$Degree\ of\ saturation\ (s_r) for\ Bulk\ soil = \frac{v_w}{v_v}$ **when $v_a = 0$ and $v_w = 0$ is ($v_v = 0$, $v_s = v_t$, $S = 0$)**

$Degree\ of\ saturation\ (s_{r_{min}}) for\ Dry\ soil = \frac{v_w}{v_v} = \frac{0}{v_a} = 0$ **S not may be < 0**

$Degree\ of\ saturation\ (s_{r_{max}}) for\ saturated\ soil = \frac{v_w}{v_v} = \frac{v_v}{v_w} = 1$ **S not may be > 1** **$0 < S < 1$**

$The\ air\ content\ (A) for\ Bulk\ soil = \frac{v_a}{v_t}$

$The\ air\ content\ (A_{max}) for\ Dry\ soil = \frac{v_a}{v_t} = \frac{v_v}{v_t} = n$ **at $v_a = v_v$ $A_{max} = n$ A not may be > n**

$The\ air\ content\ (A_{min}) for\ saturated\ soil = \frac{v_a}{v_t} = \frac{0}{v_t} = 0$ **at $v_a = 0$ $A_{min} = 0$ A not may be < 0**

(Mass–Mass) Or (Weight – Weight) Relation

$Water\ content\ (w_c) = \frac{M_w}{M_s}$ Or $= \frac{W_w}{W_s}$ **at Dry soil (wc) = 0 at Sat soil (wc) = wc_{max}**

(Mass Or Weight) –Volume Relation

$Bulk\ density\ (\rho) = \frac{M_t}{v_t} = \frac{Gs\rho_w(1+w)}{1+e} = \frac{\rho_w(Gs+se)}{1+e}$ Or moist unit weight $(\gamma) = \frac{W_t}{v_t} = \frac{Gs\gamma_w(1+w)}{1+e} = \frac{\gamma_w(Gs+se)}{1+e}$

$Solid\ density\ (\rho_s) = \frac{M_s}{v_s}$ Or solid unit weight $\gamma_{solid} = \frac{W_s}{v_s}$

$Dry\ density\ (\rho_{dry}) = \frac{M_s}{v_t} = \frac{\rho_w Gs}{1+e}$ Or dry unit weight $\gamma_{dry} = \frac{W_s}{v_t} = \frac{\gamma_w Gs}{1+e}$

$Saturated\ density\ (\rho_{Sat}) = \frac{M_t}{v_t} = \frac{\rho_w(Gs+e)}{1+e}$ Or saturated unit weight $\gamma_{Sat} = \frac{W_t}{v_t} = \frac{\gamma_w(Gs+e)}{1+e}$

$\rho_{(effective/Bount/Submerged)} = \rho_{Sat} - \rho_w$ Or effective unit weight $\gamma_{(effective/Bount/Submerged)} = \gamma_{Sat} - \gamma_w$

Derived Relation:

$\gamma_{Dry} = GS\gamma_w(1-n)$	$\gamma_{sat} = \gamma_{Dry} + n\gamma_w$	$\gamma = \gamma_w Gs(1+w)(1-n)$
$w_c Gs = se$	$A = \frac{e - wcGS}{1+e}$ Or $A = n(1-s)$; $e = \frac{n}{1-n}$	$Gs = \frac{\rho_s}{\rho_w} = \frac{M_s}{v_s\rho_w} = \frac{M_s v_w}{v_s M_w}$
$\rho_{Dry} = \frac{\rho}{1+w}$ Or $\gamma_{Dry} = \frac{\gamma}{1+w}$	$\gamma_{(effective/Bount/Submerged)} = \frac{\gamma_w(Gs-1)}{1+e} = \frac{\gamma_{Dry}(Gs-1)}{Gs}$	
$\rho_{Dry} = \frac{\rho_{solid}}{1+e}$ Or $\gamma_{Dry} = \frac{\gamma_{solid}}{1+e}$	$\rho_{Dry} = \frac{\rho_{sat}}{1+w_{Sat}}$ Or $\gamma_{Dry} = \frac{\gamma_{sat}}{1+w_{Sat}}$	$n = \frac{e}{1+e}$

Volume –Volume Relation

$void\ ratio\ (e) for\ Bulk\ soil = \frac{v_v}{v_s}$ **when $v_v = 0$ is ($v_s = v_t$, $e = 0$) and when $v_v = v_s$ is ($v_t = 2v_v$, $e = 1$)**

$void\ ratio\ (e) for\ Dry\ soil = \frac{v_v}{v_s} = \frac{v_a}{v_s}$ **when $v_a = 0$ is ($v_s = v_t$, $e = 0$) and when $v_a = v_s$ is ($v_t = 2v_a$, $e = 1$)**

$void\ ratio\ (e) for\ sat\ soil = \frac{v_v}{v_s} = \frac{v_w}{v_s}$ **when $v_w = 0$ is ($v_s = v_t$, $e = 0$) and when $v_w = v_s$ is ($v_t = 2v_w$, $e = 1$)**

e may be > 1 and e not may be < 0

$Porosity\ (n) for\ Bulk\ soil = \frac{v_v}{v_t}$ **when $v_a = 0$ and $v_w = 0$ is ($v_v = 0$, $v_s = v_t$, $n = 0$)**

$Porosity\ (n) for\ Dry\ soil = \frac{v_v}{v_t} = \frac{v_a}{v_t}$ **when $v_a = 0$ is ($v_v = 0$, $v_s = v_t$, $n = 0$)**

$Porosity\ (n) for\ saturated\ soil = \frac{v_v}{v_t} = \frac{v_w}{v_t}$ **when $v_w = 0$ is ($v_v = 0$, $v_s = v_t$, $n = 0$)**

