SOIL MECHANICS

UNCONFINED COMPRESSIVE STRENGTH

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❑ INTRODUCTION :

- The Unconfined Compressive Strength (UCS) test is a crucial method in geotechnical engineering for assessing the mechanical properties of cohesive soils. It determines the maximum compressive load a soil sample can sustain under unconfined conditions, meaning without lateral confinement. This test helps engineers understand the soil's shear strength and its behavior under load
- In the UCS test, a cylindrical soil sample is prepared and placed vertically between two loading platens. The top platen applies a constant axial load to the specimen while the bottom platen holds it in place. The load is increased until the soil specimen fails, usually by shearing along a failure plane.
- By knowing the soil's unconfined compressive strength, engineers can make informed decisions about project feasibility, soil stabilization measures, and structural design.

❑ Overview of UCS :

- **Basic Principle**: UCT applies axial loading to a cylindrical soil specimen without lateral confinement, allowing the soil to deform freely until failure occurs.
- **Comparison**: Unlike other compression tests, such as the triaxial compression test, UCT does not apply confining pressure to the soil specimen.
- **Significance**: UCT provides valuable data on the compressive strength and stress-strain behavior of cohesive soils under unconfined conditions.

❑ THEORY :

Reference IS 2720 Part(X)

The Unconfined Compressive Strength (UCS) test is a fundamental method used in geotechnical engineering to determine the strength characteristics of cohesive soils, specifically how much pressure they can withstand when not confined by external constraints. Let's dive into a more detailed explanation of each aspect:

1. **Purpose and Objective**: The primary goal of the UCS test is to assess the inherent strength of cohesive soils when they are not subjected to lateral confinement. This information is crucial for various engineering applications, such as foundation design, slope stability analysis, and construction material selection.

2. **Suitable Soil Conditions**:The test is most applicable to cohesive soils, which are typically composed of fine particles like clay and silt. These soils tend to exhibit cohesive properties due to the attraction forces between particles. The test is specifically designed for saturated cohesive soils without fissures or cracks, where the angle of shearing resistance can be assumed to be zero.

❑ THEORY cntd…

3. **Undrained Shear Strength**:One important parameter derived from the UCS test is the undrained shear strength, denoted as Cu. This value represents the soil's resistance to shearing forces when it is not allowed to drain water. In the absence of external constraints, the undrained shear strength can be estimated as half of the unconfined compressive strength (qu / 2).

4. **Test Procedure**:The UCS test involves subjecting a cylindrical specimen of cohesive soil to vertical compressive stress within a controlled laboratory environment. The specimen is typically prepared by molding undisturbed soil samples into a cylindrical shape. It's important to ensure that the sample is fully saturated to simulate real-world conditions accurately.

❑ THEORY cntd…

5. **Failure Mechanisms**:The soil specimen fails under the applied vertical stress through one of two primary mechanisms: shear along a diagonal plane or lateral bulging. Shear failure occurs when the soil undergoes internal sliding along a plane of weakness, typically at an angle to the vertical axis of the specimen. Lateral bulging, on the other hand, involves the outward deformation of the specimen due to excessive vertical stress.

6. Determining Strength:

If P_f is the failure load, and A_f is the final cross sectional area of the sample at failure, those the compressive strength q_u is given as,

$$q_u = P_f / A_f$$

Where, A_f is given as, $A_f = A_o / (1-e_a)$

e_a =total deformation of the soil sample at failure.

The shear strength of the soil is than assumed then assumed as equal to $1/2q_u$

$$C = C_u = 1/2\ q_u$$

❑ THEORY cntd…

- **Unconfined compressive strength (q_u) :** Unconfined compressive strength (q_u) is the load per unit area at which an unconfined cylindrical specimen of soil will fail in simple compression test.
- **Sensitivity :** sensitivity is defined as the ratio of unconfined compression strength of undisturbed soil sample to the unconfined compression strength of remoulded sample at constant moisture content.

