LABORATORY MANUAL

011615P: Soil & Rock Mechanics Laboratory

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CONTENTS

SYLLABUS

SOIL & ROCK MECHANICS LABORATORY

1. To determine shear strength parameter of a soil sample by direct shear test.

2. To determine the shear strength of soil by vane shear test.

3. To determine the compressive strength of a cohesive soil sample in an unconfined compression state.

4. To determine cohesion and angle of shearing resistance for c-ϕ soil.

5. To determine uniaxial compressive strength of rock core specimen

6. To determine indirect tensile strength of rock by Brazilian test.

7. To determine tensile strength of rock by four point bending method

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Course objectives:

This course will enable students to

1. Classify the type of soil.
2. Determine the shear strength parameter of the soil.
3. Determine the tensile strength of rock.
4. Determine the uniaxial compressive strength of rock

Course outcomes:

After a successful completion of the course, the students will be able to

1. Draw Mohr circle.
2. To find cohesion and angle of internal friction of soil.
3. To perform and calculate unconfined compressive strength of soil.
4. To perform and calculate indirect tensile strength of rock.

To perform and find uniaxial compressive strength of rock by three point method.

Do's

1. Bring observation note books, lab manuals and other necessary things for the class.
2. Use tools for mixing concrete and water
3. Check the instruments for proper working conditions while taking and returning the same.
4. Thoroughly clean your laboratory work space at the end of the laboratory session.
5. Maintain silence and clean environment in the lab

Don'ts

1. Do not operate the machines without the permission of the staff
2. Do not put hands or head while equipment is in running condition.
3. Do not fix or remove the test specimen while the main is switch on.
4. Do not spill the concrete and aggregates on the floor.

List of Experiments

EXPERIMENT NO. 1 **DATE: _________**

DETERMINATION OF SHEAR STRENGTH PARAMETERS BY DIRECT SHEAR TEST

Aim: To determine shear strength parameter of a soil sample by direct shear test

Apparatus Used:

- Shear box
- Loading frame (motor attached).
- Dial gauge.
- Proving ring.
- Tamper.
- Straight edge.
- Balance
- Container.
- Spatula

Theory:

The shear strength of a soil is its maximum resistance to shearing stress at failure. The shear strength depends on angle of internal friction (ϕ) and cohesion(c). Coulomb has represented the shear strength of soil by following equation:

$$\tau = c + \sigma_n \tan\phi$$

Where τ is the shear strength of soil, σ_n is total normal stress on the failure plane.

Fig.1 Direct shear test apparatus

Procedure:

- Place the sample of soil into the shear box.
- Make all the necessary adjustments for applying vertical load, for measuring vertical and lateral movements and measurement of shearing force.
- Apply a known load on the specimen and then keep it constant during the course of the test.
- Shear the specimen till failure of the specimen is noticed or the shearing resistance decreases. Take the readings of the gauges during the shearing operation.
- Repeat the tests on three or four identical specimens.

Observation Table:

S.No.	Elapsed time (min)	Horizontal dial gauge reading (mm)	Vertical dial gauge reading (mm)	Proving ring reading (kg)	Normal load (kg)

Calculation:

Normal stress (σ_n) = Normal load/ Area of the shear box

Shear stress (τ) = Shear force/ Corrected Area

Shear strain = Shear displacement/ Length of specimen

Results: Plot the graph between shear stress (τ) on y axis and Normal stress (σ_n) on X axis and calculate the shear strength parameters.

c = --------------------- kg/cm^2

ϕ = -------------------- degree

EXPERIMENT NO. 2 **DATE: _________**

Determination of shear strength of soil by vane shear test

Aim: To determine shear strength of soil by vane shear test apparatus

Apparatus Used:

- Vane shear test apparatus
- Spatula
- Cylindrical container
- Caliper.

Theory:

The laboratory vane shear apparatus consists shear vane which consists four steel blades defined as vanes which are welded at right angles to a steel rod whose diameter does not exceed 0.25 cm. Generally the diameter of the vane is 1.2 cm and height is equal to twice of its diameter i.e., 2.4 cm.

