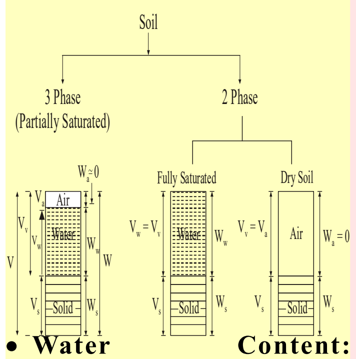
Soil	Deposited by
Alluvial Soil	River
Marine Soil	Sea water
Lacustrine Soil	Still water like as lakes
Aeolian Soil	Wind
Glacial Soil	Ice

Note: Loess is an aeolian soil.



- **Water Content:** $W = \frac{W_W}{W_S} \times 100$
- **Void Ratio:** $e = \frac{V_V}{V_S}$
- **Porosity:** $n = \frac{V_V}{V} \times 100$
- **Degree of Saturation:** $S = \frac{V_W}{V_v} \times 100$
- **Air Content:** $a_c = \frac{V_a}{V_v} = 1 - S$

% Air Voids $\eta = \frac{V_a}{V}$, $\eta = n\, a_c$

- **Bulk Unit Weight:** $\gamma = \frac{W}{V} = \frac{W_S + W_W}{V_a + V_W + V_S}$
- **Dry Unit Weight:** $\Upsilon_d = \frac{W_S}{V}$
- **Saturated Unit Weight:** $\Upsilon_{sat} = \frac{W_{sat}}{V}$
- **Specific Gravity:** $G = \frac{W_S}{V_S \cdot \gamma_W} = \frac{\gamma_S}{\gamma_W}$
- **Appearent or Mass Specific Gravity:** $G_m = \frac{W}{V\Upsilon_W} = \frac{\Upsilon}{\Upsilon_W}$
- $W_S = \frac{W}{1+w}$
- $n = \frac{e}{1+e}$ or $e = \frac{n}{1-n}$
- $Se = WG$
- $\Upsilon = \frac{G\gamma_W(1+W)}{(1+e)}$
- $\Upsilon_{sat} = \left[\frac{G+e}{1+e}\right].\Upsilon_w$
- $\Upsilon_d = \frac{G\Upsilon_w}{1+e}$
- $\Upsilon' = \left[\frac{G-1}{1+e}\right]\Upsilon_w$
- $\Upsilon_d = \frac{\Upsilon}{1+w}$

Method for Determination of water content

- **Oven drying Method:** $W = \frac{W_2 - W_1}{W_3 - W_1} \times 100$
- **Pycnometer Method:** $W = \left[\frac{(W_2 - W_1)}{(W_3 - W_4)}\left(\frac{G-1}{G}\right) - 1\right] \times 100$

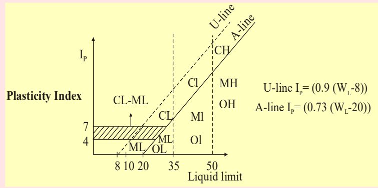
Determination of Unit Weight:

1. Core Cutter method
   - Field method suitable for, fine grained and clayey soil.
   - Not suitable for stoney, gravelly soil and dry soil.
2. Water displacement method
   - Suitable for ohesive soils only
3. Sand replacement method
   - Field method & used for gravelly, sandy and dry soil
4. Water ballon method
   - Volume of the pit is measured by covering the pit with plastic sheet and then filling it with water.
   - Wt. of water thus calculated is equal to volume of soil excavated.

- **Plasticity Index [I_p]:** $I_P = W_L - W_P$
- $I_C = \frac{W_L - W_N}{I_P}$, $I_L = \frac{W_N - W_P}{I_P}$ $(I_C + I_L = 1)$
- **Flow Index:** $I_f = \frac{W_1 - W_2}{\log_{10}\left(\frac{N_2}{N_1}\right)}$, $I_t = \frac{I_P}{I_f}$
- **Sensitivity:** $S_t = \frac{(q_u)\text{ undisturbed}}{(q_u)\text{ Remoulded}}$
- **Relative Density/Density Index:** $I_D = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$
- **Activity of Clay:** $A_C = \frac{\text{Plasticity Index}}{\text{\% by weight fine than } 2\mu}$

$C_u = \frac{D_{60}}{D_{10}}$, ($C_u > 4$ Gravel, $C_u > 6$ Sand)

$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$, $1 \le C_C \le 3$ for well Graded soil



Hydrometer correction: $C_T = C_M - C_d \pm C_t$

Quick sand condition: In case of upward seepage flow, if the upward seepage force becomes equal to the buoyant weight of soil, the effective stress in soil becomes zero.