$0 < n < 1$

$Dr\ Or\ Ir = \frac{e_{max} - e}{e_{max} - e_{min}}$ **is $0 < Dr < 1$**

$Dr\ Or\ Ir$ for **Dense** Or **Compact soil** $(e = e_{min}) = \frac{e_{max} - e_{min}}{e_{max} - e_{min}} = 1$ **is Dr_{max}**

$Dr\ Or\ Ir$ for **Loose soil** $(e = e_{max}) = \frac{e_{max} - e_{max}}{e_{max} - e_{min}} = 0$ **is Dr_{min}**

Compactive effort (energy E)

$$= \frac{Weight\ of\ hammer \times Height\ of\ drop\ hammer \times Number\ of\ blows\ per\ layer \times Number\ of\ layers}{Volume\ of\ mold}$$

Number of layer:	**Height of drop of hammer:**	**Weight of of hammer:**
Standard Test = 3 layers	Standard Test = 305 mm	Standard Test = 2.5 Kg =5.5 lb
Modified Test = 5 layers	Modified Test = 450 mm	Modified Test = 4.5 Kg =10 lb

Number of blows per layer =25 $Volume\ of\ mold = 0.944 \times 10^{-3}\ m^3$

$$\frac{E_{Modified}}{E_{Standard}} = 4.4$$

$$\rho_d = \frac{\rho_s}{1+e} = \frac{\rho_w \times S}{w_c + \frac{\rho_w}{\rho_s} \times S} = \frac{\rho_w \times S}{w_c + \frac{S}{Gs}} = \frac{\rho_w Gs}{1+e}$$

$$R.C = \frac{\rho d - field}{\rho dry\ max - laboratory}$$

$R.C \geq 95\%\ accepted$

$o.p.t \pm 2\%\ accepted$

$$R.C = 80 + 0.2 \times Dr$$

$$Cu = \frac{D_{60}}{D_{10}}$$

1<Cc<3 Cu≥ 4 **Well graded for Gravel**

1<Cc<3 Cu≥ 6 **Well graded for Sand**

$$Cc = \frac{{D_{30}}^2}{D_{10} \times D_{60}}$$

Cu=1 uniform soil (one grain soil)

$$SL = wi(\%) - \Delta w(\%) = \left(\frac{M_1 - M_2}{M_2}\right) \times 100 - \left(\frac{V_1 - V_2}{M_2}\right) \times \rho_w \times 100$$

SATURATED SOIL	Dry SOIL
V_1	V_2
M_1	M_2

$$LL = w_N \left(\frac{N}{25}\right)^{\tan \beta = 0.121}$$

$$PI = LL - PL$$

$$LI = \frac{w - PL}{PI}$$

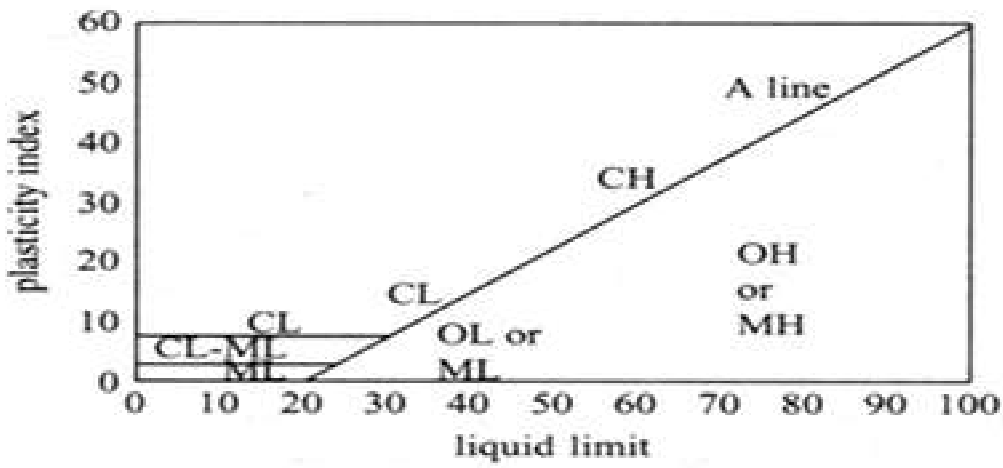
LI < 0 : brittle fracture if sheared

0 < LI < 1: Plastic soild fracture if sheared

LI < 0 : viscous liquid if sheared

$$A = \frac{PI}{\%clay\ fraction\ (Wt) < 0.002mm}$$

$$St = \frac{strength(undistubed)}{strength(distubed)}$$



$LL_{Oven\ dry} < 0.75\ LL_{Air\ dry}$ **Organic**

$LL_{Oven\ dry} \geq 0.75\ LL_{Air\ dry}$ **Not Organic**

$A\ Line\ PI = 0.73(LL - 20)\ > PI\ \ Silt$

$A\ Line\ PI = 0.73(LL - 20)\ < PI\ \ Clay$

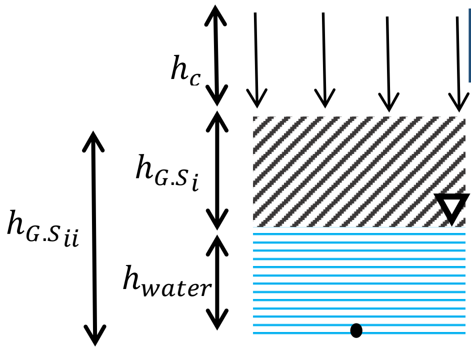
$U\ Line\ PI = 0.9(LL - 20)$

Passing #200 <50%

Coarse grain soil

COARSE More than 50% retained sieve #200	Gravel: more than 50% coarse fraction retained on sieve #4	Less than 5% fines	$C_u > 4,\ 1 \leq C_c \leq 3$	→ GW
			Not satisfying GW	→ GP
		More than 12% fines	Below 'A' line	→ GM
			Above 'A' line	→ GC
	Sand: less than 50% coarse fraction retained on sieve #4	Less than 5% fines	$C_u > 6,\ 1 \leq C_c \leq 3$	→ SW
			Not satisfying SW	→ SP
		More than 12% fines	Below 'A' line	→ SM
			Above 'A' line	→ SC

