Soil Settlement

By

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Soil Settlement:

Total Soil Settlement = Elastic Settlement + Consolidation Settlement

$$S_{total} = S_e + S_c$$

Elastic Settlement or Immediate Settlement depends on
- Load Type (Rigid; Flexible)
- Settlement Location (Center or Corner)

Elastic Settlement
- Theory of Elasticity
- Time Depended Elastic Settlement (Schmertman & Hartman Method (1978)

Elastic settlement occurs in sandy, silty, and clayey soils.

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Consolidation Settlement (Time Dependent Settlement)

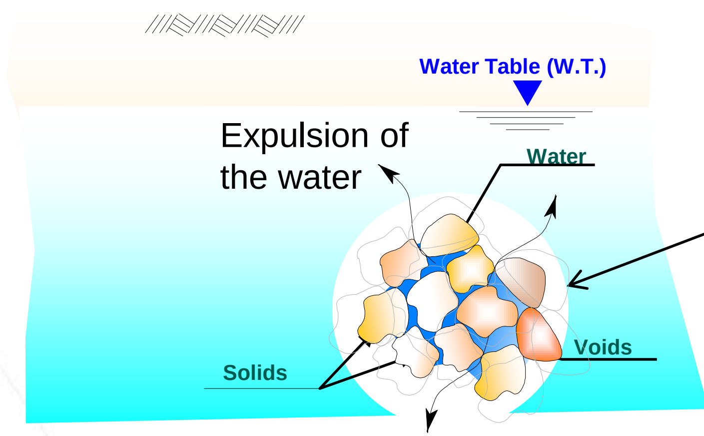
* Consolidation settlement occurs in cohesive soils due to the expulsion of the water from the voids.
* Because of the soil permeability the rate of settlement may varied from soil to another.
* Also the variation in the rate of consolidation settlement depends on the boundary conditions.

$$S_{Consolidation} = S_{primary} + S_{secondary}$$

Primary Consolidation — Volume change is due to reduction in pore water pressure

Secondary Consolidation — Volume change is due to the rearrangement of the soil particles

(No pore water pressure change, Δu = 0, occurs after the primary consolidation)



When the water in the voids starts to flow out of the soil matrix due to consolidation of the clay layer. Consequently, the excess pore water pressure (Δu) will reduce, and the void ratio (e) of the soil matrix will reduce too.

Elastic Settlement

$$S_e = \frac{Bq_o}{E_s}(1 - \mu_s^2)\frac{\alpha}{2}$$ (corner of the flexible foundation)