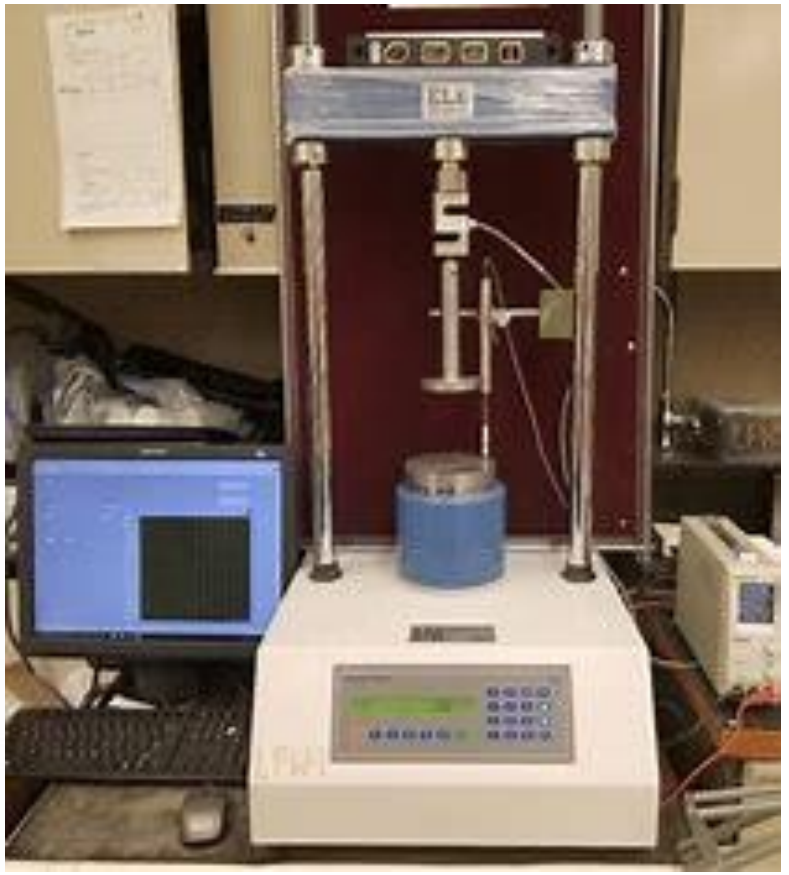
$$S_t = \frac{(q_u)_{\text{Undisturbed Soil}}}{(q_u)_{\text{Remoulded Soil}}}$$

❑ THEORY cntd…

- Soil consistency can be easily known from the value of unconfined compressive strength.
- sample should always be extracted along the same direction in which it entered the tube in the field.
- Where no maximum stress is observed, stress at 20% strain will give the unconfined compression test

❑ APPARATUS :

- Compression machine
- Dial Gauge
- Proving Ring
- Split mould of internal diameter 38 mm and length 76 mm.
- Sampling tube of internal diameter 30 mm and length 200 mm
- Metal Plate
- Moving Plate
- Vernier calliper
- Balance
- Sampling extractor



❑ PROCEDURE :

A) Preparation of the soil specimen to be tested.

- 145.6 grans of oven dried sample is taken in a tray whose MDD was predetermined to be 16.9 kN/m². 27 ml of water was added to the soil sample and mixed thoroughly to achieve the OMC water content of 18%.
- The soil is kneaded properly to get a homogeneous mixture. Then the kneaded soil was filled in a mould having the dimensions of 38 mm diameter and 76mm height.
- The compacted soil specimen obtained with the help of sample extractor and split sampler.
- After the specimen was formed, it was removed from the mould. The ends were trimmed along perpendicular to the long axis.
- Height and diameter of the specimen was measured andrecorded in the observation table
- The above steps were repeated to obtain two more Such soil samples.

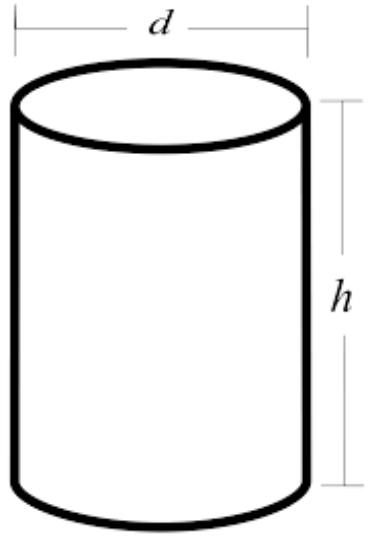
❑ PROCEDURE :

B) Testing of the Soil specimen

- Sample 1 was set on the pedestal of the equipment and all the necessary adjustment's were made for application of axial loads and measurement of the deformation,
- The axial load was applied at a strain of about 0.5 to 27. per minute and the load was applied till the sample failed
- The failure pattern was sketched and the observations were recorded by the machine.
- Sample no 2 and 3 are tested in the same way.

