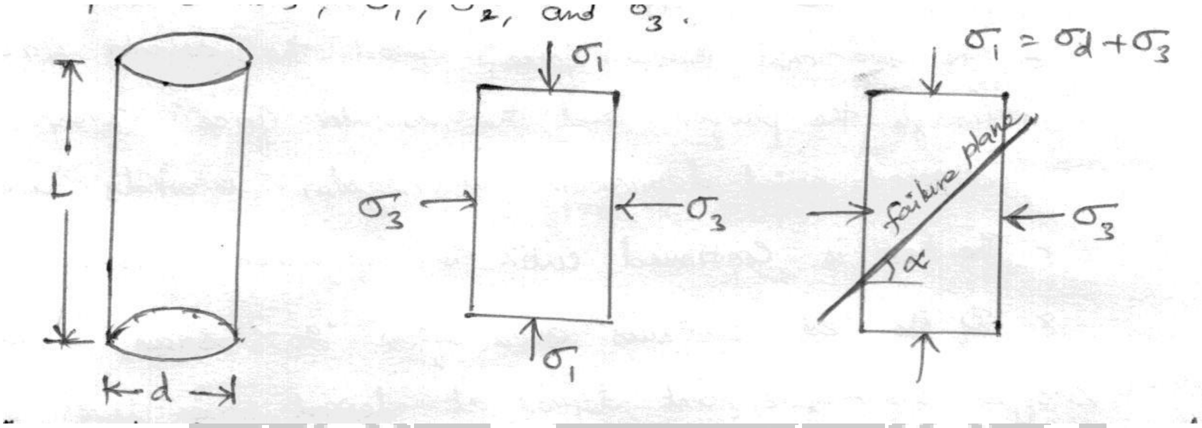
TRAIAXAIL COMPRESSION TEST:

It was introduced by Casagrande and Terzaghi in 1936 and most extensively used type of shear test. As the name indicates in this test the specimen is compressed by applying all the three principal stresses, $\sigma 1\ \sigma 2\ and\ \sigma 3$.



The soil specimen used specimen used in the test is cylindrical in shape with length **2 to 2.5 times the diameter**. The triaxial compression test equipment essentially consists of triaxial cell, loading frame with accessories for applying gradually increasing axial load on specimen at constant rate, of strain, provision for measuring axial force and displacement, contact pressure system to apply and maintain constant cell pressure, pore pressure measuring apparatus and volume change gauge.

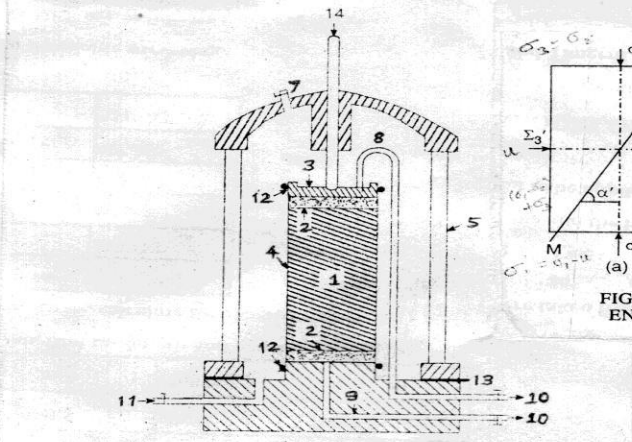
PROCEDURE:

- The triaxial cell [Fig] consists of a high pressure cylindrical cell, made of a transparent material like Perspex, fitted between base and top cap.
- The base is provided with an inlet for cell fluid, outlets for drainage of pore water from specimen and measurement of pore pressure.
- At the top an air release value to expel air from the cell and a steel plunger for applying axial force on specimen are provided.
- The soil specimen is kept inside the triaxial cell with porous plate (non porous plates for undrained test) at top and bottom.
- The loading cap is placed on top porous plate.
- The specimen is enclosed in a rubber membrane to prevent its contact with the cell fluid.
- After filling the cell with fluid (usually water) required cell pressure (σ_3) is applied by means of contact pressure system.
- The additional axial force called the deviator force is applied through the plunger and the deviator force corresponding to different axial deformations at regular intervals are noted.
- The test is continued until the specimen fails.
- If the test continues even after 20% strain, it may be stopped and failure point defined at desired strain level upto 20%.