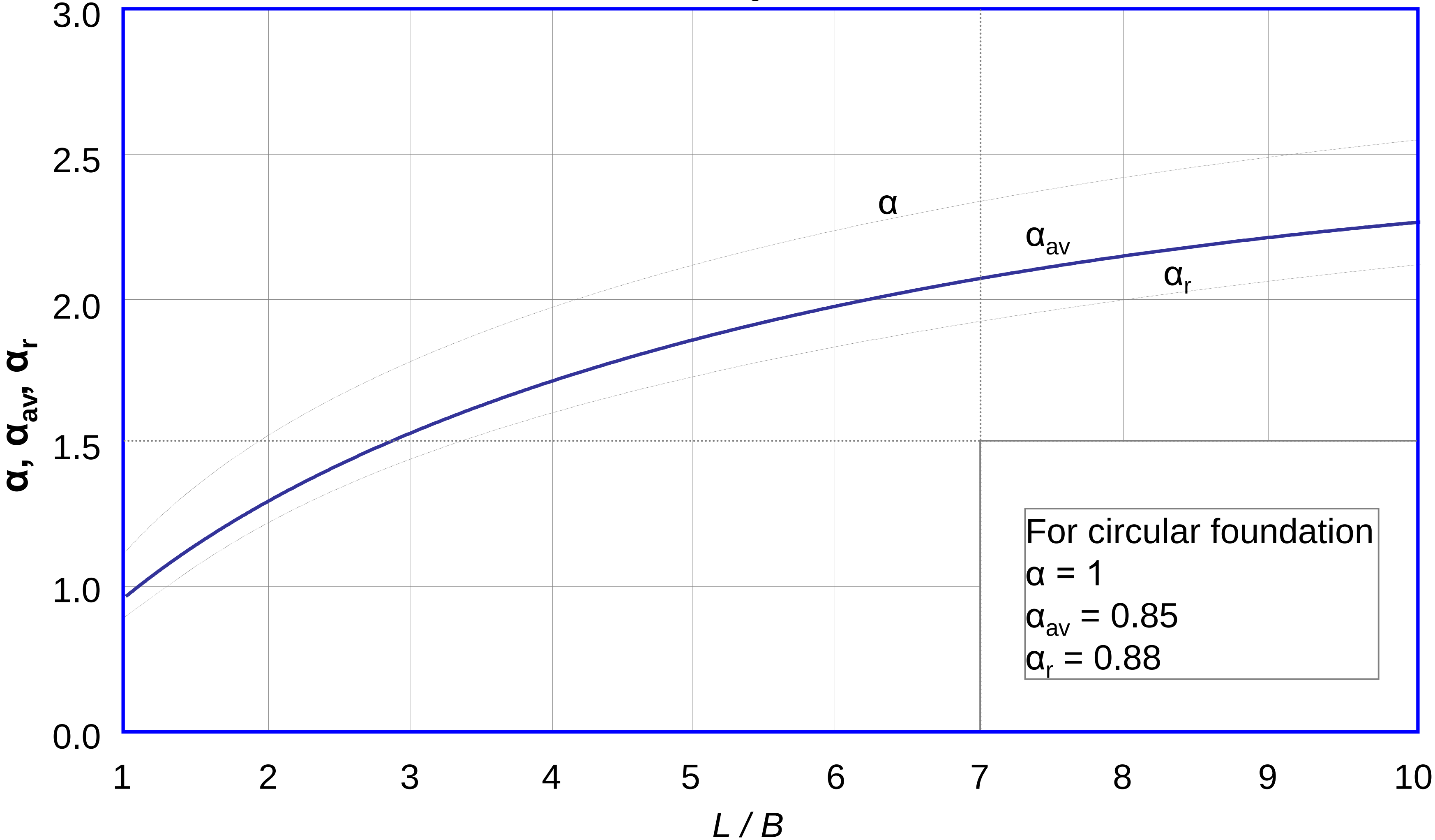
$$S_e = \frac{Bq_o}{E_s}(1 - \mu_s^2)\alpha$$ (center of the flexible foundation)

Where $\alpha = \frac{1}{\pi}$ [ln ($\sqrt{1 + m^2} + m$ / $\sqrt{1 + m^2} - m$) + m. ln ($\sqrt{1 + m^2} + 1$ / $\sqrt{1 + m^2} - 1$)

