Geotechnical Engineering–I

BSc Civil Engineering – 4th Semester

Lecture # 20

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by

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Lecture Handouts: https://groups.google.com/d/forum/geotec-1

CONSOLIDATION TEST
Pressure ~ Deformation Curve

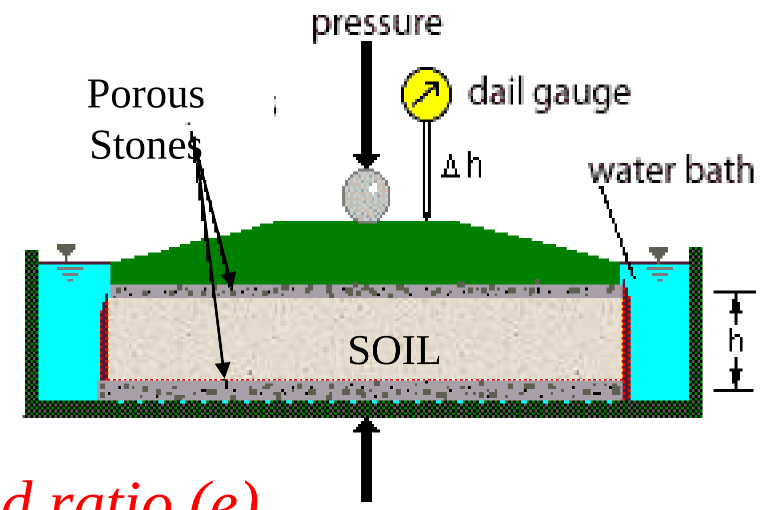
Pressure ~ Deformation curve

i. Cc (Compression index)

ii. Cr (Recompression index)

iii. a_V (Coefficient of compressibility)

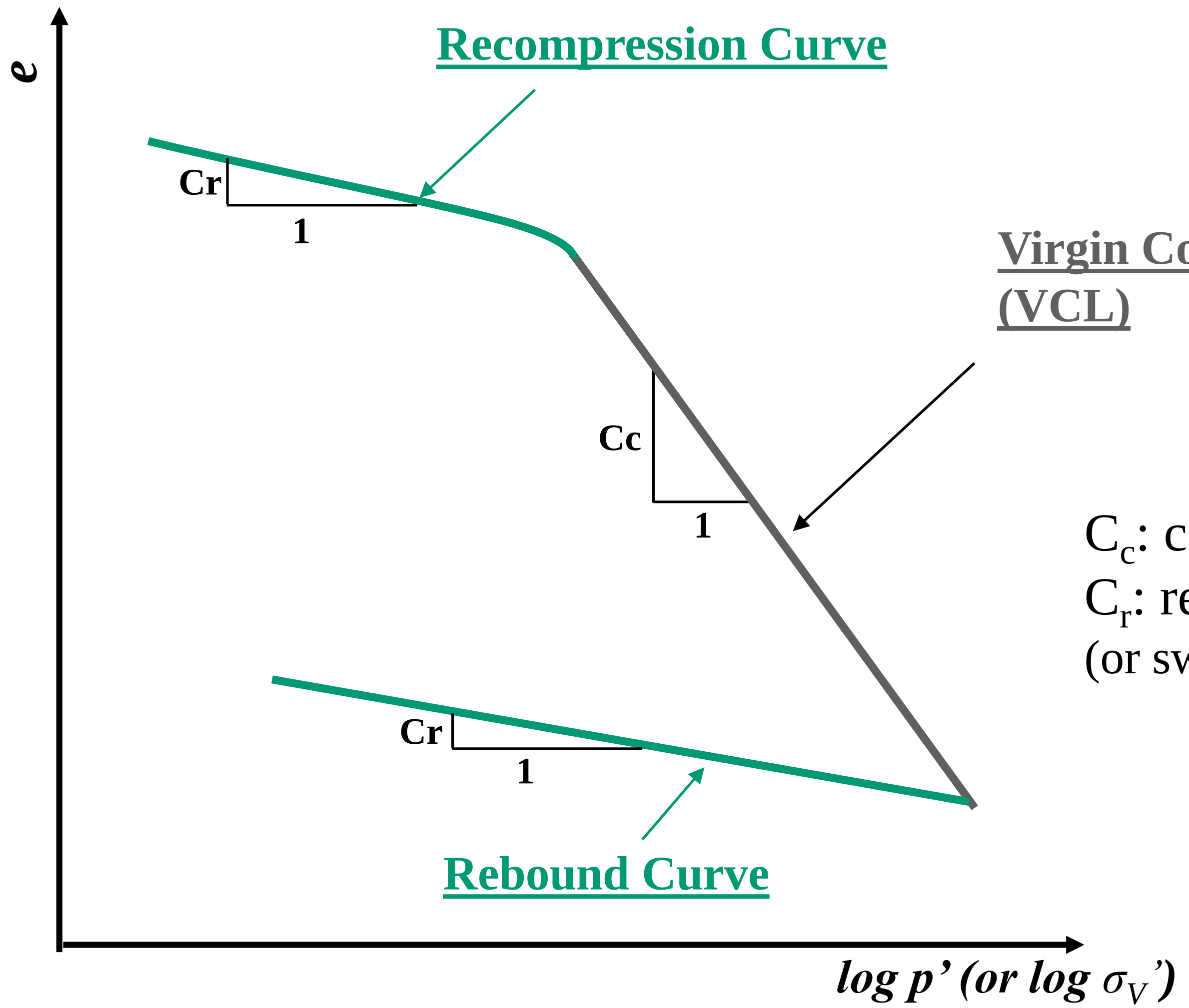
iv. m_V (Coefficient of volume change)