Fig.2 Vane shear apparatus

Procedure:

- Prepare two or three specimens of the soil sample.
- Mount the specimen container with the specimen on the base of the vane shear apparatus. If the specimen container is closed at one end, it should be provided with a hole of about 1 mm diameter at the bottom.
- Lower the shear vanes into the specimen to their full length without disturbing the soil specimen. The top of the vanes should be at-least 10 mm below the top of the specimen. Note the readings of the angle of twist.
- Rotate the vanes at a uniform rate say 0.1^{o}/s by suitable operating the torque application handle until the specimen fails.
- Note the reading of the angle of twist.
- Find the value of blade height in cm.
- Find the value of blade width in cm.

Observation Table:

S.No.	Initial reading (degree)	Final reading (degree)	Difference (degree)	$T=\frac{Spring\ constant}{180\text{xdifference in degree}}$

Calculation:

Shear strength = $\frac{Applied\ Torque(T)}{\Pi(\frac{D^2H}{2}+\frac{D^3}{6})}$

Where,

D is the diameter of vane

H is the height of vane

Result: Shear strength of soil is --------------------------------- kg/cm^2

EXPERIMENT NO. 3 **DATE: _________**

Determination of compressive strength of a cohesive soil sample in an unconfined compression state

Aim: To determine the compressive strength of a cohesive soil sample in an unconfined compression state.

Apparatus Used:

- Unconfined compression machine
- Dial gauge
- Sampling tube
- Split mould
- Sample extractor
- Spatula

Theory: In an unconfined compression test no confining pressure is applied. The unconfined compressive strength is obtained by dividing the failure load by area of cross-section of the simple at failure.

Fig.4 Unconfined compressive strength apparatus

Procedure:

- Take two frictionless bearing plates of 75 mm diameter.
- Place the specimen on the base plate of the load frame (sandwiched between the end plates).
- Place a hardened steel ball on the bearing plate.
- Adjust the center line of the specimen such that the proving ring and the steel ball are in the same line.
- Fix a dial gauge to measure the vertical compression of the specimen.
- Adjust the gear position on the load frame to give suitable vertical displacement.
- Start applying the load and record the readings of the proving ring dial and compression dial for every 5 mm compression.
- Continue loading till failure is complete.
- Draw the sketch of the failure pattern in the specimen.

Observation Table:

Initial diameter of specimen (d_o) = ----------------------- cm

Initial length of specimen (L_o) = ------------------------- cm

Initial area of specimen (A_o) = ----------------------------- cm^2

Least count of proving ring (LC1) = ------------------------- div

Least count of deformation dial gauge (LC2) = -------------------- div

S.N0	Deformation dial gauge reading (div)	Deformation (div x LC2) (mm)	Proving ring dial gauge reading (div)	Load(Q) (div x LC1) (kg)	Strain(ε) ($\Delta L/L_o$)	Corrected area(A_c) $A_o/(1-\varepsilon)$ cm^2	Compressive stress (Q/A_c) kg/cm^2

Calculation:

Result: Failure angle = --------------------- degree

Cohesion = ------------------------- kg/cm^2

Unconfined compressive strength = ------------------- kg/cm^2

EXPERIMENT NO. 4 **DATE: _________**

Determination of cohesion and angle of internal friction for c-ϕ soil

Aim: To determine cohesion and angle of shearing resistance for c-ϕ soil .

Apparatus used:

- 3.8 cm (1.5 inch) internal diameter 12.5 cm (5 inches) long sample tubes.
- Rubber ring.
- Triaxial Apparatus.
- Stop watch

Theory:

The triaxial test is the most important and accurate test of soil for shear strength parameter in which drainage condition can be controlled in any condition. In triaxial test a cylindrical specimen is stressed in vertical and lateral directions and the shear parameters cohesion (c) and angle of internal friction (ϕ) are obtained, from which the shear strength of soil is determined. In this test the plane of shear failure is not pre-determined. The triaxial tests are superior where confining stress is to be applied. In order to determine cohesion (c) and angle of shearing resistance (ϕ) of soil, Mohr's circles are drawn. The tangent line is drawn on Mohr's circles. It is called strength envelope. The intercept with ordinate gives cohesion and slope of the line (envelope) gives angle of internal friction (ϕ).

