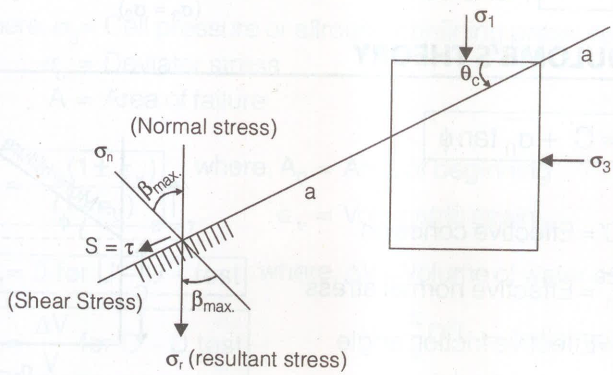
9. SHEAR STRENGTH OF SOIL

SHEAR STRENGTH

Shear strength of a soil is the capacity of the soil to resist shearing stress. It can be defined as the maximum value of shear stress that can be mobilized within a soil mass.



- Plane a-a is critical plane
- θ_c = Angle of critical plane (a – a)
- σ_1 and σ_3 are stresses on given planes

(i) $\boxed{\theta_c = \frac{\pi}{4} + \frac{\beta_{maximum}}{2}}$ where, $\beta_{max.}$ = Angle between resultant stress and normal stress on critical plane.
= Friction angle of soil = ϕ

$$\boxed{\theta_c = \frac{\pi}{4} + \frac{\phi}{2}}$$

↓ for clay's $\boxed{\phi = 0}$

$$\boxed{\theta_c = \frac{\pi}{4}}$$

(ii) $\boxed{\tau = \sigma_\eta \tan\phi}$, for sands or ϕ-soil.

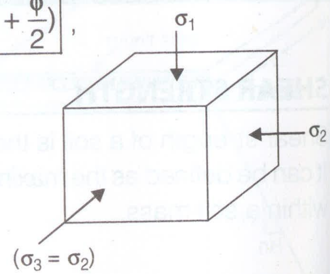
(iii) $\boxed{\tau = C + \sigma_\eta \tan\phi}$, for C-ϕ soil.

(iv) $\boxed{\tau = C}$, for C-soil (clays).

(v) $\boxed{\sigma_1 = \sigma_3 \tan^2(45° + \frac{\phi}{2}) + 2C\tan(45° + \frac{\phi}{2})}$, for C-ϕ soil

(vi) $\boxed{\sigma_1 = \sigma_3 \tan^2(45° + \frac{\phi}{2})}$, for ϕ-soil.

(vii) $\boxed{\sigma_1 = 2C}$, for C-soil.



MOHR COULOMB'S THEORY

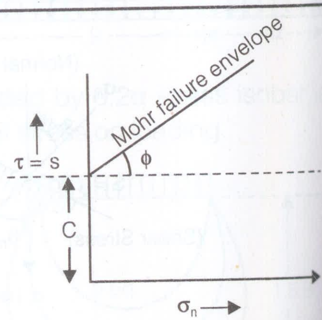
$$\boxed{\tau = s = C' + \overline{\sigma_n} \tan\phi'}$$

where,

C' = Effective cohesion

$\overline{\sigma_n}$ = Effective normal stress

and ϕ' = Effective friction angle

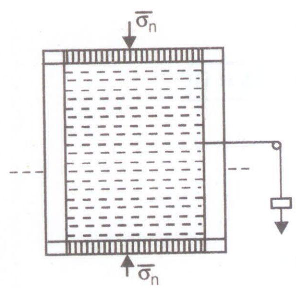


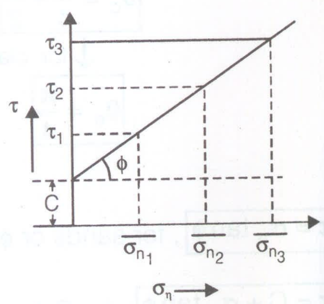
NOTE: Under dry stage total stress parameter and effective stress parameters are equal.