Assume the soil above the surface of the water **Dry Or Bulk Soil** and below **Saturated Soil.**



$$Stress = \frac{Weight}{Area} = \gamma \times h \quad \textbf{Unit} \ \frac{KN}{m^2}$$

$$u = \gamma_{water} \times h_{water}. \quad (\gamma_{water} = 9.81\ KN/m^2)$$

$$\sigma_{effective} = \Sigma(\gamma_{effective} \times h_{G.S})$$

$for - Saturated\ Soil\ \gamma_{effe} = (\gamma_{Sat} - \gamma_w).$

$-Bulk\ Or\ Dry\ Soil\ \gamma_{effe} = \gamma_{Bulk}\ Or\ \gamma_{Dry}.$

$$\sigma_{total} = \Sigma(\gamma_{total} \times h_{G.S})$$

$for - Saturated\ Soil\ \gamma_{total} = \gamma_{Sat}.$

$-Bulk\ Or\ Dry\ Soil\ \gamma_{total} = \gamma_{Bulk}\ Or\ \gamma_{Dry}.$

$$\sigma_{effective} = q + \Sigma(\gamma_{effective} \times h_{G.S})$$

$$\sigma_{total} = q + \Sigma(\gamma_{total} \times h_{G.S})$$

$$u = \gamma_{water} \times h_{water}$$

q only added to $\sigma_{effective}$ and σ_{total}

$-q = 0$ **(Immediately).**

$.-q =$ ***be considered*** **(Many years after the fill)**

$$\Delta\sigma_z = \frac{3P}{2\pi}\frac{z^3}{L^5} = \frac{3P}{2\pi}\frac{Z^3}{(r^2+z^2)^{5/2}} = \frac{P}{z^2} I_1 \ \textit{for point load.}$$

$$I_1 = \frac{3}{2\pi}\frac{1}{\left(\left[\frac{r}{z}\right]^2 + 1\right)^{5/2}} \ \textit{for point load.}$$

$$\Delta\sigma_z = \frac{2qz^3}{\pi(x^2+z^2)^2} = \frac{2q}{\pi z[(x/z)^2+1]^2}$$ **for Vertiacl stress by vertical line**

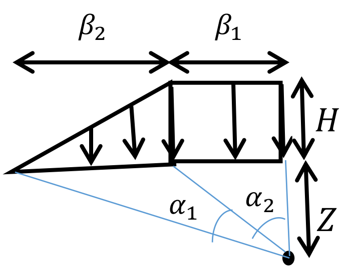
$$\Delta\sigma_z = \Delta\sigma z = \frac{2q}{\pi}\frac{xz^2}{[x^2+z^2]^2}$$ **for Vertiacl stress by horizontail line**

$$\Delta\sigma z = q\left[1 - \frac{1}{\left[\left(\frac{R}{z}\right)^2 + 1\right]^{\frac{3}{2}}}\right]$$ **for Vertical Stress below the Center of a Uniformly Loaded Circular Area**

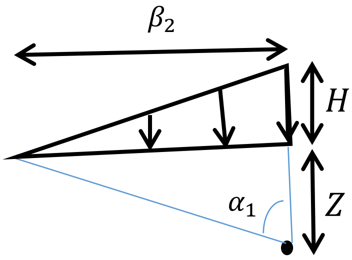
$$\Delta\sigma z = \frac{q}{\pi}\left[\left(\frac{\beta_1+\beta_2}{\beta_2}\right)(\alpha_1+\alpha_2) - \frac{\beta_1}{\beta_2}(\alpha_2)\right]$$

$$\alpha_1 = \left(tan^{-1}\left(\frac{\beta_1+\beta_2}{z}\right) - tan^{-1}\left(\frac{\beta_1}{z}\right)\right) \times \frac{\pi}{180}$$

$$\alpha_2 = tan^{-1}\left(\frac{\beta_1}{z}\right) \times \frac{\pi}{180}$$



$$\Delta\sigma z = \frac{q\alpha_1}{\pi} \qquad \alpha_1 = tan^{-1}\left(\frac{\beta_2}{z}\right) \times \frac{\pi}{180}$$



$q = \gamma H$

$\gamma = unit\ weight\ of\ the\ embankment$

$H = height\ of\ the\ embankment$

$$m = \frac{L\ or\ B}{z} \qquad n = \frac{L\ or\ B}{z}$$

$\Delta\sigma z = qI_3$ ***for*** **Vertical Stress Caused Loaded Areaby a Rectangular**

$\Delta\sigma z = q$ ***Surcharge load***

$$\Delta\sigma z = \frac{q \times B}{(B+Z)}$$ ***Strip load***

$$\Delta\sigma z = \frac{q \times B^2}{(B+Z)\times(B+Z)}$$ ***Square load***

$$\Delta\sigma z = \frac{q \times D^2}{(D+z)\times(D+z)}$$ ***Circle load***

$$\Delta\sigma z = \frac{q(B \times L)}{(B+z)\times(L+z)}$$ ***Rectangular load***

$$k_x\frac{\partial^2 h}{\partial x^2}+k_z\frac{\partial^2 h}{\partial z^2}=0 \text{ (Laplace equation of continuity)}$$