m = B/L

B = width of foundation
L = length of foundation

$$S_e = \frac{Bq_o\ (1 - \mu_s)\ \alpha}{E_s}$$



Values of α, α_{av}, and α_r

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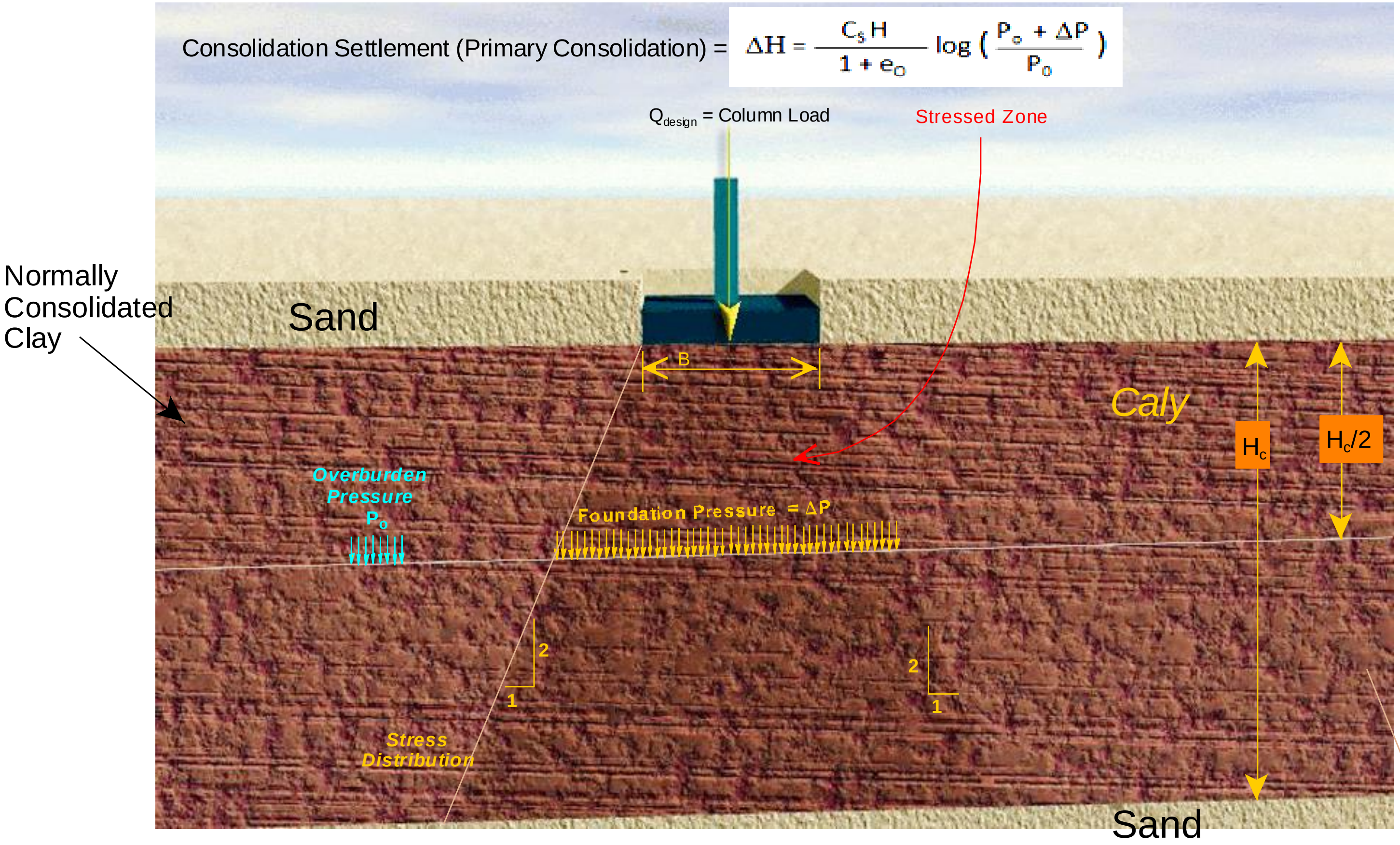
Consolidation Settlement