Deformations plotted in terms of *void ratio (e)*

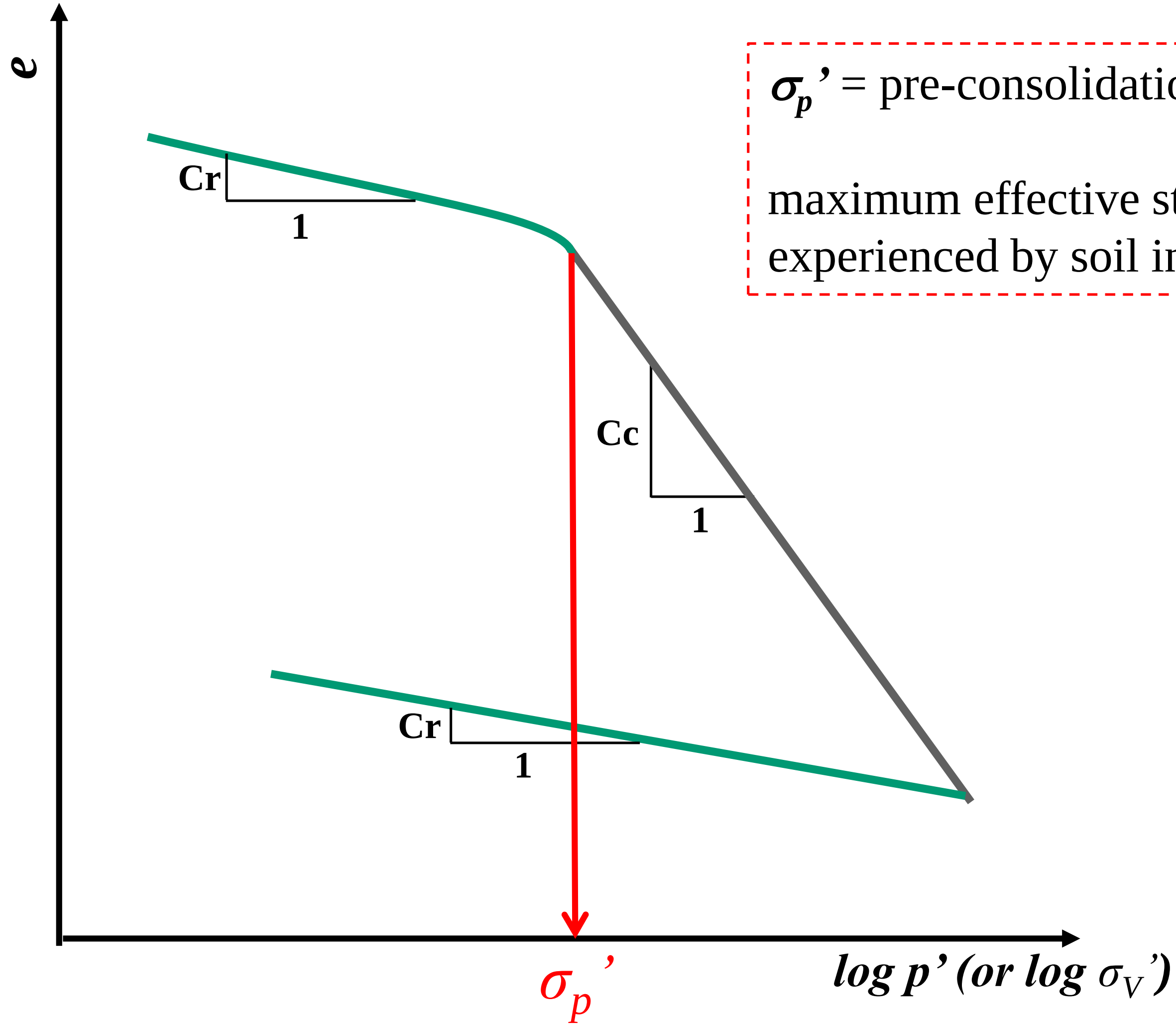
- Void ratio ~ pressure plot *(e ~ p* plot*)*
- Void ratio ~ log of pressure (*e ~ log p* plot)