$k_x = k_z$ (isotropic soil)

$$vx = k_x i_x = k_x\frac{\partial h}{\partial x}$$

$$vz = k_z i_z = k_z\frac{\partial h}{\partial z}$$

$$i=\frac{\Delta h}{L}$$

$$i_{cr}=\frac{\gamma^{/}}{\gamma_w}=\frac{\gamma-\gamma_w}{\gamma_w}=\frac{Gs-1}{1+e} \text{ at } \sigma_{eff}=0$$

$v = ki$ at normal condtion Or Darcy velocity

$v_{cr} = ki_{cr}$ at Critical condtion

$v = ki$ (Discharge velocity Or Darcy velocity)

$$v_s=\frac{v}{n}=\frac{ki}{n} \text{ (Seepage velocity)}$$

k = hydraulic conductivity of soil (cm/sec)

$q = vA$ at normal condtion

$q_{cr} = v_{cr}A$ at Critical condtion

$q = vA$ by Area total

$q = v_s A_{voide}$ by Area Voide

$k = 10^{-2}{D_{10}}^2$ For Clean Uniform sands (Hazan)

$$q = k\Delta H\frac{Nf}{Nd}$$ (Seepage discharge or Flow rate In isotropic soil $\frac{m^3}{sec}/m$)

$$\Delta h=\frac{\Delta H = H_1-H_2}{Nd} \text{ (Head loss or Drop head m)}$$

$h_i = \Delta H - Nd_i\Delta h - z$ (Pressure head m)

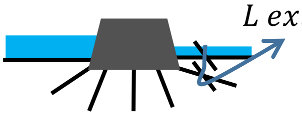
$u_i = \gamma_w h_i = \gamma_w[\Delta H - Nd_i\Delta h - z]$ (Pour pressure m)

$$p_w=\frac{(u_i+u_{ii})}{2}\times L_{Dam}$$ (pressure of water or uplifit force KN/m)

$$F.s=\frac{\text{The weight of the dam}}{\text{pressure of water}}$$ (Factor of safety against Uplift force) $Wt.Dam = \gamma_{concrete}\times A_{concrete}$

$$F.s=\frac{i_{cr}}{i_{exit}} \text{ (Factor of safety against piping force)}$$

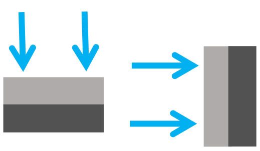
$$i_{exit}=\frac{\Delta h}{Lexit\ Or\ min}$$



$$q=\bar{k}\Delta H\frac{Nf}{Nd}=\sqrt{k_x\times k_z}\Delta H\frac{Nf}{Nd} \text{ (Anisotropic soil)}$$

$$k_{H_{eq}}=\frac{H_1K_1+H_2K_2+H_3K_3}{H_1+H_2+H_3}$$

$$k_{V_{eq}}=\frac{H_1+H_2+H_3}{\left(\frac{H_1}{K_1}\right)+\left(\frac{H_2}{K_2}\right)+\left(\frac{H_3}{K_3}\right)}$$



$\Delta\sigma_z$ = At $t=0$ Δu Or u_e Symbolized u_i $\sigma_{total_{final}}=\sigma_o+\Delta\sigma_z$ $u_{final}=u_o+\Delta\sigma_z$	$\Delta u = u_e = 0$ At $t=\infty$ $\sigma_{total_{final}}=\sigma_o+\Delta\sigma_z$ $u_{final}=u_o$ $\sigma_{effe_{final}}^{`}=\sigma_o+\Delta\sigma_z-u_o$

$$U_{avg}=\sqrt{\frac{4Tv}{\pi}} \qquad 0\le Tv\le 0.197$$

$$U_{avg}=1-\frac{8}{\pi^2}e^{\frac{-\pi^2 Tv}{4}} \qquad Tv>0.197$$

$$Tv=\frac{\pi}{4}{U_{avg}}^2 \qquad U\le 0.60$$

$$Tv=-0.933Log(1-U)-0.085 \qquad U>0.60$$

$$O.C.R=\frac{\sigma_P^{`}}{\sigma_o^{`}}$$

h: The distance from the surface of the soil in the middle of the clay layer.

Ho :Thick layer clay

-Normally Consolidation Clay (O.C.R) = 1 $\sigma_P^{`}=\sigma_o^{`}$

-Under Consolidation Clay (O.C.R) < 1 $\sigma_P^{`}<\sigma_o^{`}$

-Over Consolidation Clay (O.C.R) > 1 $\sigma_P^{`}>\sigma_o^{`}$

$$\Delta\sigma z=\frac{1}{6}(\Delta\sigma z_{top}+4\Delta\sigma z_{mid}+\Delta\sigma z_{bottom})$$

$\sigma_o^{`}=\gamma^{`}h \qquad \sigma_f^{`}=\sigma_o^{`}+\Delta\sigma z$

1. $S_f=H_O\dfrac{\Delta e}{(1+e_0)}$

$S_f=m_v H_O\Delta\sigma z$

2. $S_f=\dfrac{c_c}{(1+e_0)}H_O Log\left(\dfrac{\sigma_f^{`}}{\sigma_o^{`}}\right)$

$\sigma_P^{`}<\sigma_o^{`}<\sigma_f^{`} \quad O.C.R\le 1$

3. $S_f=\dfrac{c_r}{(1+e_0)}H_O Log\left(\dfrac{\sigma_f^{`}}{\sigma_o^{`}}\right)$

$\sigma_o^{`}<\sigma_f^{`}<\sigma_P^{`} \quad O.C.R>1$

4. $S_f=\dfrac{c_r}{(1+e_0)}H_O Log\left(\dfrac{\sigma_P^{`}}{\sigma_o^{`}}\right)+\dfrac{c_c}{(1+e_0)}H_O Log\left(\dfrac{\sigma_f^{`}}{\sigma_P^{`}}\right)$