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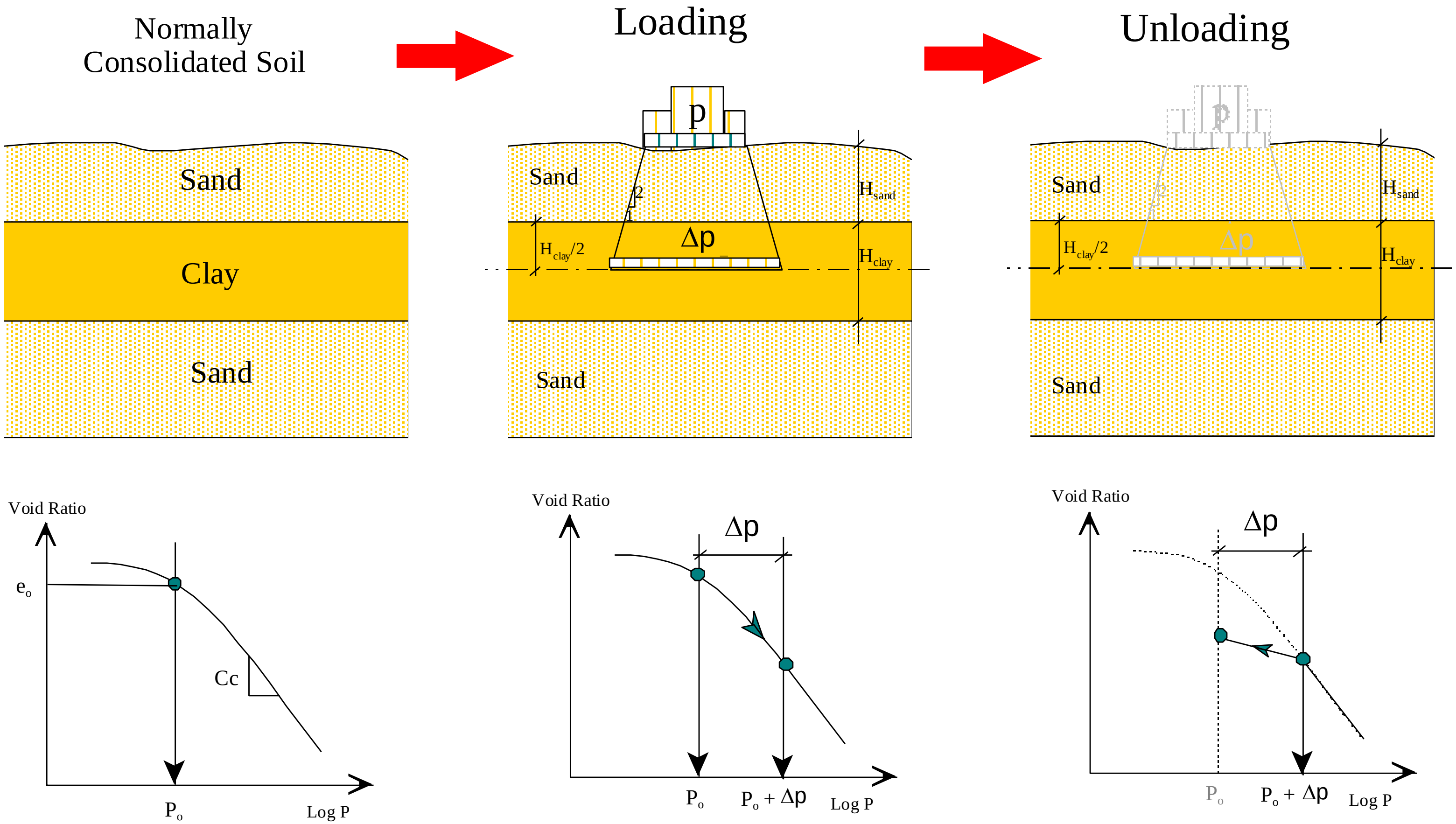
Consolidation Settlement



$$\Delta H = \frac{C_S H}{1 + e_O} \log \left(\frac{P_o + \Delta P}{P_0} \right)$$