e ~ log p' (*e ~ log* σ_{v0}') PLOT



C_c: compression index
C_r: recompression index
(or swelling index)

PRE-CONSOLIDATION PRSSSURE



σ_p’ = pre-consolidation pressure

maximum effective stress experienced by soil in past.

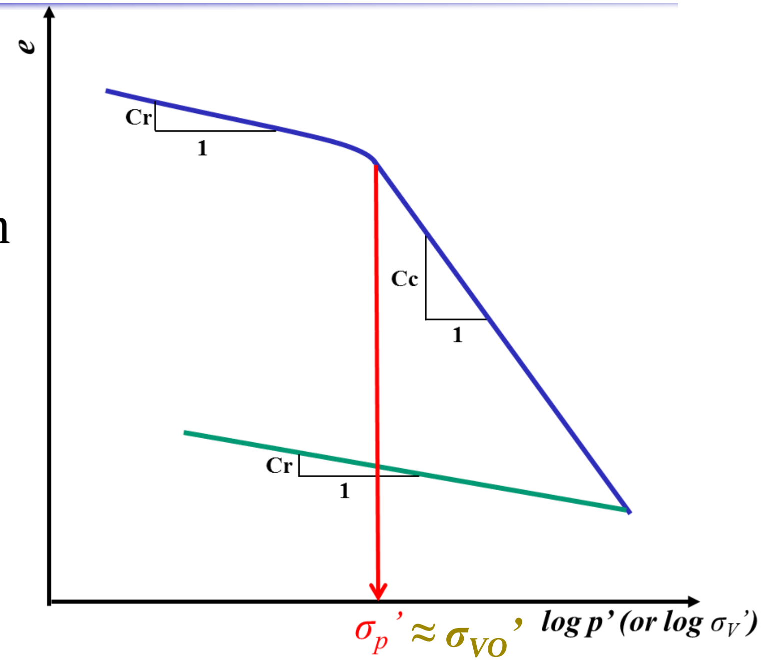
STRESS HISTORY

Normally Consolidated Soil

If the *present effective stress (σ_{v0}')* in the clay is the *greatest stress* it has ever experienced in its history.