$\sigma_o^{`}<\sigma_P^{`}<\sigma_f^{`} \quad O.C.R>1$

$S_f=\dfrac{c_r}{(1+e_0)}H_O Log\left(\dfrac{\sigma_f^{`}}{\sigma_o^{`}}\right)=-ve \quad \sigma_o^{`}>\sigma_f^{`}$

$$U_{avg}=\frac{S_c}{S_f}$$

$$U_z=1-\frac{u_e}{\Delta\sigma_z=u_i}$$

$t=0 \qquad U_z=0$

$t=\infty \qquad U_z=1$

$$\frac{\partial u_e}{\partial t}=cv\frac{\partial^2 ue}{\partial z^2}$$

$$Tv=\frac{cv\ t}{dr^2}$$

$$K=c_v m_v\gamma_w$$

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

$$\sigma f' = \frac{\sigma 1' + \sigma 3'}{2} + \frac{\sigma 1' - \sigma 3'}{2}\cos 2\theta$$

$$\sigma T f = \frac{\sigma 1 + \sigma 3}{2} + \frac{\sigma 1 - \sigma 3}{2}\cos 2\theta$$

$$\sin\phi' = \frac{\frac{\sigma 1' - \sigma 3'}{2}}{c'\cot\phi' + \frac{1}{2}(\sigma 1' + \sigma 3')}$$

ϕ = Angle of friction
θ = Angle of failure

$$\tau f' = \frac{\sigma 1' - \sigma 3'}{2}\sin 2\theta$$

$$\theta = 45° + \frac{\phi'}{2}$$

$$\tau f = \frac{\sigma 1 - \sigma 3}{2}\sin 2\theta$$

$$\theta = 45° + \frac{\phi}{2}$$

$$\sigma 1' = \sigma 3' \tan^2\left(45° + \frac{\phi'}{2}\right) + 2c'\tan\left(45° + \frac{\phi'}{2}\right)$$

$$\sigma f' = \frac{\sigma 1' + \sigma 3'}{2} - \frac{\sigma 1' - \sigma 3'}{2}\sin\phi'$$

$$\sin\phi T = \frac{\sigma 1 - \sigma 3}{\sigma 1 + \sigma 3} \quad if \quad c = 0$$

UU Test:

$\phi T = \phi u = 0$

$su = cu = \frac{\sigma 1 - \sigma 3}{2}$

V = Constant
U = Unknown

su = Undrained Shear Strength

Mohr – Coulomb Circle:

$Center = \frac{\sigma 1 + \sigma 3}{2}$

$r = \frac{\sigma 1 - \sigma 3}{2}$

$\theta 3 = 45 + \frac{\phi}{2}$

$\theta 1 = 45 - \frac{\phi}{2}$

CD Test:

$$\sigma f' = \frac{\sigma 1' + \sigma 3'}{2} - \frac{\sigma 1' - \sigma 3'}{2}\sin\phi'$$

$$\phi' = \sin^{-1}\left(\frac{\sigma 1' - \sigma 3'}{\sigma 1' + \sigma 3'}\right)$$

$U = 0$
$\sigma T = \sigma'$

CU Test:

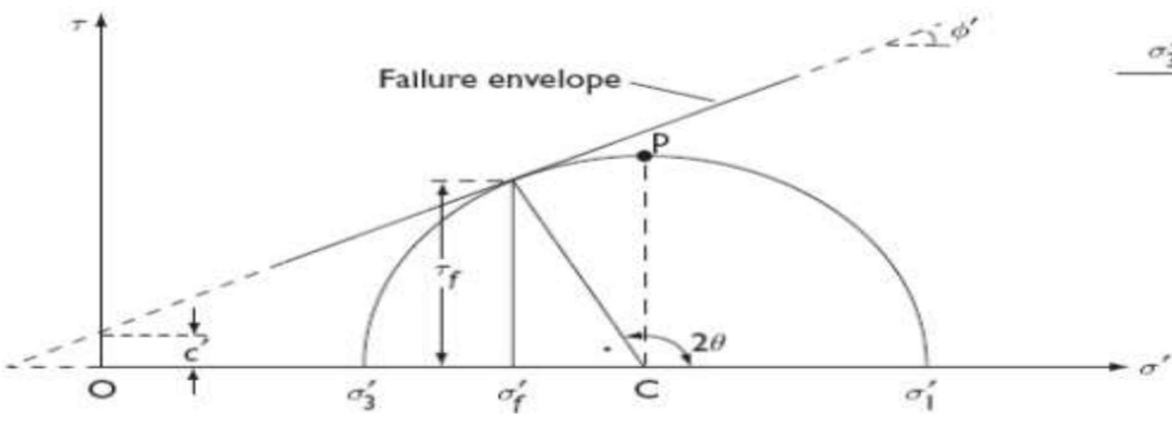
$\sigma 1 = \sigma 3 + \Delta\sigma d$
$\sigma 3' = \sigma 3 - Uf$
$\sigma 1' = \sigma 1 - Uf$

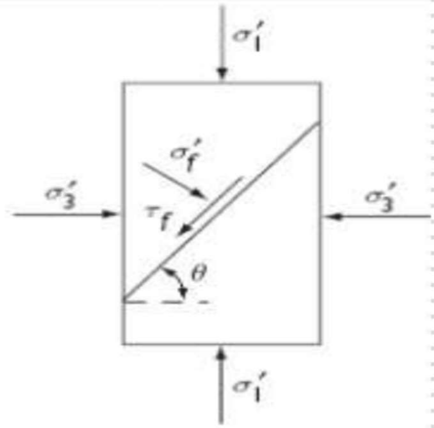
$\phi' > \phi$
$cr > c'$

Sand Normally Consolidated Clay $c = 0$

Over Consolidated Clay $c \neq 0$

$$\phi' = 2\left[\tan^{-1}\left(\frac{\sigma 1'(I) - \sigma 1'(II)}{\sigma 3'(I) - \sigma 3'(II)}\right)^{0.5} - 45°\right]$$ for two speciments