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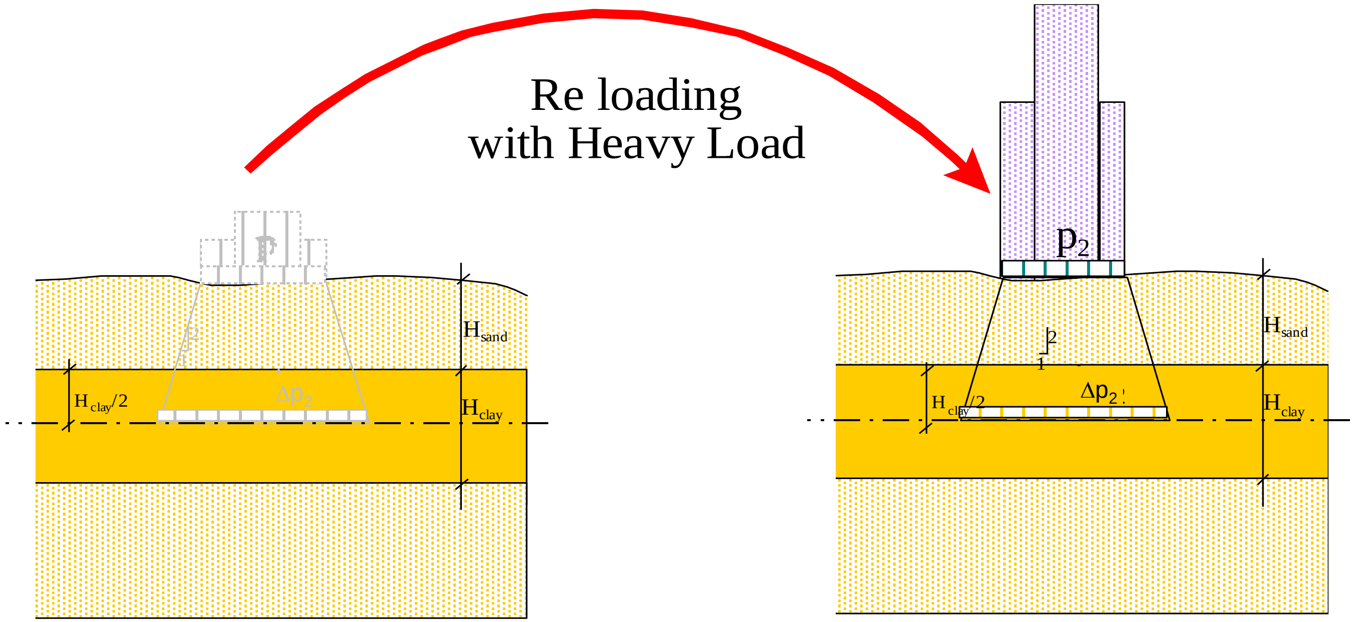
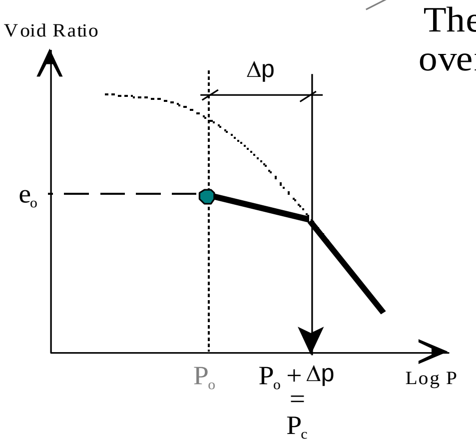
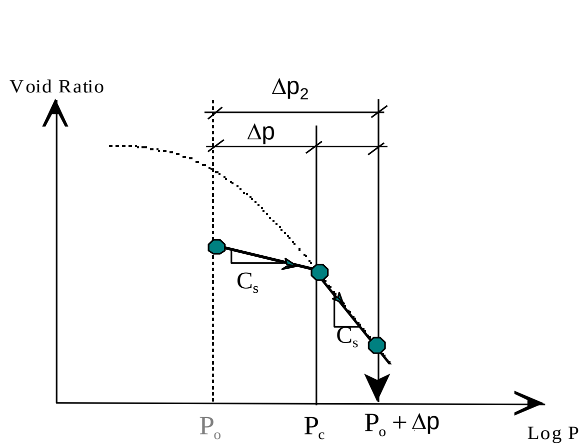