i.e., pre-consolidation pressure *(σ_p')* ≈ present effective stress *(σ_{v0}')*

(σ_p') ≈ ± 10% of (σ_{v0}')

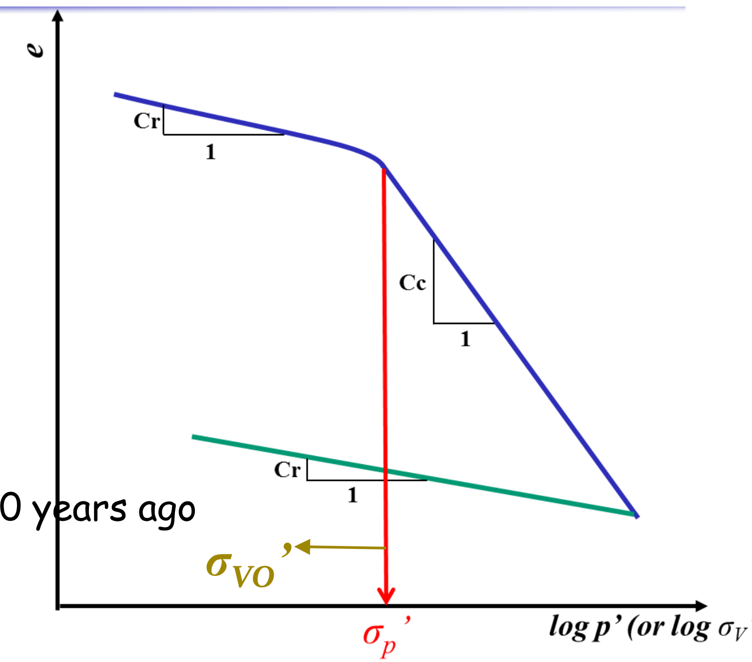


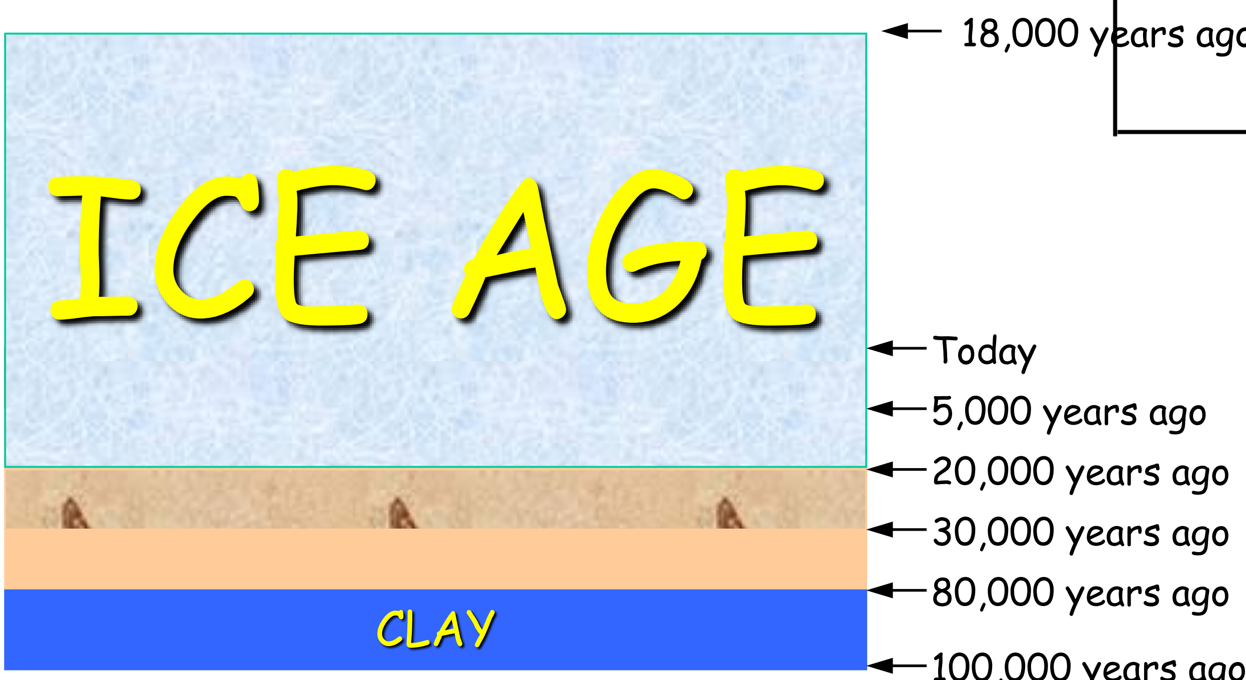
STRESS HISTORY

Over Consolidated Soil

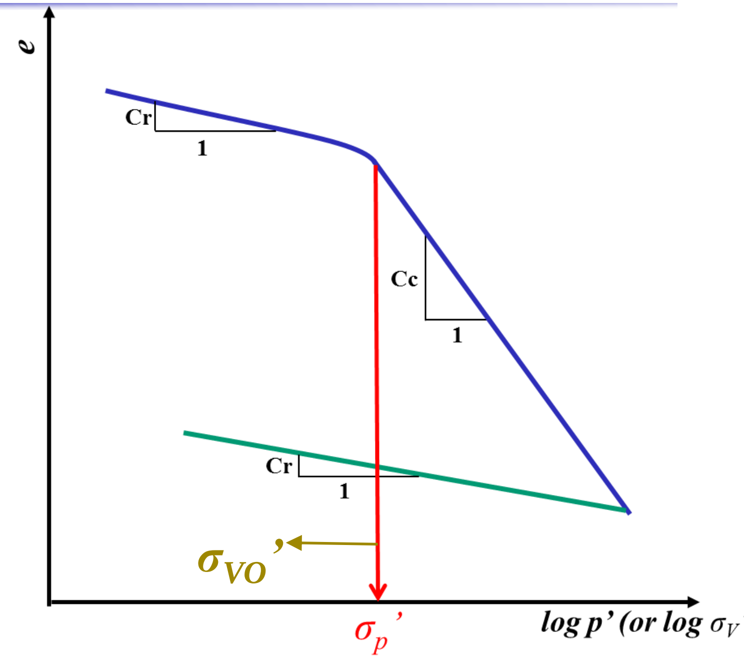
If the *present effective stress (σ_{v0}')* in the clay is smaller than the effective stress experienced in the past.

i.e., pre-consolidation pressure *(σ_p')* > present effective stress *(σ_{v0}')*





STRESS HISTORY



Over Consolidated Soil

If the *present effective stress (σ_{v0}')* in the clay is smaller than the effective stress experienced in the past.

i.e., pre-consolidation pressure *(σ_p')* > present effective stress *(σ_{v0}')*

STRESS HISTORY

Over Consolidation Ratio (OCR)