$\tau_f = C + \sigma_f \times tan(\emptyset)$

τ: *shear strength of soil*

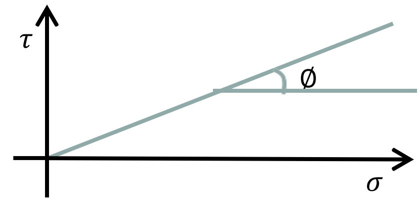
C: *cohesion intercept*

$\emptyset$: *angle of friction*

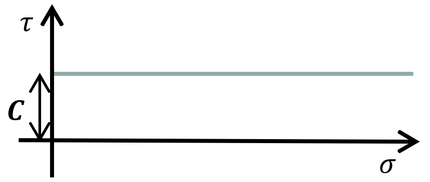
σ: *total normal stress on the failure plane*

MR

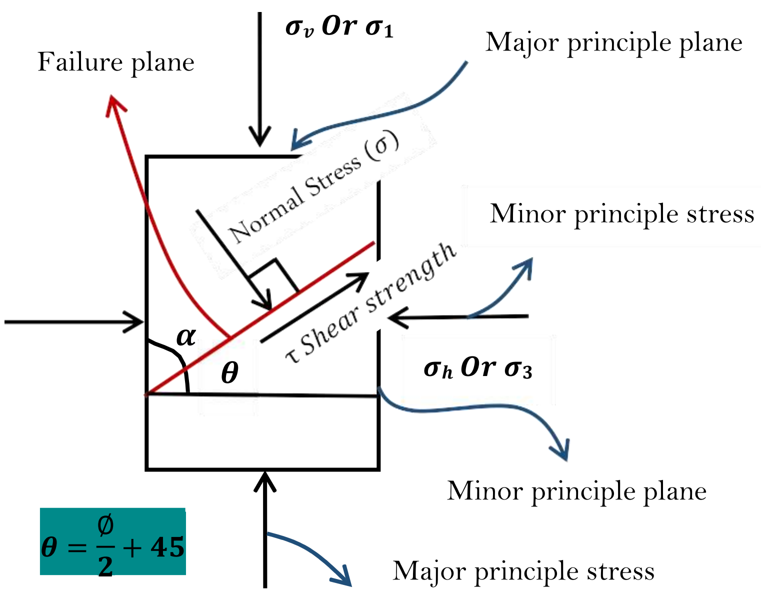
- **Sandy Soil Or Normal Consolidated Clay** — $C: 0 \quad \tau_f = {}_f \times tan(\emptyset)$



- **Clayey Soil** — $\emptyset: 0 \quad \tau = C$



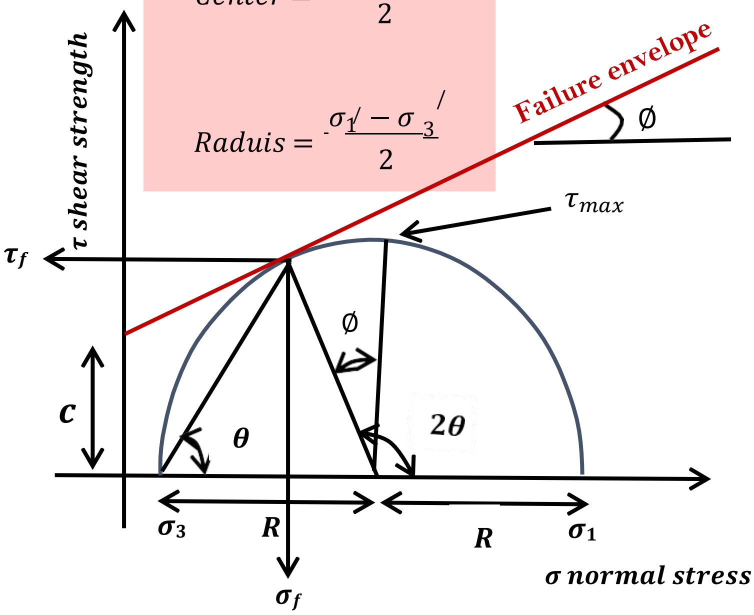
C and ∅ shear parameter



$$\theta = \frac{\emptyset}{2} + 45$$

$$Center = \frac{\sigma_1' + \sigma_3'}{2}$$

$$Raduis = \frac{\sigma_1' - \sigma_3'}{2}$$



$$\tau_f = \frac{1}{2}(\sigma_1 - \sigma_3)\sin(2\theta) \qquad \sigma_f = \frac{1}{2}(\sigma_1 + \sigma_3) + \frac{1}{2}(\sigma_1 - \sigma_3)\cos(2\theta)$$

$$\sin(\emptyset) = \frac{\frac{1}{2}(\sigma_1 - \sigma_3)}{C\cot(\emptyset) + \frac{1}{2}(\sigma_1 + \sigma_3)} \qquad \sigma_1 = \sigma_3 \tan^2(45 + \frac{\emptyset}{2}) + 2C\tan(45 + \frac{\emptyset}{2})$$

Direct shear test (Shear box test).