The soil become overconsolidated soil



$$\Delta H = \frac{C_S H}{1 + e_O} \log \left(\frac{P_C}{P_o} \right) + \frac{C_C H}{1 + e_O} \log \left(\frac{P_o + \Delta P}{P_C} \right)$$

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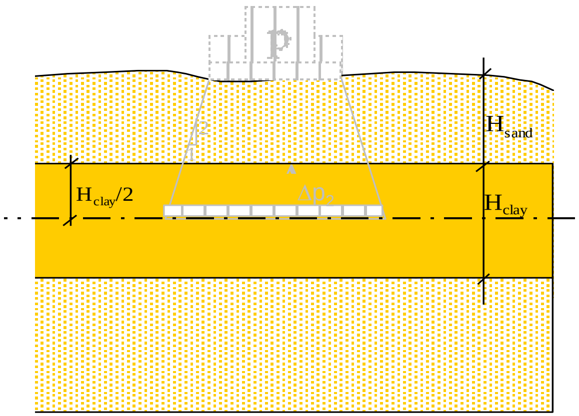
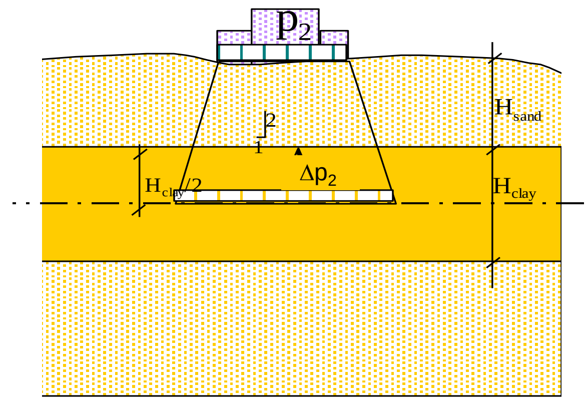
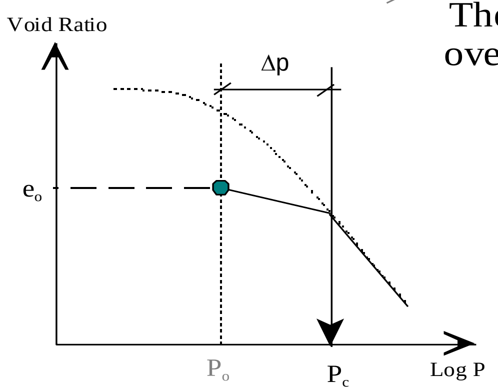
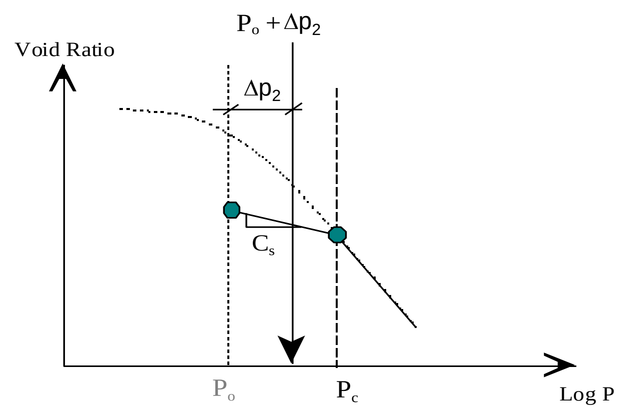
Re loading with light Load





The soil become overconsolidated soil





$$\Delta H = \frac{C_S H}{1 + e_O} \log \left(\frac{P_o + \Delta P_2}{P_o} \right)$$