$$OCR = \frac{\sigma'_p}{\sigma'_{v0}}$$

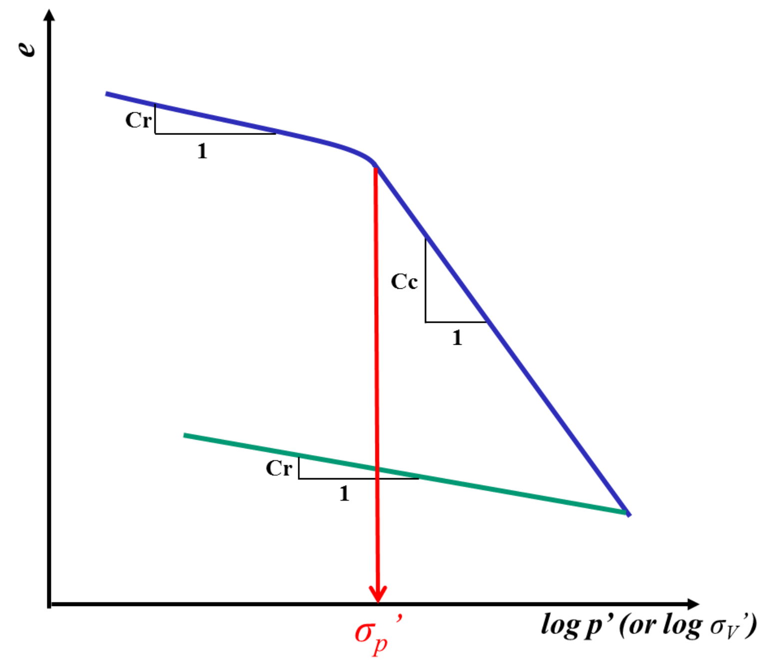
σ_{v0}' = present effective overburden pressure

σ_p' = pre-consolidation pressure (maximum pressure in past)

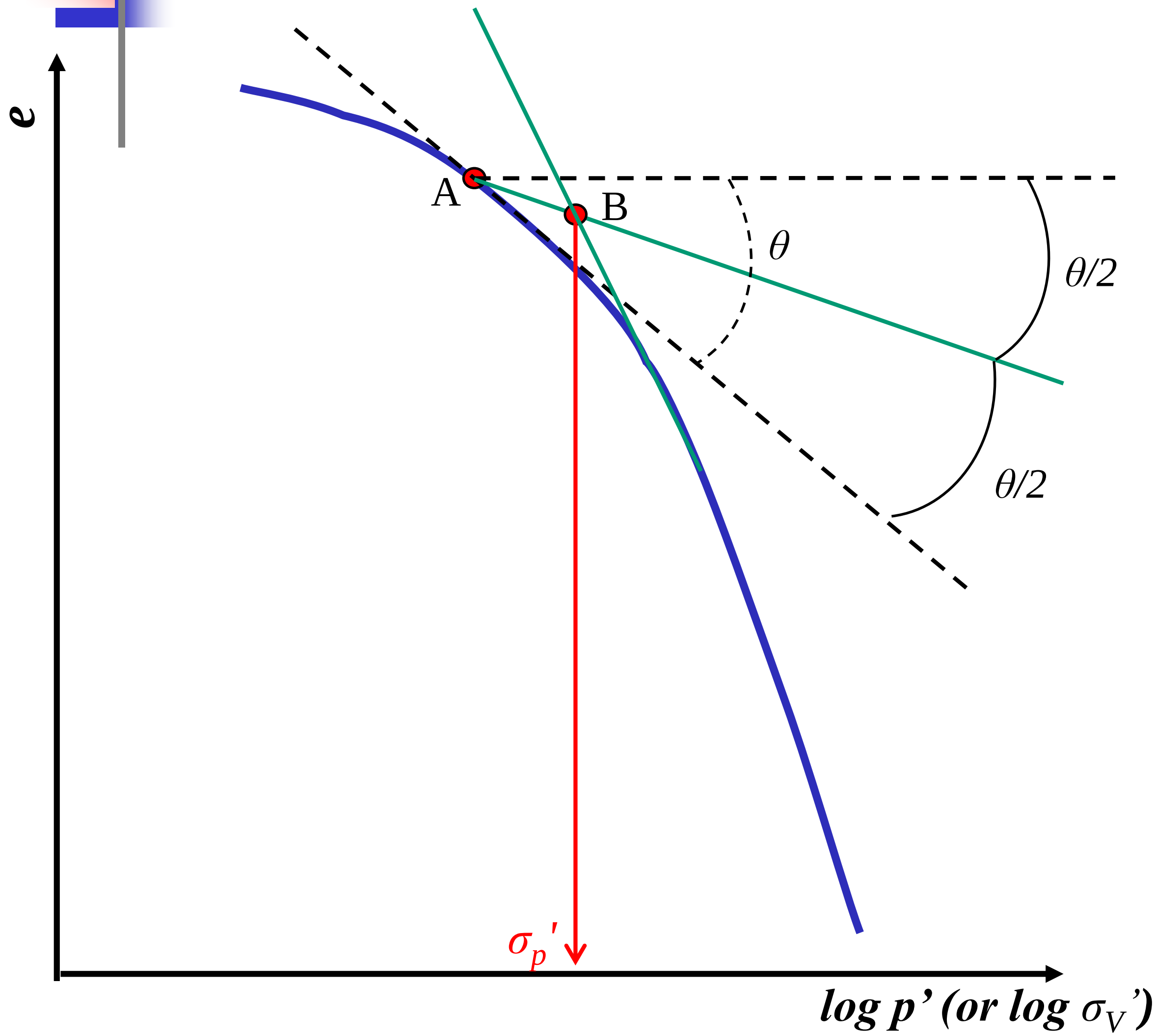
Normally consolidated soils $\rightarrow$ *OCR = 1*