Function of **effective st** $\tau = \sigma' \times tan(\emptyset') + C'$

$$Slope = Es = \frac{\Delta t}{\Delta D} = modulus\ of\ elasticity$$

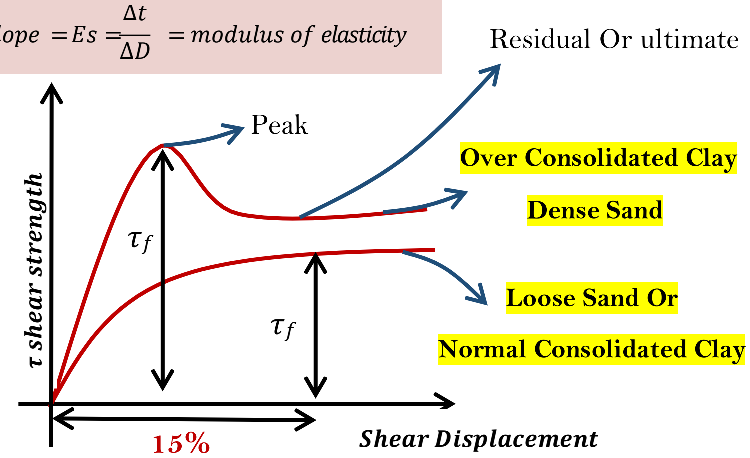
$$Normal\ force(\sigma) = \frac{Normal\ force}{Cross-sectional\ area\ of\ the\ specimen}$$

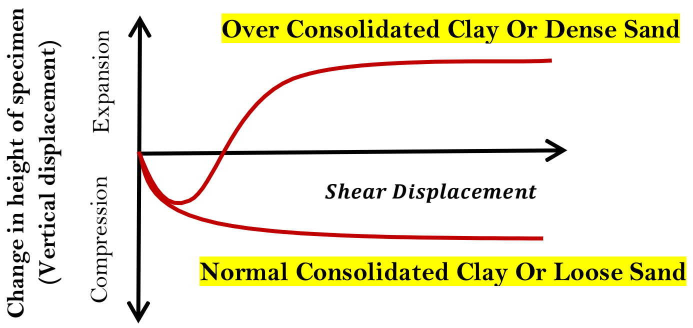
$$\text{Shear force}(\tau) = \frac{Resisting\ Shear\ force}{Cross-sectional\ area\ of\ the\ specimen}$$

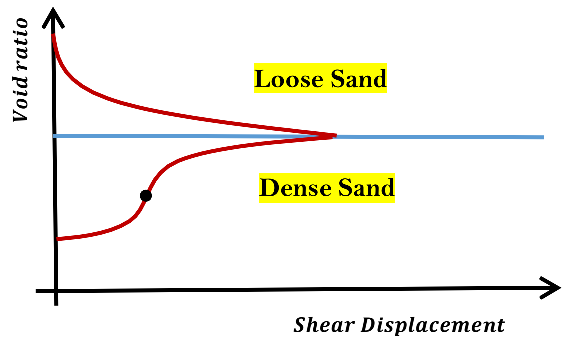
$C = C'$ ***and*** $\emptyset = \emptyset'$ ***and*** $\sigma = \sigma' - U = \sigma' - 0 = \sigma'$

Over Consolidated Clay Residual C′ = O

Over Consolidated Clay peak C′ ≠ O && ∅ ≠ 0







Triaxle Test

1. (CD) Or (S) Test.

Function of **effective stress** $\tau = \sigma' \times tan(\emptyset') + C'$

$$Axial\ Strain\ (\varepsilon_a) = \frac{\Delta h}{h}$$

$$Volume\ Strain\ (\varepsilon_V) = \frac{\Delta V}{V}$$

Find C/ && Ø/

2. (CU) Or (R) Test.

Function of **effective stress** $\tau = \sigma' \times tan(\emptyset') + C'$

Function of **total stress** $\tau = \sigma \times tan(\emptyset) + C$

Find C/ && Ø/ && C && Ø

2. (UU) Or (Q) Test

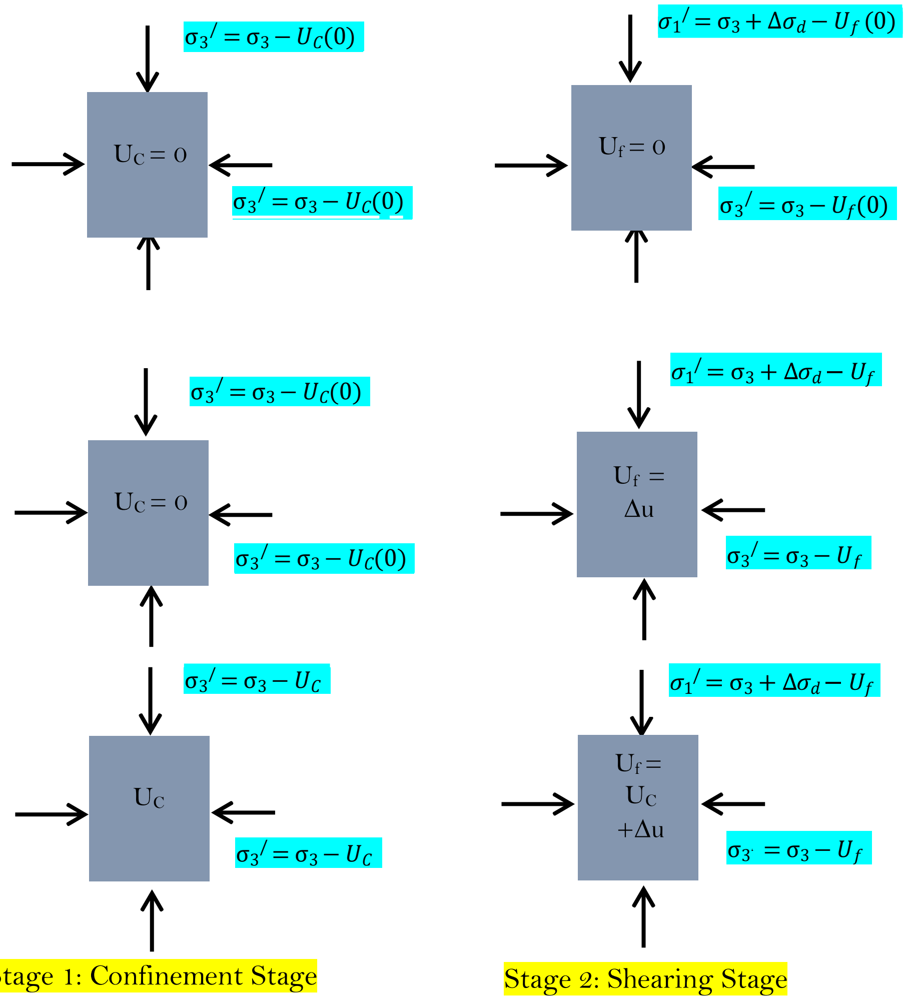
Function of **total stress** $\tau = \sigma \times tan(\emptyset) + C$