- The deviator stress 'σ_d' at any stage of the test is given by

$\sigma_d = F / A_c$

σ_d = Deviator stress
F= Deviator force ie., additional axial force
A_c= cross sectional area of the specimen



1. SOIL SPECIMEN
2. POROUS DISC
3. TOP CAP
4. RUBBER MEMBRANE
5. PERSPEX CYLINDER
6. LOADING RAM
7. AIR RELEASE VALVE
8. TOP DRAINAGE TUBE
9. BOTTOM DRAINAGE TUBE
10. CONNECTIONS FOR DRAINAGE OR PORE PRESSURE MEASUREMENT
11. CELL FLUID INLET
12. RUBBER RINGS
13. SEALING RING
14. AXIAL LOAD THROUGH PROVING RING

FIG. 18.7. THE TRIAXIAL CELL.

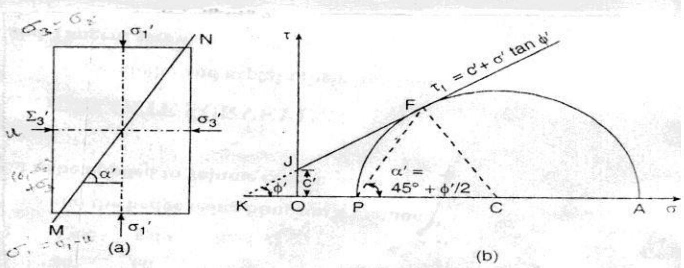
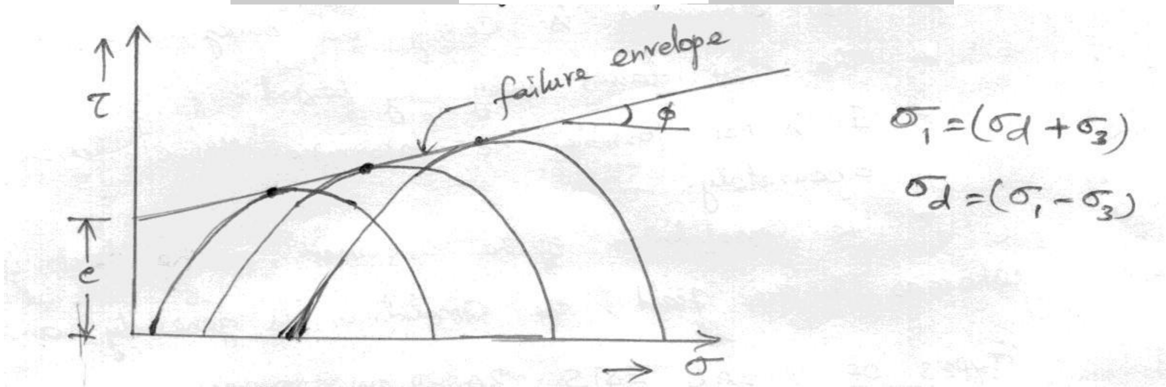


FIG. 18.10. STRESS CONDITIONS AND FAILURE ENVELOPE IN TRIAXIAL COMPRESSION TESTS.

- After finding deviator stress σ_d at failure, we have major principal stress at failure $\sigma 1 = (\sigma d + \sigma 3)$.
- With this set of $(\sigma 1, \sigma 3)$ values, Mohr circles at failure is drawn.
- The test is conducted on preferably a minimum of 3 specimens subjected to different values of $\sigma 3$.
- The Mohr circle at failure is drawn for each specimen and the common tangent touching all the circles will be failure envelope (fig)
- C and ϕ are readout from the plot.



MOHR CIRCLES AT FAILURE

If Ai = Initial cross sectional area of specimen

Li = Initial length of specimen

A_c = Corrected area of specimen when axial compression is ΔL

and change in volume is ΔV .

Initial volume, Vi = Ai Li and volume at any stage of compression,

$(V_i + \Delta V) = A_c (L - \Delta L)$

$$A_c = \frac{V_i + \Delta V}{L_i - \Delta L}$$

Incase of undrained test, on saturated soil sample, $\Delta V = 0.$ and

$$A_c = \frac{V_i + \Delta V}{L_i - \Delta L} = \frac{A_i}{1 - \frac{\Delta L}{Li}}$$

$$A_c = \frac{A_i}{1 - \in}$$

$$A_c = \frac{A_i}{1 - \in}$$

$\in \rightarrow Axial$ strain at that stage

MERITS:

- Complete control of the drainage condition is possible
- The Possibility to vary the cell pressure (or) confining pressure
- Precise measurement of pore water pressure is possible
- Stress distribution is uniform
- The test involves three stresses, it shows the behavior of field condition
- Determine the state of stress at any stage during the test and of failure.

DEMERITS:

- The apparatus is costly and bulky
- The test takes very long period
- It is not possible to determine the cross sectional area of the specimen accurately
- The Consolidation of the specimen in the test is isotropic, whereas ih the field, the consolidation is generally an isotopic.

