SHEAR STRENGTH

-> The shear strength of the soil is the resistance to deformation by continuous shear displacement of soil particles.

-> The failure conditions for a soil may be expressed in terms of limiting sher stress called shear strength.

-> All stability analysis in soil mechanics involve a basic knowledge of the shearing properties and shearing resistance of the soil.

Mohr's Coulomb failure theory

(i) This theory was first proposed by coulomb (1776) and later generalised by mohr.

(ii) The shear failure occurs in soils by slippage of particles due to shear stresses. The failure is essentially by shear, but shear stresses at failure depends upon the normal stresses on potential failure plane. According to Mohr, the failure is caused by a critical combination of the normal and shear stresses.

(iii) If we plot shear stress at failure as ordinate and against normal stresses as abscissa we obtain a curve called the strength envelope. It can be represented by equation $\tau_f = f(\sigma)$

(iv) Coulomb assumed the relation between τ_f & σ to be linear & gave the following equation popularly known as Coulomb's equation

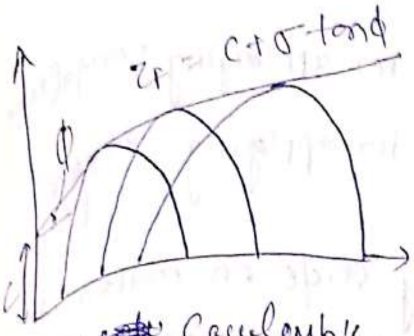
$$\tau_f = c + \sigma \tan\phi$$

(v) where 'c' is the intercept of the strength envelope on the τ axis and $\tan\phi$ the slope of the strength envelope. 'c' is known as cohesion & ϕ is the angle of internal friction or more comprehensively angle of shearing resistance.

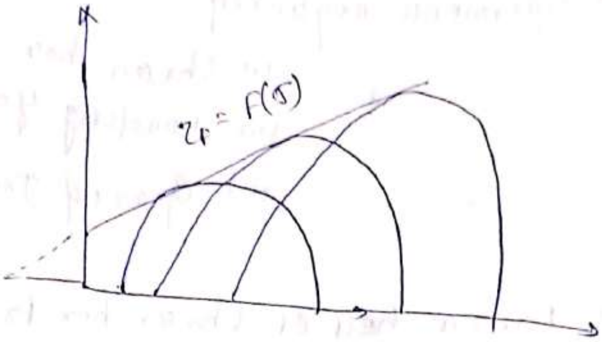
(vi) c & ϕ together are called shear strength parameters and are variable for any soil depending upon conditions of testing such as drainage conditions and rate of strain.

(vii) Mohr generalised the strength envelope also known as failure envelope as a curve which becomes flatter with increasing normal stress.

(viii) In conclusion it can be stated that the strength envelope will be a straight line if it is assumed to be ~~constant~~ constant. In case of Mohr generalised envelope, a straight line can be used within a range of σ values. The strength envelope will be tangential to any Mohr circle at failure as shown in fig.



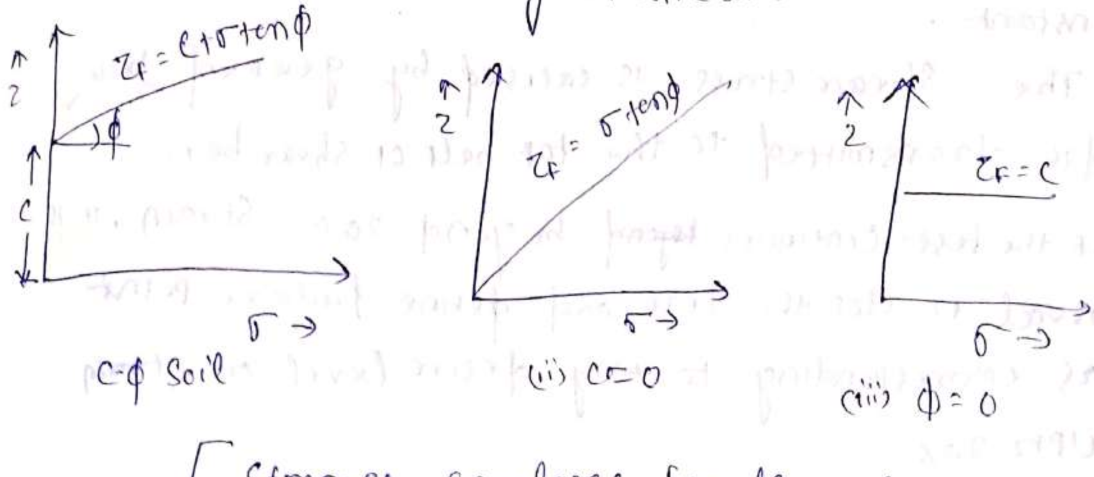
(a) ~~[struck]~~ Coulomb's envelope



(b) ~~[struck]~~

Based on values of shear strength parameters, soils can be described as

(i) Cohesive soil
(ii) Cohesionless soil
(iii) Purely cohesive soil.



[Strength envelopes for three types of soil)

Measurement of Shear Strength

Various laboratory tests were conducted for determination of shear strength.

(a) Direct shear test
(b) Unfined soil compression test
(c) triaxial shear test
(d) Vane Shear test.

(a) Direct Shear test

* Equipments required
  - (i) Shear box
  - (ii) Loading yoke - for applaying normal force
  - (iii) Geared Jack - for applying shear force

(i). Lower half of shear box freely slide on roller to which Shear Force is applied by gear Jack

(ii) The soil Specimen is Placed at its mid. height for continuing drain. test Perforated grid plates and poros Stones are used.

