
	525						
	550						
	575						
	600						
	625						
	650						
	675						
	700						

Cell pressure kPa (σ_3)	Dial gauge reading (divisions)	Deformation mm (divisions*least count)	Strain (%), ε = (deformation/ht. of specimen*100)	Proving ring reading (divisions)	Load taken (kN) (divisions*proving ring constant)	Corrected area (m^2) = $A_0/\{1-(\varepsilon/100)\}$	Deviator Stress, (σ_d) kPa (= (load taken/corrected area)
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	125						
	150						
	175						
	200						
	225						
	250						
	275						
	300						
	325						
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	375						
	400						
	425						
	450						
	475						
	500						
	525						
	550						
	575						
	600						
	625						
	650						
	675						
	700						

Cell pressure kPa (σ_3)	Dial gauge reading (divisions)	Deformation mm (divisions*least count)	Strain (%), ε = (deformation/ht. of specimen*100)	Proving ring reading (divisions)	Load taken (kN) (divisions*proving ring constant)	Corrected area (m^2) = $A_0/\{1-(\varepsilon/100)\}$	Deviator Stress, (σ_d) kPa (= (load taken/corrected area)
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	500						
	525						
	550						
	575						
	600						
	625						
	650						
	675						
	700						

Sample No.	Cell pressure, σ_3 (kPa)	Compressive stress at failure, σ_d (kPa)	Strain at failure (%)	$\sigma_1 = \sigma_3 + \sigma_d$	p = $(\sigma_1+\sigma_3)/2$	q = $(\sigma_1-\sigma_3)/2$
1.						
2.						
3.						

* Plot σ_d vs ε, (Deviatoric stress vs. axial strain plot) for all confining pressure in a single plot.

*Plot p versus q for the peak values from three tests (Modified failure envelope).

GENERAL REMARKS:

a) It is assumed that the volume of the sample remains constant and that the area of the sample increases uniformly as the length decreases. The calculation of the stress is based on this new area at failure, by direct calculation, using the proving ring constant and the new area of the sample.

b) The strain and corresponding stress is plotted with stress abscissa and curve is drawn. The maximum compressive stress at failure and the corresponding strain at different cell pressure are found out.

c) The stress results of the series of triaxial tests at increasing cell pressure are plotted as a Modified failure envelope using **p = $(\sigma_1+\sigma_3)/2$** as abscissa and **q = $(\sigma_1-\sigma_3)/2$** as ordinate. In this diagram a best fit line is plotted with in which the slope represents the value of ψ while the intercept represents the value of **a**.

d) From the relation, $\sin\varphi = \tan\psi$,

$a = c^* \cos\phi$;

The value of **cohesion, c and the angle of shearing resistance, ϕ** will be determined as the soil shear strength parameters.