TYPES OS SHEAR TESTS BASED ON DRANAGE AND THEIR APPLICABILITY

1. **Unconsolidated Undrained Test (UU)**

   In this type of test, no drainage is permitted during the consolidation stage. The drainage is also not permitted in the sheer stage. As so time is allowed for consolidation (or) dissipation of excess pore water pressure, the test can be conducted quickly in a few minutes the test is also Known as **quick test**. All parameters are expressed interms of total stress concepts. **Plain grids (or) non porous plates** are used.

2. Consolidated Undrained Test:

   In this test, the specimen is allowed to consolidated in the first stage. The drainage is permitted until the consolidation is completed. In the second stage, when the specimen is shared, no drainage is permitted. All parameters are expressed interms of total stress concepts. **Perforated grids (or) porous plates** are used.

3. **Consolidated Drained Test (CD):**

   In this test, the drainage of specimen is permitted in both stages. The Sample is allowed to consolidated fully and dissipation of pore water is possible. All parameters are expressed as effective stress. The magnitude of effective stress & total stress both are equal.

   ie., u = o ; $\sigma = \sigma' + u$ $\therefore \sigma = \sigma'$

   Porous plate (or) perforated grids are used for specimen.

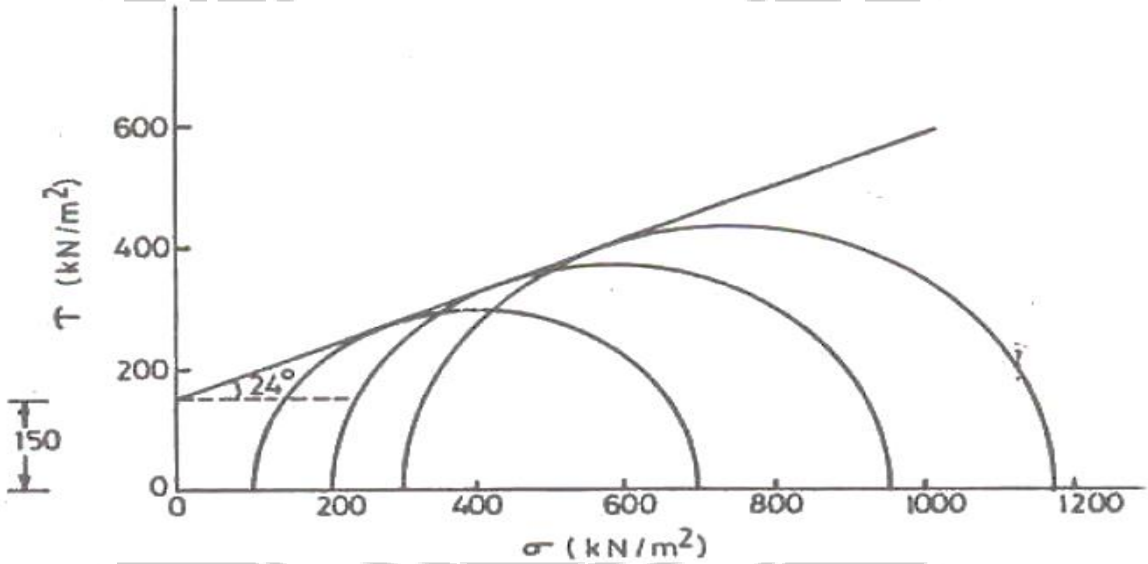
   The test may continue for several hours to several days. It is also known as **slow test**.

Problems:

1)The following results were obtained from a series of consolidated undrained test on a soil ,in which the pore water pressure was not determined .Determine the cohesion intercept and the angle of shearing resistance.

Sample number	Confining pressure(KN/m^2)	Deviator stress at failure (KN/m^2)
1	100	600
2	200	750
3	300	870

The major principal stresses in the three test are 700,950 and 1170 KN/m^2



From the plot C=150 KN/m^2 ,$\varphi=24^0$

2)The stresses on a failure plane in a drained test on a cohesionless soil are as under:

Normal stress(σ)=100 KN/m^2

Shear stress(τ)=40 KN/m^2

a) Determine the angle of searing resistance and the angle which the failure plane makes with the major principal plane.
b) Find the major and minor principal stresses.