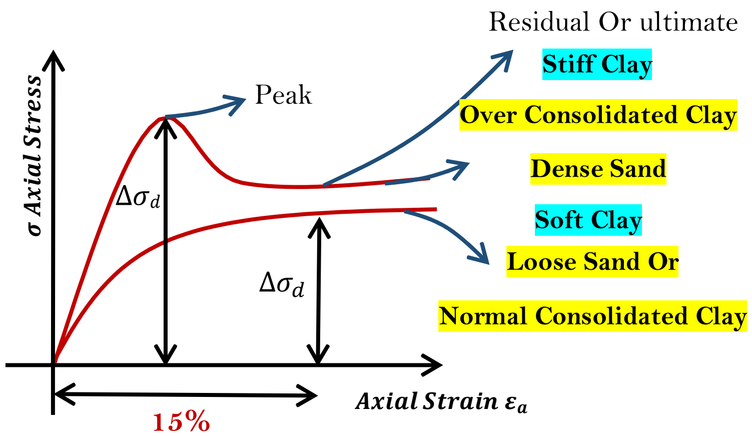
$S = 100\%\ \emptyset = 0\ ,\ C = C_{max}$

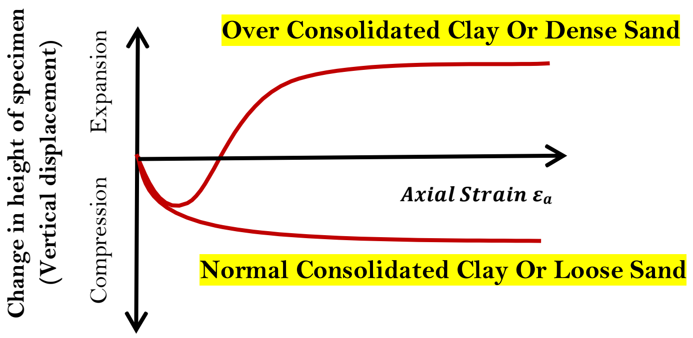
$S < 100\%\ \emptyset > 0\ ,\ C < C_{max}$

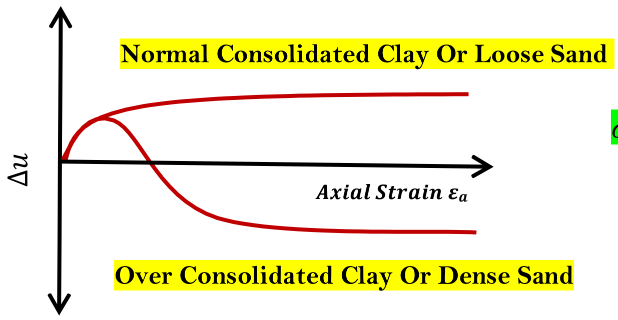
$$A_f = \frac{A_0}{(1 - \varepsilon_a)}$$

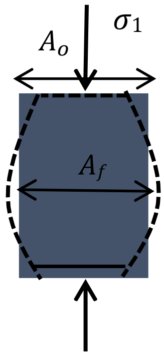
Find C && Ø











$\sigma_3 = 0$

$$\emptyset = 2\left(tan^{-1}\left(\frac{\sigma_1'{}_{(I)} - \sigma_1'{}_{(II)}}{\sigma_3'{}_{(I)} - \sigma_3'{}_{(II)}}\right)^{0.5} - 45\right)$$

Su for NC

$$\frac{S_U}{P_O'} = 0.45(PI)^{\frac{1}{2}} \quad \textit{PI in demical and} > 0.5$$

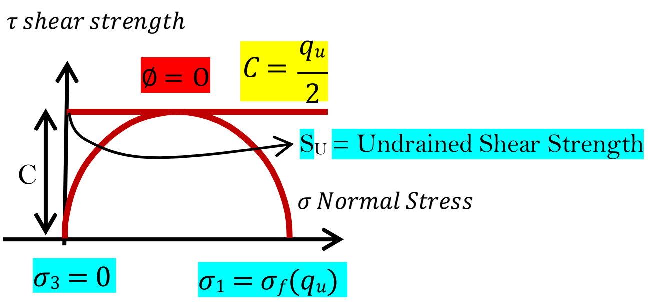
$$\frac{S_U}{P_O'} = 0.11 + 0.0037PI \quad \textit{PI in percent}$$

Su = Undrained Shear Strength

Po' = In Situ overburden stress

PI = plasticity index

Note for A Consolidated – Undrained triaxle test



$$q_u = \sigma_f = \frac{P_f}{A_f}$$

$$A_f = \frac{A_0}{(1 - \varepsilon_a)}$$

$$(\varepsilon_a) = \frac{\Delta h}{h}$$

$$(O.C.R)^{0.8} = \frac{\left(\frac{C_u}{P_O'}\right)_{Over\ consolidated\ Clay}}{\left(\frac{C_u}{P_O'}\right)_{Normally\ consolidated\ Clay}}$$

$$\frac{C_u}{P_O'} = (0.23 \pm 0.04)(O.C.R)^{0.5}$$