Over-consolidated soils $\rightarrow$ *OCR > 1*

Under-consolidated soils $\rightarrow$ *OCR < 1*



Determination of Pre-Consolidation Pressure (σ_p') (*Casagrande's Method*)

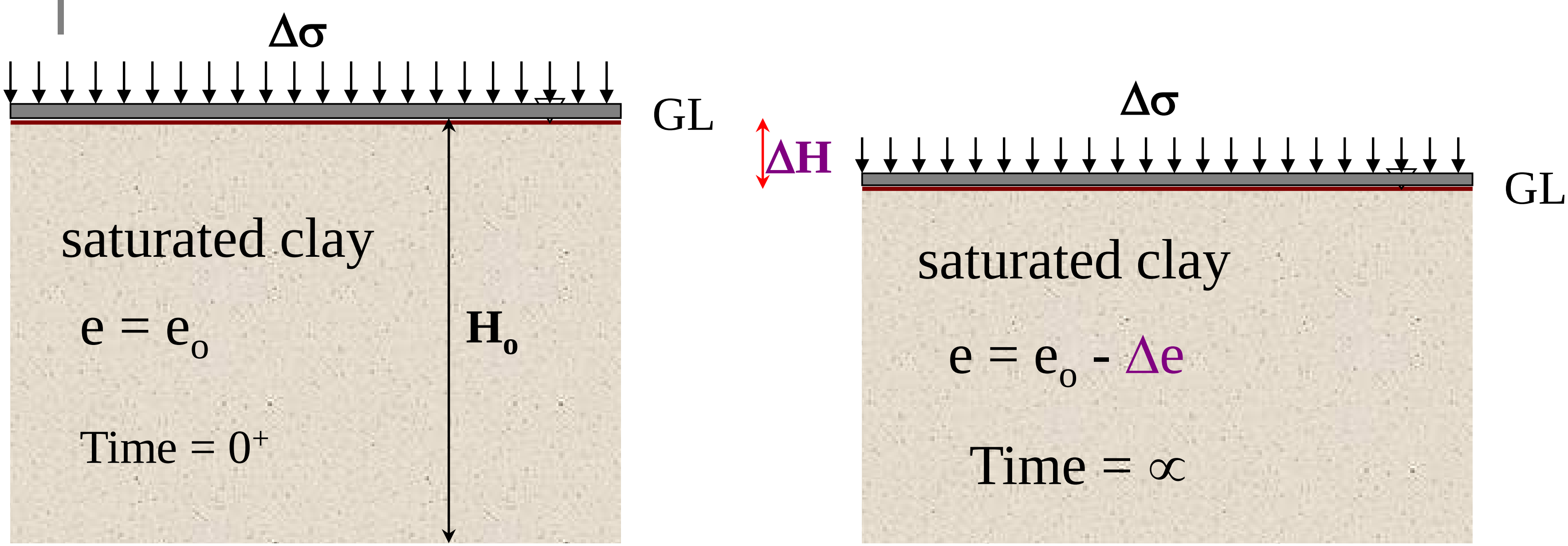


Steps:

1. Mark the point of *maximum curvature* (point *'A'*).
2. Draw a *horizontal line* from 'A'.
3. Draw a *tangent* to the curve *at point 'A'*.
4. *Bisect* the *angle 'θ'*.
5. *Extend* the straight line portion of *virgin compression curve backward*.
6. The pressure corresponding to *point of intersection 'B'* is the pre-consolidation pressure (σ_p').