(iii) A normal Stress 'σ' sigma is applaid and is kept constant.

(iv) The Shear stress is caused by geared Jack and is transmitted to the top half of shear box.

(v) If the test Continues ~~beyond~~ beyond 20% Strain, it is usual to stop the test and define failure point as corresponding to any desire level of strain upto 20%

(vi) By plotting τ_f ~~and~~ against σ the failure envelope is obtained by measurement of plot.

(viii) The shear box test can be either strain controlled or stress controlled.

(B) Triaxial Compression test

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(i) In this test the specimen is compressed by all the three principal stresses σ_1, σ_2 and σ_3

Equipments used are.

(i) Triaxial cell
(ii) Loading frame - for increasing axial load
(iii) Constant Pressure System
- To apply and Maintain cell pressure
(iv) Pore Pressure measuring apparatus.

→ The triaxial cell consist of a high pressure cylindrical cell made of a transparent Material, and is provided at the base with inlet for cell fluid, outlet for drainage of pore water.

→ At the top an air released valve to expell 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 plates at top and bottom. The loading cap is placed on the top of porous plate. The specimen is enclosed in a rubber membrane to prevent its contact with cell fluid after filling the cell with fluid. required cell pressure σ_3 is applied by means of constant pressure system.

→ The axial stress called deviator stress is applied through plunger.

→ 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%.

Deviator stress at any point = $\sigma_d = \frac{F}{A_c}$

F = deviator force

A_c = cross sectional area of specimen

→ with the set of σ_1 and σ_3 values, Mohr's circle at failure is drawn with three different σ_3 values & 3 different Mohr's circle were obtained. Then a tangent is drawn over failure envelope & $c - \phi$ are obtained from the plot.

Unconfined compression test

→ Unconfined compression test can be regarded as the special case of triaxial compression test in which no lateral pressure or confining pressure is applied so that $\sigma_2 = \sigma_3 = 0$. The soil specimen is cylindrical in shape with length about 2 to 2.5 times its diameter.

→ The laboratory equipment for conducting unconfined compression test has facilities for compressing the specimen at uniform rate of strain and measuring the axial deformation and axial force.

→ The maximum compressive stress resisted by specimen before failure is called unconfined compression strength it is defined by q_u

$$q_u = \frac{F}{A_c}$$

where, F = Axial compressive force at failure.

A_c = Corrected area of cross section of specimen at failure.

$$A_c = \frac{A_0}{1-\epsilon}$$

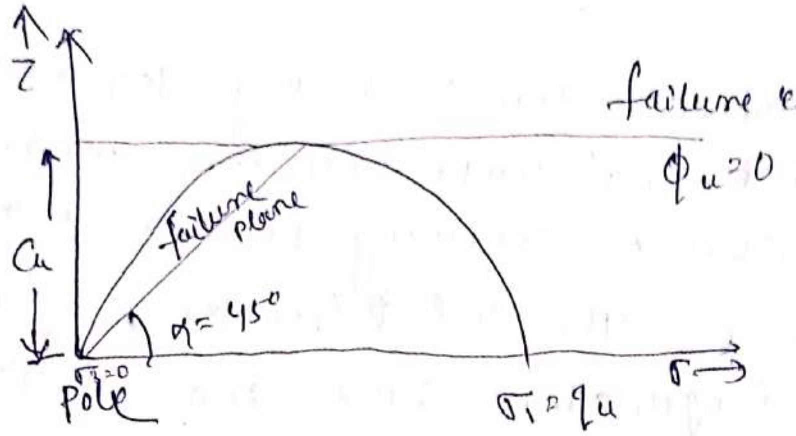
where A_0 = initial area of cross section

ϵ = Axial strain at failure point

$$= \frac{\Delta L}{L_0}$$

→ The unconfined compression test is a quick test in which no drainage is allowed.

→ This test is conducted on saturated clay volume change is assumed to be zero.



The undrained shear strength parameters obtained are denoted by C_u and ϕ_u.

→ The test results are acceptable for soils having low friction or little friction the angle α which plane makes with the horizontal is measured after sketching the failed specimen.

Vane shear test

(i) Vane shear test is a quick test used to determine undrained shear strength of cohesive soils.

(ii) The Equipment essentially consist of four high tensile steel plates called vanes which are welded orthogonally to the bottom end of a steel rod called the torque rod.

with an arrangement to measure the torque and rotation.

(iii) A typical arrangement consist of a calibrated torsion spring attach to the top of torque rod which is rotated by a combination of worm gear and worm wheel the vane shear test is conducted both on laboratory and in field.

(iv) A typical laboratory set of vane has 20 mm height diameter of 12 mm across vanes with blade thickness of 0.5 to 1 mm.

(v) To conduct the test vanes are generally pushed into the soil and the torque rod is rotated at uniform rate usually 1° per minute.

(vi) The torque corresponding to angle of rotation 'θ' at uniform interval are noted. Torque 'T' is plotted as ordinate against angle of rotation 'θ' as abscissa.

The torque 'T_F' at failure is found and is used to calculate the shear strength τ_f

(i) when both top and bottom end pertake shearing = $T_F = \pi d^2 \tau_f \left(\frac{H}{2} + \frac{d}{6} \right)$

(ii) when only bottom end involve in shearing

$$T_F = \pi d^2 \tau_f \left(\frac{H}{2} + \frac{d}{12} \right)$$