❑ Size of specimen :

- The test is performed on a cylindrical sample with a height to diameter ratio of 2 : 1
- If h/d > 2, then the shear strength is underestimated.
- If h/d < 2, then it is overestimated.
- The UCS test provides valuable information about the load-bearing capacity and stability of soil.
- It helps in assessing the strength and compressibility of soil under unconfined conditions.



h/d = 2

❑ FAILURE PATTERN :

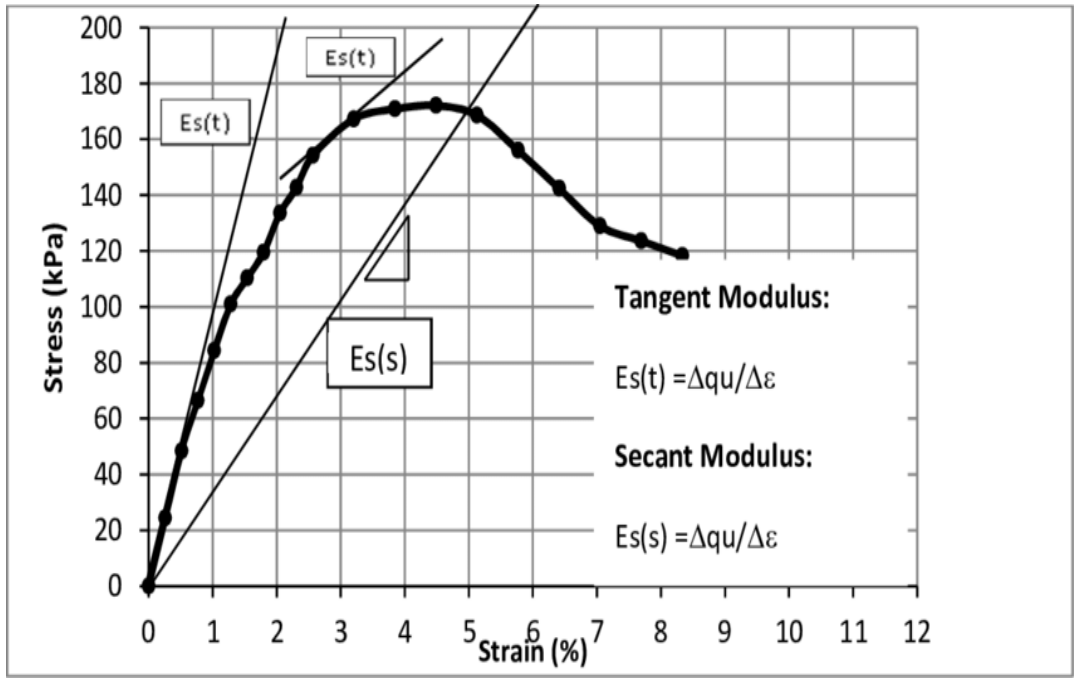
Failure pattern of soil specimens are as fallow :

Sample 1

Sample 2

Sample 3

❑ GRAPH :



The peak of this Stress – Strain graph curve will give the Unconfined Compressive Stress

❑ DISCUSSION :

Classification of soil on the basis of UCS

Soil Properties	Unconfined Compression Strength (kg/cm^2)
Very soft	< 0.25
Soft	0.25 – 0.50
Firm	0.5 – 1
Stiff	1 – 2
Very stiff	2 – 4
Hard	> 4

Classification of soil on the basis of sensitivity

Characteristics	Sensitivity
< 2	Insensitive
2 – 4	Moderately sensitive
4 – 8	Sensitive
8 – 16	Very sensitive
16 – 32	Slightly quick
32 – 64	Medium quick
> 64	Quick