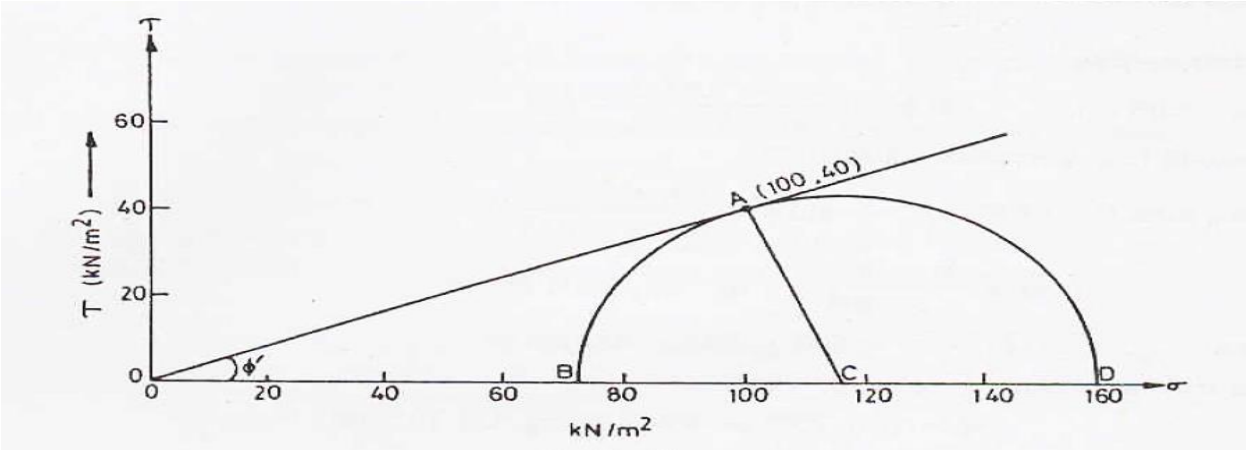
$$tan\varphi' = \frac{40}{100} = 0.4$$

$$\Phi=21.80^0$$

The angle which the failure plane makes with the major principal plane,

$$\theta = 45 + \frac{\varphi'}{2}$$

$$= 45 + \frac{21.8}{2} = 55.9^0$$



σ_3=73KN/m ^{2} ,σ_1=159 KN/m^2

Analytical method:

Length $OA = \sqrt{100^2 + 40^2}$ =107.7

AC=OA tan φ'=107.7Xtan 21.8^0 =43 KN/m^2

OC=OA Secφ'=107.7Xsec 21.8^0 =116 KN/m^2

OD=OC+AC=116+43=159 KN/m^2=σ_1

OB=OC-AC=116-43=73 KN/m^2=σ_3

3)A cylindrical sample of soil having cohesion of 0.8kg/cm^2 and angle of internal friction of 20°,is subjected to a cell pressure of 1.0kg/cm^2. Calculate the maximum deviator stress at which the sample will fail and the angle made by the failure plane with the axis of the sample.

Solution:

$\sigma_3 = 1.0\ Kg/cm^2$,C=0.8kg/cm^2

$$\sigma_1 = \sigma_3 \tan^2 \alpha_f + 2Ctan\ \alpha_f$$

$$\alpha_f = 45 + \frac{\varphi}{2}$$

$$\alpha_f = 45 + \frac{20}{2} = 55^0$$

$$\sigma_1 = 1\tan^2 55^0 + 2X0.8tan\,55^0 = 4.32Kg/cm^2$$

$$\sigma_d = \sigma_1 - \sigma_3 = 4.32 - 1 = 3.32\ kg/cm^2$$

Angle made by the failure plane with the axis of the sample

$$= 90^0 - \alpha_f = 90^0 - 55^0 = 35^0$$

4) A standard specimen of cohesionless and was tested in triaxial compression and the sample failed at a deviator stress of 482kN/m^2 when the cell pressure was 100kN/m^2 under drained condition. Find the effective angle of shearing resistance of sand. What would be the deviators sand the major principal stress at failure for another identical specimen of sand if it is tested under cell pressure of 200 kN/m^2?

Given:

σ_d =482 KN/m^2

σ_3 =100 KN/m^2

C=0

$$\sigma_1 = \sigma_3\tan^2\alpha_f + 2Ctan\,\alpha_f$$

$$\tan^2\alpha_f = \frac{\sigma_1}{\sigma_3} = \frac{582}{100}$$

$$\alpha_f = 5.82$$

$$\alpha_f = 45 + \frac{\varphi}{2}$$

$$\varphi = 2(67.485 - 45) = 44.97^0$$

For another specimen:

σ_3 =200 KN/m^2 ,C=0

$$\sigma_1 = \sigma_3\tan^2\alpha_f + 2Ctan\,\alpha_f$$

$$\sigma_1 = \sigma_3\tan^2\alpha_f$$

=200X5.82=1164KN/m^2

$$\sigma_d = \sigma_1 - \sigma_3 = 1164 - 200 = 964\text{KN/m}^2$$

5)Two identical specimen of 4cm in diameter and 8cm height of partially saturated compacted soil are tested in a triaxial cell under undrained condition.The first specimen failed at an deviator load(additional load) of 720KN.under a cell pressure of 100 KN/m^2 . The second specimen failed at an deviator load(additional load) of 915 KN.under a cell pressure of 200 KN/m^2 .The increase in volume of first specimen at failure is 1.2 ml and its shorten by 0.6 cm at failure. The increase in volume of second specimen at failure is 1.6 ml and its shorten by 0.8 cm at failure. Determine the apparent cohesion and angle of shearing resistance. By analytical method.