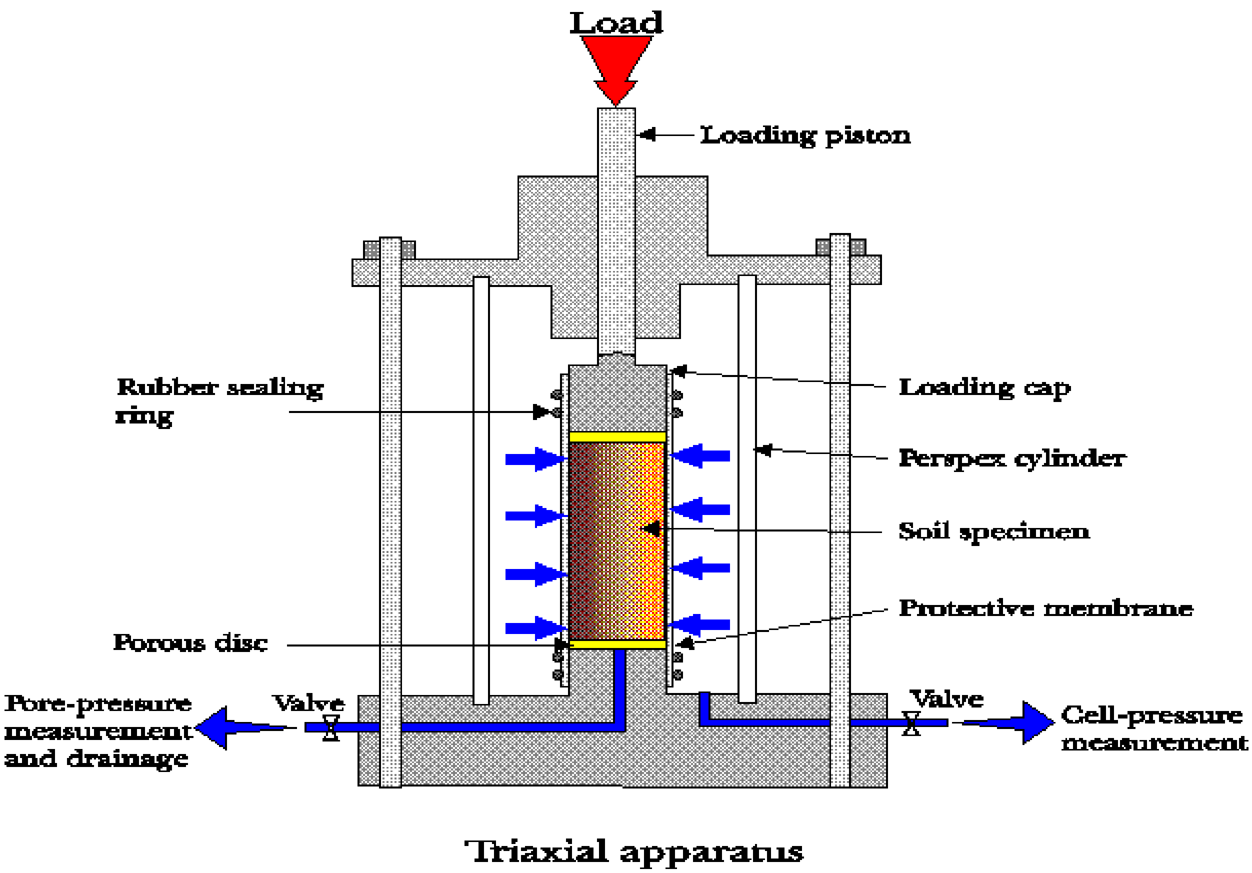

Fig.4 Triaxial test setup

Procedure:

- .Prepare the sample and measure their length and diameter.
- Put the soil sample in a rubber membrane.
- Placed the soil sample in a compression machine
- Apply a given magnitude of cell pressure.
- Apply deviator load on the sample until it will fail
- Record proving ring reading.