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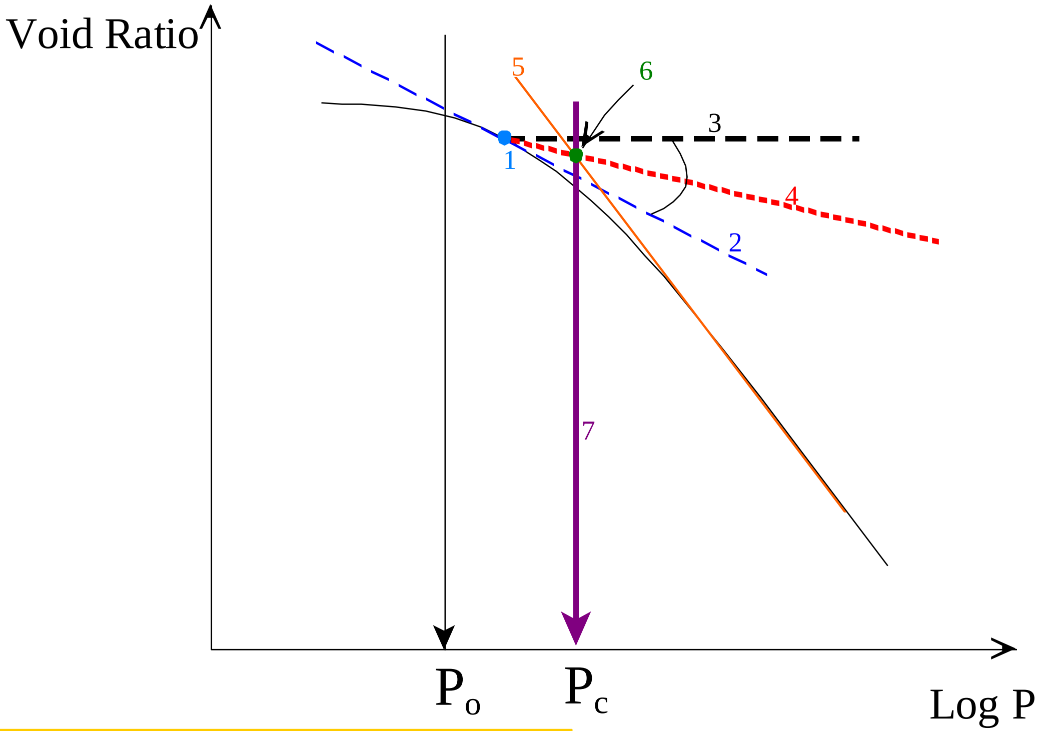
Determining The Preconsolidation Pressure (Pc)