Given data:

Triaxial test

Diameter=4cm

height=8cm

first specimen:

deviator load(additional load) =720 KN

cell pressure = 100 KN/m^2

increase in volume ΔV=1.2 ml=1.2 cm^3

shorten by length= 0.6 cm

Second specimen:

deviator load(additional load) =915 KN

cell pressure = 200 KN/m^2

increase in volume ΔV=1.6 ml=1.6 cm^3

shorten by length= 0.8 cm

To find:

and angle of shearing resistance

Solution:

For first specimen:

$$A_2 = \frac{V_1 \pm \Delta V}{L_1 - \Delta L}$$

$$A_2 = \frac{V_1 + \Delta V}{L_1 - \Delta L}$$

$V_1 = A x L_1$

$$V_1 = \frac{\pi d^2}{4} X L_1$$

$$V_1 = \frac{\pi x 4^2}{4} X 8 = 100.53 cm^3$$

$$A_2 = \frac{100.53 + 1.2}{8 - 0.6} = 13.74 cm^2$$

Calculation of σ_d:

$$\sigma_d = \frac{additional\ axial\ load}{A_2}$$

$$= \frac{720}{13.74}$$

$$= 52.37 \frac{N}{cm^2} = 523.7 KN/m^2$$

$$\sigma_1 = \sigma_3 + \sigma_d$$

$= 100 + 523.7 = 623.7 KN/m^2$

Triaxial equation:

$$\sigma_1 = \sigma_3 N\varphi + 2Cu\sqrt{N\varphi}$$

$$624 = 100 N\varphi + 2Cu\sqrt{N\varphi} - - - - - (1)$$

For second specimen:

$$A_2 = \frac{V_1 \pm \Delta V}{L_1 - \Delta L}$$

$$A_2 = \frac{V_1 + \Delta V}{L_1 - \Delta L}$$

$V_1 = A x L_1$

$$V_1 = \frac{\pi d^2}{4} X L_1$$

$$V_1 = \frac{\pi x 4^2}{4} X8 = 100.53cm^3$$

$$A_2 = \frac{100.53 + 1.6}{8 - 0.8} = 14.184cm^2$$

Calculation of σ_d:

$$\sigma_d = \frac{additional\ axial\ load}{A_2}$$

$$= \frac{915}{14.184}$$

$$= 64.506 \frac{N}{cm^2} = 645.06KN/m^2$$

$$\sigma_1 = \sigma_3 + \sigma_d$$

$$=200+645=845KN/m^2$$

Triaxial equation:

$$\sigma_1 = \sigma_3 N\varphi + 2Cu\sqrt{N\varphi}$$

$$845 = 200N\varphi + 2Cu\sqrt{N\varphi} - - - - - (2)$$

$$Solve\ (1)\&(2)$$

$$(1) - - - \quad 624 = 100N\varphi + 2Cu\sqrt{N\varphi}$$

$$(2) - - - \quad 845 = 200N\varphi + 2Cu\sqrt{N\varphi}$$

(1)-(2) =-221=-100 $N\varphi$

$$N\varphi = \frac{221}{100} = 2.21$$

solve $N\varphi$ in equation(1)

$$(1) - - - \quad 624 = 100x2.21 + 2Cu\sqrt{2.21}$$

$$624 = 221 + 2.97Cu$$

$$403 = 2.97Cu$$

$$Cu = 135.69 \frac{KN}{m^2} = 136\ KN/m^2$$

Calculation of angle of shearing resistance:

$$N\varphi = \tan^2\left[45 + \frac{\varphi}{2}\right]$$

$$2.21 = \tan^2\left[45 + \frac{\varphi}{2}\right]$$

Square root on both sides

$$\sqrt{2.21} = tan\left[45 + \frac{\varphi}{2}\right]$$

$$\tan^{-1} 1.486 = 45 + \frac{\varphi}{2}$$

$$11.072 = \frac{\varphi}{2} = 22.1447$$

$$\varphi = 22^0 8' 93$$