Observation table:

Initial length of the sample (A_o) = ------------------------------ cm

Initial diameter of the sample (d_o) = --------------------------- cm

Initial area (A_o) = ----------------------- cm^2

Initial volume of sample (Vo) = ------------------------ cm^3

Confining pressure, $\sigma_3 =$ ----------------------- kg/cm^2

Least count of proving ring (LC1) = -------------------------- div

Least count of deformation dial gauge (LC2) = ---------------------- div

S.No.	Deformation dial reading (div)	Deformation (div x LC2) (mm)	Proving ring reading (div)	Deviator load (div x LC1) (kg)	Corrected area (A_c) cm^2	Deviator stress (σ_d) kg/cm^2

Calculation:

Corrected area (A_c) = $\frac{V-\Delta V}{L-\Delta L}$

Total stress (σ_1) = Cell pressure (σ_3) + deviator stress (σ_d)

Deviator stress (σ_d) = Deviator load/A_c

Graph: Plot the Mohr's circles and calculate c and ϕ

Result: From the Mohr's circles diagram the strength parameters found to be c= ------------------- kg/cm^2 and angle of internal friction = ----------------------- degree.

EXPERIMENT NO. 5 **DATE: _________**

Determination of uniaxial compressive strength of rock specimen

Aim: To determine uniaxial compressive strength of rock specimen.

Apparatus Used:

- Testing machine
- Vernier caliper
- Rock specimen
- Dial gauge

Theory:

The uniaxial compressive strength of rock specimen is an important parameter. Cylindrical specimen of rock loaded axially between platens in a testing machine. The stress value at failure is defined as the compressive strength of the specimen and is given by relationship

$$UCS = P_f / A$$

Where,

UCS = uniaxial compressive strength of the specimen

P_f = Applied failure load

A = cross sectional area of specimen

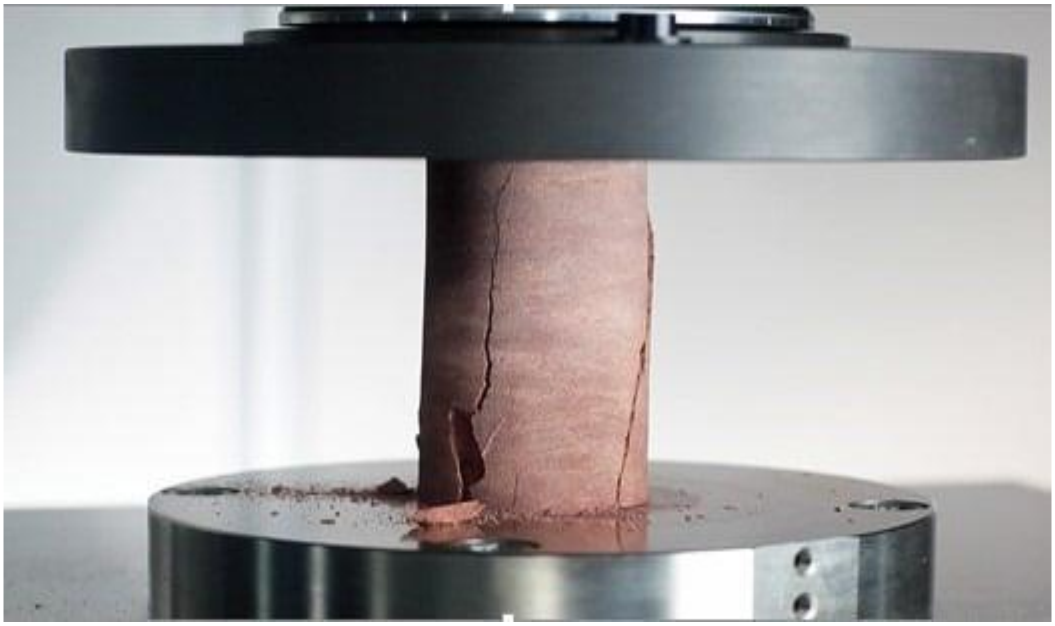

Fig.1 Compressive strength testing of cylindrical specimen

Procedure:

- Measure the length and diameter of cylindrical specimen.
- Load the specimen under testing machine (TM) in such a way that the stress rate is within the limit of 0.5- 1.0 MPa/sec.
- Note the load when the specimen fails.
- Also obtain the stress-strain curve or load vs. displacement curve from TM.