Cassagrande Graphical Method



$OCR = P_c/P_o$

OCR = 1 → Normally Consolidated

OCR > 1 → Over Consolidated

OCR > 4 → Heavily Over Consolidated

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Rate of Consolidation

Settlement at any time = S_{time}

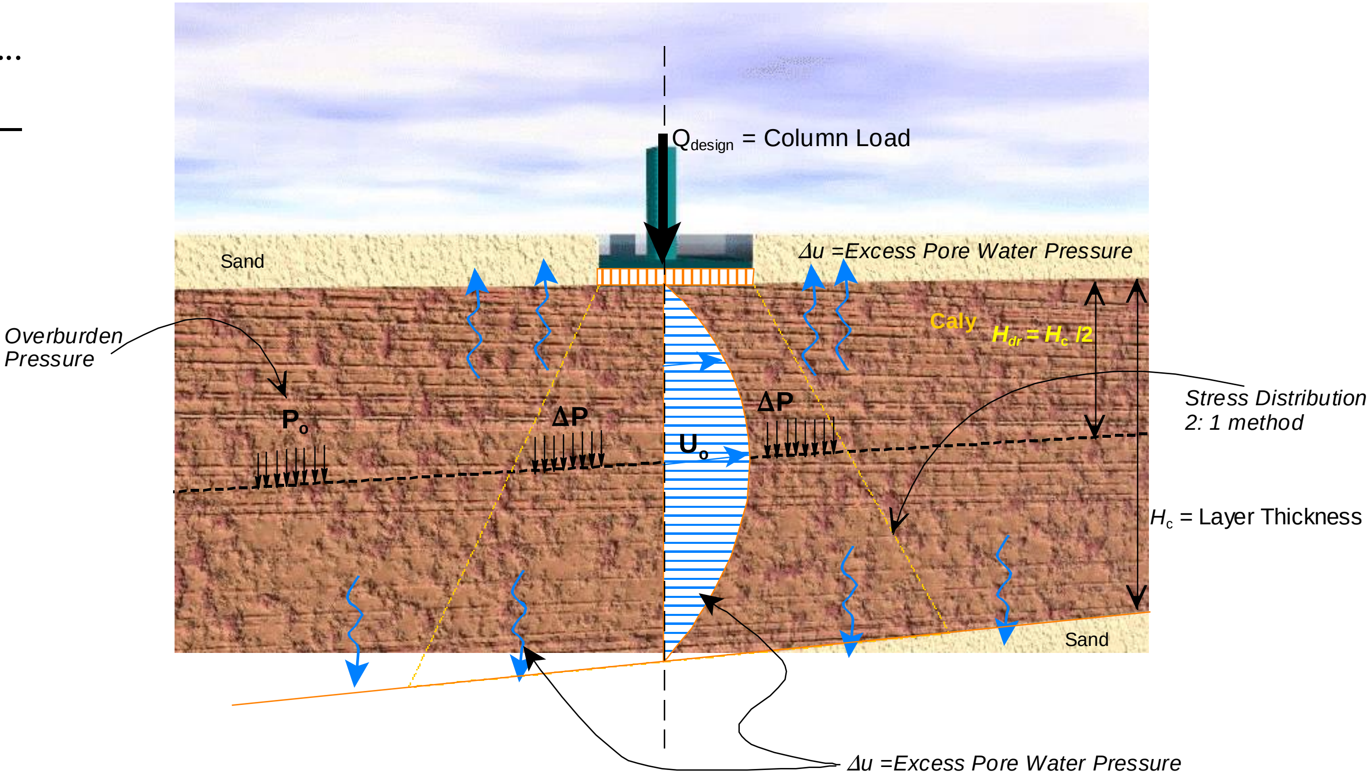
$$S_{time} = S_{ultimate} * U\%$$

$$S_{ultimate} = (C_c/1+e_o)\ H_c \ .\ \log[(P_o + \Delta P)/P_o]$$

$U\% = f(T_v)$ ....

$T_v = f(c_v)$ ......

$$T_v = \frac{c_v \ .\ t}{(H_{dr})^2}$$



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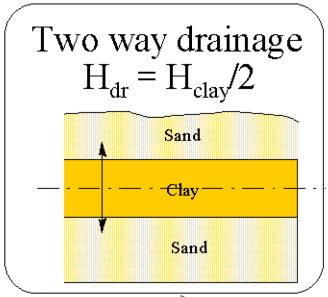
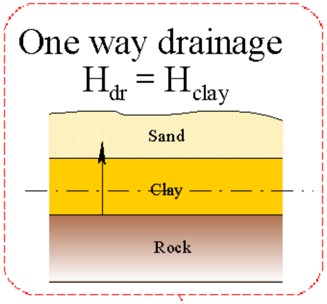
Rate of Consolidation





Settlement at any time = S_{time}

$$S_{time} = S_{ultimate} * U\%$$

$U\% = f\,(T_v)$ .... T_v = Time Factor

From Tables

$T_v = f\,(c_v)$ ...... C_v = Coefficient of Consolidation

$$T_v = \frac{c_v \,.\, t}{(H_{dr})^2}$$

t = time (month, day, or year)

$(H_{dr})^2$ = Drainage Path

H_{dr} = H or H/2

C_v is obtained from laboratory testing

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