❑ DISCUSSION cont…

- Cohesion of the soil sample may be calculated by using the following relations

$$\sigma_1 = \sigma_3 \, tan^2 \, \alpha + 2C \, tan. \, \alpha$$

Where:- σ_1 = Major principal stress at failure

$\sigma 3$ = Minor principal stress at failure

a = Failure angle with major principal plane

$$\alpha = 45^o + \emptyset/2$$

Where:- $\emptyset$ = Angle of internal friction

In unconfined compression test, $\sigma_3 = 0$

$$\sigma_1 = q_u$$

❑ DISCUSSION cont…

Hence, $\mathbf{q_u = 2C \tan (45° + \emptyset/2)}$

∴ $\mathbf{C = q_u / (2 \tan(45° + \emptyset/2))}$

If the soil sample is fully saturated and no drainage is allowed, then ø = 0,

$\mathbf{C = q_u/2}$

- **Shear Strength of the soil is estimated from coulomb's equation :**

$$\tau_f = C + \sigma_{ef} \tan \emptyset$$

Where:- τ_f = Shear strength

σ_{ef} = Effective normal stress

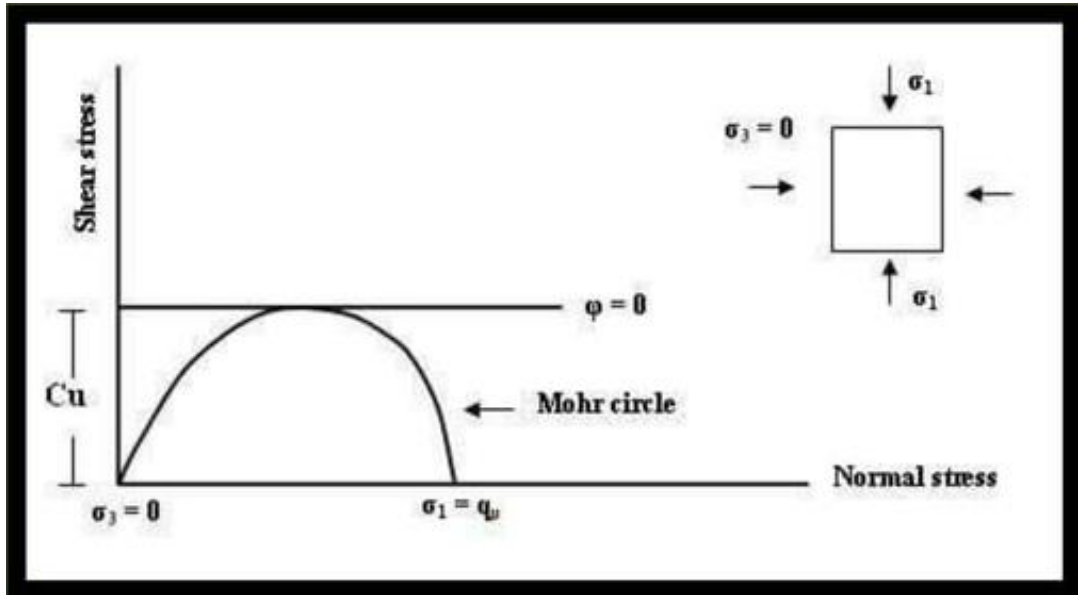
If ø = 0, then

$$\tau_f = C + \sigma_{ef} \tan \emptyset$$

$$\tau_f = C$$

❑ DISCUSSION cont…

- The Mohr circle can be draw for stress conditions at failure. As the minor principal stress is zero, the Mohr circle passes through the origin .The failure envelop is horizontal. The cohesion intercept is equal to the radius of the circle.



Mohr circle for Unconfined Compression Test

❑ CONCLUSION

- The test results aid in engineering decisions regarding foundation design, slope stability, and construction practices.
- Variations in UCS values across different soil samples reflect the heterogeneity and geotechnical properties of the soil.
- Understanding the UCS of soil is crucial for ensuring the safety and durability of civil engineering projects.
- Further research and analysis may be necessary to correlate UCS values with specific soil types and environmental conditions for more accurate predictions.

THANK YOU