Observation Table:

Length of specimen = -------------------------------------- cm

Diameter of specimen = ------------------------------------ cm

Area of specimen = -- cm^2

S.No.	Failure load (P_f) (kg)	UCS = P_f/A (kg/cm^2)
Average		

Calculation:

Result: The uniaxial compressive strength of rock specimen is found to be -- kg/cm^2.

EXPERIMENT NO. 6 **DATE: _________**

Determination of indirect tensile strength of rock by Brazilian test

Aim: To determine indirect tensile strength of rock by Brazilian test.

Apparatus Used:

- Loading device
- Rock specimen
- Vernier caliper
- Flat loading platens
- Curve loading jaws

Theory:

The Brazilian test is a simple indirect testing method to obtain the tensile strength of brittle material such as concrete, rock, and rock-like materials. In this test, a thin circular disc is diametrically compressed to failure. The compression induces tensile stresses normal to the vertical diameter, which are essentially constant over a region around the center. The indirect tensile strength is typically calculated based on the assumption that failure occurs at the point of maximum tensile stress, i.e., at the center of the disc. The suggested formula for calculating the splitting tensile strength is

$$\sigma_t = 2P/\Pi.D.t$$

Where, P is load at failure

D is the diameter of the specimen

T is the thickness of specimen

σ_t is indirect tensile strength or splitting tensile strength

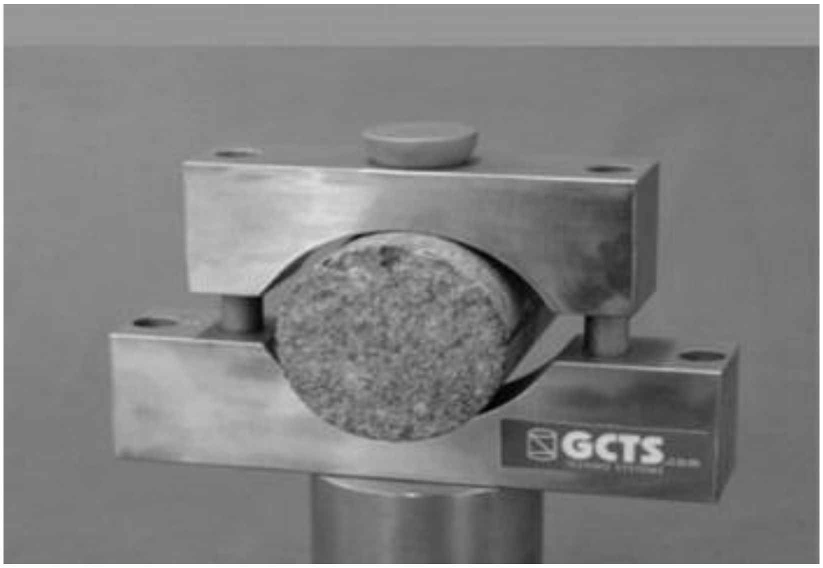

Fig.2 Indirect tensile strength of rock specimen (Brazilian test)

Procedure:

- **Marking-** The desired vertical orientation of the specimen shall be indicated by marking a diametral line on each end of the specimen. This line shall be used in centering the specimen in the testing machine to ensure proper orientation, and they are also used as the reference lines for thickness and diameter measurements.
- **Positioning-** Position the test specimen to ensure that the diametral plane of the two lines marked on the ends of specimen line up with the center of the thrust of the spherically seated bearing surface to within 0.013 mm.
- **Loading-** Apply a continuously increasing compressive load to produce an approximately constant rate of loading or deformation such that failure will occur within I to 10 min of loading.

Observation:

Diameter of specimen (D) = ----------------------------------- cm

Thickness of specimen (t) = ----------------------------------- cm

Failure load of specimen (P) = ---------------------------------- kg

Calculation:

Result: The indirect tensile strength of rock specimen is found to be --------------------- -------------------------------- kg/cm^2.

EXPERIMENT NO. 7 **DATE: __________**

Determination of tensile strength of rock by four point bending method

Aim: To determine tensile strength of rock by four point bending method.