Critical hydraulic gradient: $i_{cr} = \frac{\gamma_{sub}}{\gamma_w} = \frac{G-1}{1+e} = (G-1)(1-n)$,

FOS $= \frac{i_{cr}}{i_e}$

Darcy's Law: $q = kiA$

Measrement of Permeability:

- **Constant Head Permeameter Test:** $K = \frac{q}{iA} = \frac{qL}{Aht}$
- **Falling Head Permeameter Test:** $K = \frac{2.3aL}{At}\log_{10}\left(\frac{h_1}{h_2}\right)$
- **Confined Flow Pumping Test:** $K = \frac{2.3q}{2\pi D}\frac{\log_{10}\left(\frac{r_2}{r_1}\right)}{h_2 - h_1}$
- **Unconfined Flow Pumping Test:** $K = \frac{2.3q}{\pi(H^2 - h^2)}\log_{10}\frac{R}{r}$
- **Kozeny-Carman Equation:** $K = \frac{1}{K_0 . S^2}.\frac{\gamma}{\mu}.\frac{e^3}{1+e}$
- **Allen Hazen's Equation:** $K = C.D_{10}^2$
- **Coefficient of Consolidation Equation:** $K = C_v.M_v.\gamma_w$

$V_s = \frac{V}{n}$,

$R = 3000d\sqrt{K}$, $S_y + S_R = n$

Permeability of Stratified Soils

- **Horizontal Flow:** $K_H = \frac{K_1H_1 + K_2H_2 + ...}{H_1 + H_2 + ...}$
- **Vertical Flow:** $K_v = \frac{H_1 + H_2 + ...}{\frac{H_1}{K_1} + \frac{H_2}{K_2} + ...} = \frac{\Sigma H}{\Sigma H/K}$

Note: $K_H > K_v$ always.

- **Boussinesq's Equations:** $\sigma_Z = \frac{3q}{2\pi z^2}\left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]^{5/2}$
- **Seepage Calculation:** $q = k.H\frac{N_F}{N_d}$
- **Westergaard's Solution:** $\sigma_z = \frac{1}{\pi}\frac{q}{z^2} \times \frac{1}{\left[1+2\left(\frac{r}{z}\right)^2\right]^{3/2}} = k_w.\frac{q}{Z^2}$

$C_c = \frac{e_1 - e_2}{\log\bar{\sigma}_2 - \log\bar{\sigma}_1}$,

$a_v = \frac{\Delta e}{\Delta\bar{\sigma}}$, $M_v = -\frac{\frac{\Delta V}{V}}{\Delta\bar{\sigma}}$

$M_V = -\frac{\Delta e}{(1+e_0)\Delta\bar{\sigma}} = \frac{a_v}{1+e_0}$

- **Terzaghi Equation for one-dimension consolidation:** $\frac{du}{\partial t} = C_v.\frac{\partial^2 u}{\partial_z^{\ 2}}$
- **Time Factor:** $T_v = \frac{C_v.t}{H^2}$

$T_v = \frac{\pi}{4}(u)^2$, $u \le 60\%$

$T_v = 1.781 - 0.933\log(100 - u)$; $u > 60\%$

- **Degree Of Consolidation:** $V_z = \frac{u_i - u_z}{u_i}$, $\frac{\Delta H}{H} = \frac{\Delta e}{1+e_o}$
- **Calculation of Settlement:** $\Delta H = C_C \times \frac{H_0}{1+e_0}\log\left(\frac{\bar{\sigma}_0 + \Delta\bar{\sigma}}{\bar{\sigma}_0}\right)$

$\Delta H = m_v.H_0.\Delta\bar{\sigma}$,

$C_C = 0.009(w_L - 10)$

- **Triaxial Test:** $\sigma_1 = \sigma_3\tan^2\left(45^\circ + \frac{\phi}{2}\right) + 2c\tan\left(45^\circ + \frac{\phi}{2}\right)$
- **Vane Shear test:** $S = \frac{T}{\pi d^2\left(\frac{h}{2} + \frac{d}{6}\right)}$ [when both top & bottom end shear the soil]
- **Pore Pressure Parameter (Given by Skempton):** $\Delta U = B[\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3)]$

$B = \frac{\Delta U}{\Delta\sigma_3}$ (For saturated soil, $B = 1$, for dry soil, $B = 0$)

- **Stability of slope:** $F = \frac{\tan\phi}{\tan\beta}$, $\tau = \gamma z\cos\beta\sin\beta$

Stability Number $= S_N = \frac{C_m}{\gamma H.} = \frac{c}{F_c.\gamma H}$ (Max. value $= 0.261$)

- **Active Earth Pressure For Cohesive:**

$P_a = K_a\gamma z - 2C\sqrt{K_a}$

$Z = 0$ when $P_a = -2C\sqrt{K_a}$

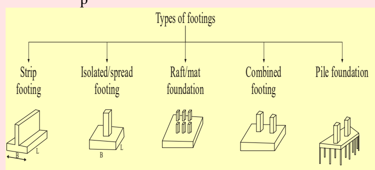
$Z_C = \frac{2C}{\gamma\sqrt{K_a}}$, $H_c = 2Z_c$

- **Earth Pressure at Rest:** $\frac{\sigma_h}{\sigma_v} = \frac{\mu}{1-\mu} = K_0$,

Coefficient of earth pressure at rest.