DIRECT SHEAR TEST

$$\boxed{\tau = s = C' + \overline{\sigma_n} \tan\phi'}$$

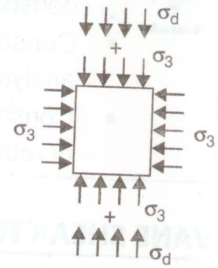
Suitable for sands





TRIAXIAL SHEAR TEST

- $\boxed{\sigma_1 = \sigma_3 + \sigma_d}$
- $\boxed{(\sigma_d)_{failure} = (\sigma_1 - \sigma_3)_{failure} = \frac{P}{A}}$
- $\boxed{\tau = S = C + \overline{\sigma_n} \tan\phi}$



where, σ_3 = Cell pressure or allround confining pressure

σ_d = Deviator stress

A = Area of failure

$\boxed{A = \frac{A_0(1 \pm \epsilon_v)}{(1 - \epsilon_L)}}$ where, A_0 = Area of beginning

ϵ_v = Volumetric strain

$\boxed{\epsilon_v = 0 \text{ for U – U – test}}$ where, ΔV = Volume of water escaped out

$\boxed{\epsilon_v = \frac{\Delta V}{V} \text{ for C – D test}}$ $V = \frac{\pi}{4}D^2L$ = Initial volume

ϵ = Axial strain

UNCONFINED COMPRESSION TEST

- $\boxed{q_u = (\sigma_1)_f}$

where, q_u = unconfined compressive strength.

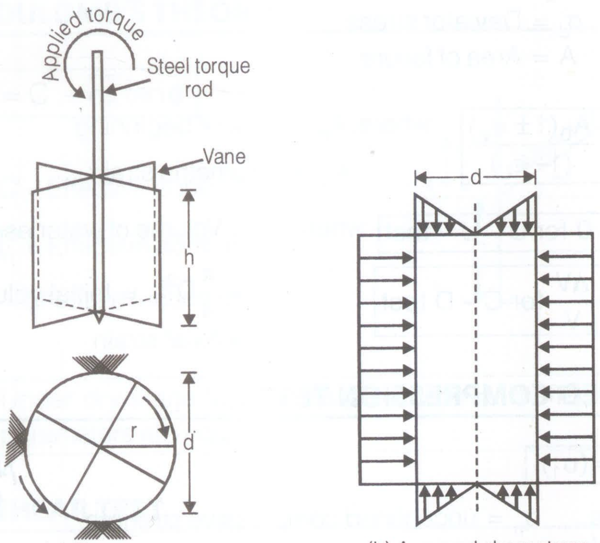
Here, $\boxed{\sigma_3 = 0}$

- $\boxed{(\sigma_1)_f = 2C\tan\left(45° + \frac{\phi}{2}\right)}$, for C-ϕ soil
- $\boxed{(\sigma_1)_f = 2C}$, for C-soil.
- $\boxed{\tau = S = C = \frac{q_u}{2}}$, for clay's or c-soil.

> **Remember**
> - Unconsolidated undrained test (UU test) suitable for construction of building over saturated clays.
> - Consolidated undrained test (CU) suitable for stability analysis of earthern dam during sudden drawdown.
> - Consolidated drained test (CD) suitable for stability analysis of retaining wall having sandy fills.

VANE SHEAR TEST

- It is suitable for sensitive clays.



(a) Shear vane

(b) Assumed shear stress distribution

	Lab Size	Field Size
Height of vane (H)	20 mm	10 to 20 cm
Dia of vane (D)	12 mm	5 to 10 cm
Thickness of vane (t)	0.5 to 0.1 mm	2 to 3 cm

Shear Strength

- $$S = \tau = \frac{T}{\pi D^2\left(\frac{H}{2} + \frac{D}{6}\right)}$$

When top and bottom of vanes both take part in shearing.

- $$S = \tau = \frac{T}{\pi D^2\left(\frac{H}{2} + \frac{D}{12}\right)}$$

When only bottom of vanes take part in shearing.

- $$S_t = \frac{(q_u)_{undisturbed}}{(q_u)_{remolded}}$$

Where s_f = Sensitivity

PORE PRESSURE PARAMETER

(i) $$B = \frac{\Delta U_c}{\Delta\sigma_c} = \frac{\Delta U_c}{\Delta\sigma_3}$$

where, B = Pore pressure parameter

ΔU_C = Change in pore pressure due to increase in cell pressure

$\Delta\sigma_c$ = $\Delta\sigma_3$ = Change in cell pressure.

- $0 \le B \le 1$
- $B = 0$, for dry soil.
- $B = 1$, for saturated soil.

(ii) $\bar{A} = A.B$

where A = Pore pressure parameter

- $$\bar{A} = \frac{\Delta U_d}{\Delta\sigma_d}$$

where, ΔU_d = Change in pore pressure due to deviator stress.

$\Delta\sigma_d$ = Change in deviator stress

(iii) $\Delta U = \Delta U_c + \Delta U_d$ $\quad$ ΔU = Change in pore pressure

(iv) $\Delta U = B[\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3)]$

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