Apparatus Used:

- Universal Testing Machine (UTM)
- Vernier caliper
- Rock sample
- Steel Scale

Theory:

In this test beam is subjected to bending till failure occurs. This is also called as flexural test. Generally four point flexural loading system is used in this test. The bottom surface of the beam is supported at two points; one nears each end. The top portion of the beam is loaded at the third points. This system produces pure bending in the middle third of the beam. The flexural strength (modulus of rupture) is given by

$$\sigma = \frac{16\,P\,L}{3\Pi D^3}$$

Where,

P is the load recorded when the sample fails in bending.

L is length of specimen

D is diameter of specimen

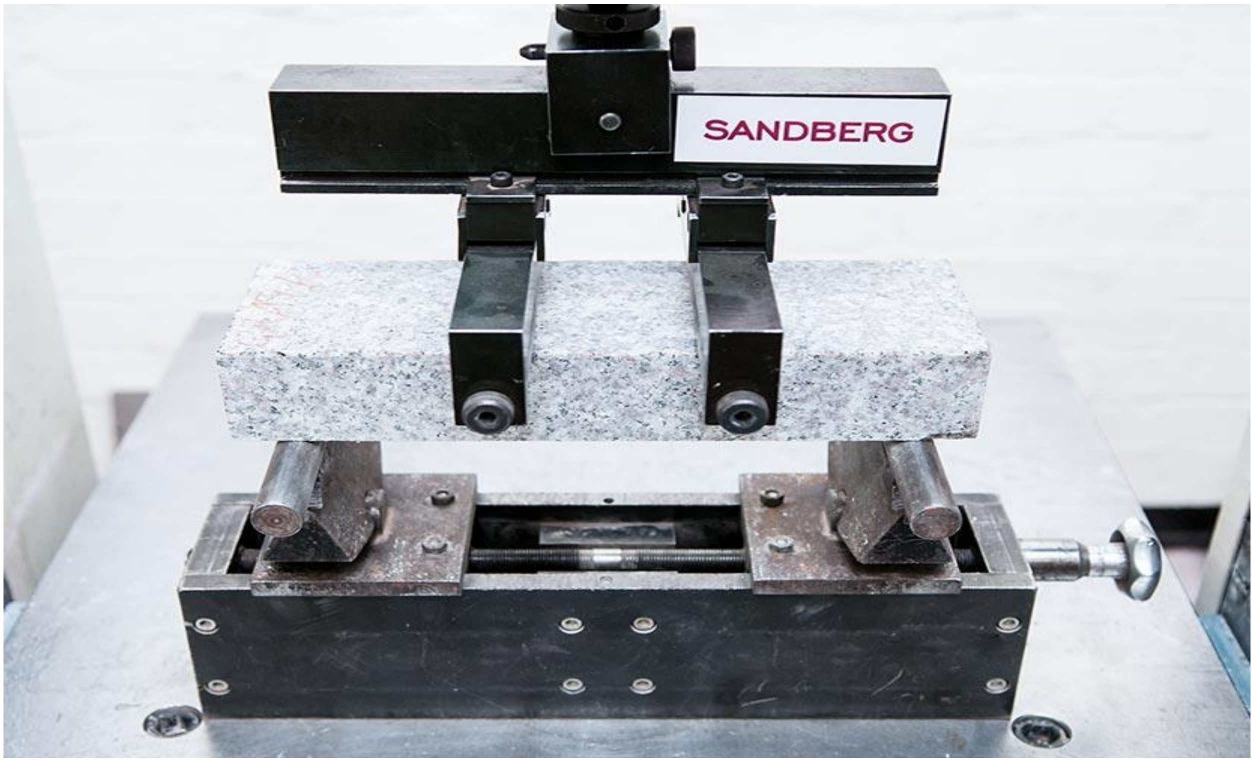

Fig.3 Bending test of rock specimen

Procedure:

- Measure the dimension of the rock specimen
- Place the specimen on UTM with proper care.
- Apply loading on the specimen
- Record the maximum load at which sample fails in bending.

Observation:

Length of specimen (L) = ------------------------------ cm

Diameter of specimen (D) = ----------------------------- cm

Failure load (P) = --------------------------- kg

Calculation:

Result: The bending tensile strength of rock is found to be ---------------------------- ------------------ kg/cm^2.