$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \tan^2\left(45^\circ - \frac{\phi}{2}\right)$

$= \frac{1}{K_p}$



- **Net Safe Bearing Capacity:** $q_{ns} = \frac{\text{Net ultimate bearing capacity}}{\text{Factor of safety.}}$

$q_{ns} = \frac{q_{nu}}{F} = \frac{q_u - \gamma D_f}{F}$

- **Safe Bearing Capacity:** $q_{saf} = \frac{q_u - \gamma D_f}{F} + \gamma D_f$
- **Elastic Settlement:** $S = k.q.\sqrt{A}\frac{(1-\mu^2)}{E}$
- **Bearing Capacity for Strip footing**

$q_{ult} = CN_c + \gamma D_f N_q + \frac{1}{2}\gamma bN_\gamma$

- **Bearing Capacity of Shallow Circular Footing**

$q_{ult} = 1.3CN_c + \gamma D_f N_q + 0.3\gamma bN_\gamma$

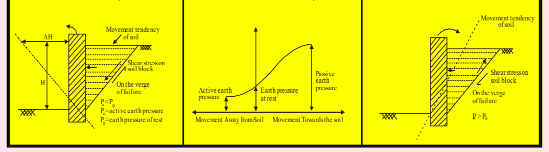
- **Bearing Capacity of Shallow Square Footing**

$q_{ult} = 1.3CN_C + \gamma D_f N_q + 0.4\gamma bN_\gamma$

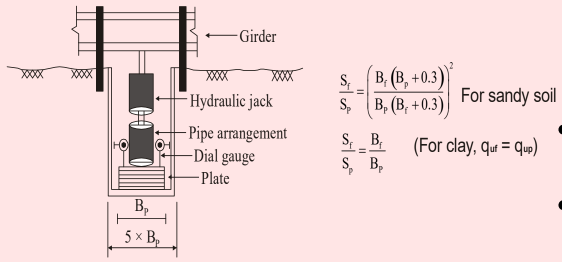
Note: Load carrying capacity in order - Strip < Circular < Square Footing

Classification of lateral earth pressure

Active earth pressure (wall moves away from backfill)	Earth pressure at rest (wall does not moves at all)	Passive earth pressure (wall moves towards the backfill)

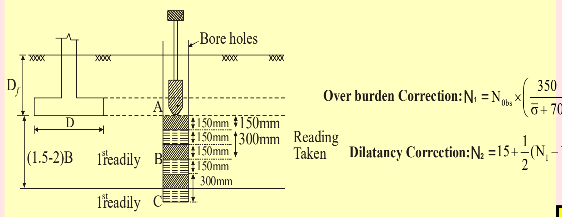


- **Plate Load test:** (IS 1888–1982)



It is used to calculate
(a) Ultimate bearing capacity
(b) Allowable bearing capacity
(c) Safe settlement of foundation
Significant only for cohesionless soil

Standard Penetration Test:



Classification of Piles based on various factors -

(a) Function/Action - Fender, sheet, batter, tension (uplift), load bearing etc.
(b) Installation method - Driven, jack, screw & Bored (cast in-situ) piles.
(c) Material - Steel, timber, concrete & composite piles.
(d) Displace-ment of soil - Displacement and non-displacement piles.
(e) Mode of load transfer - End bearing, friction and combined piles.

- **Ultimate bearing Capacity of pile Load taken by base + load by skin friction.**

$Q_u = Qp_u + Q_f$,

$Q_u = q_{pu} \times A_b + F_s A_s$.

- **Engineering News Formula: Ultimate load on pile**

$Q_{allowable} = \frac{WH}{6(S+C)}$ C = 2.5 cm for drop hammer
C = 0.25 cm for single acting steam hammer

Boring and its methods

It is the making & advancing of bore holes is called boring

Various methods of boring -

(a) **Auger boring** - It is use in partially saturated sands, silts and medium to stiff clays. But it gives highly disturbed sample. It is suitable for small depth of exploration (hand operated auger upto 6m depth) like as highway & borrow pit etc.
(b) **Wash boring** - It gives disturbed sample. It is not use in hard soils, rock and soil containing boulder.
(c) **Percussion boring** - In it, heavy drilling bit is dropped and raised. It can be used only in boulder & gravel strata.
(d) **Rotary boring** - It gives least disturbed samples.

Soil samples

- Disturbed sample are those in which natural soil structure gets modified or destroyed during the sampling operation.
- Undisturbed samples are those in which original soil structure is preserved as well as mineral properties have not undergone any change. These samples are use in size distribution, Atterberg's limits, coefficient of permeability, consolidation parameters, shear strength parameters.
- **Inside Clearance:** $C_i = \frac{D_3 - D_1}{D_1} \times 100\%$
- **Out Side Clearance:** $C_0 = \frac{D_2 - D_4}{D_4} \times 100$

Note: $C_0 > C_i$ always.

- **Area ratio:** $A_r = \frac{D_2^{\ 2} - D_1^{\ 2}}{D_1^{\ 2}} \times 100$
- **Recovery Ratio:** $L_r = \frac{\text{Recovery length of the Sample.}}{\text{Penetration length of the Sample}}$

CIVIL ENGINEERING ROCKET CHART

FOR QUICK REVISION