SETTLEMENT COMPUTATIONS

Settlement in Field



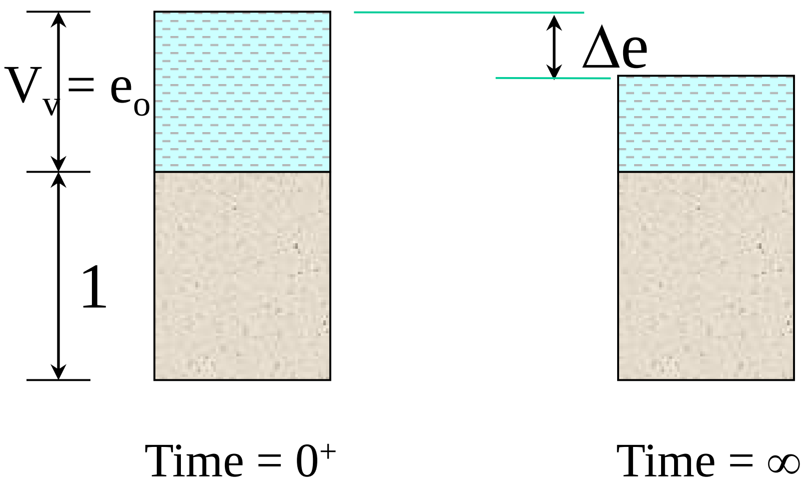
Average vertical strain, $\varepsilon_f = \dfrac{\Delta H}{H_o}$

SETTLEMENT COMPUTATIONS

Settlement in Lab (Consolidation Test)

Consider a soil element where $V_s = 1$ initially.

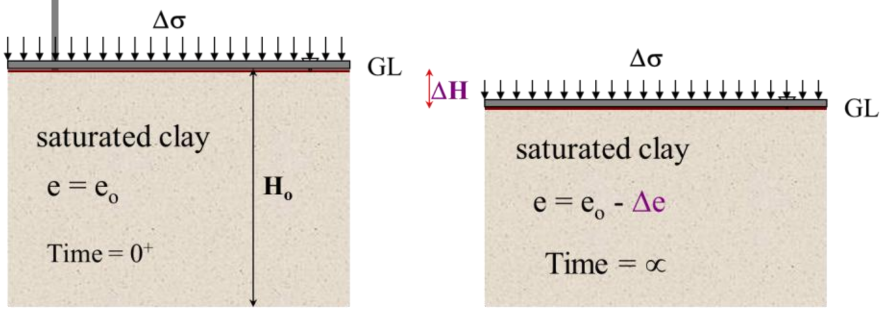
$$e = \frac{V_V}{1}$$



$$\therefore \text{Average vertical strain, } \varepsilon_L = \frac{\Delta e}{1 + e_o}$$

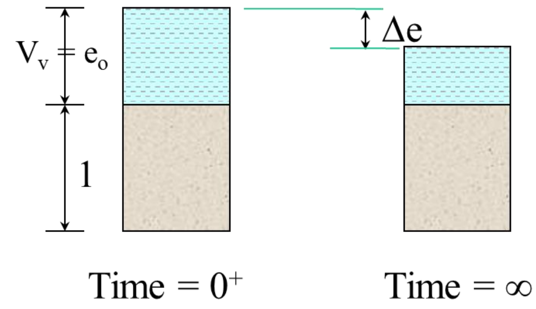
SETTLEMENT COMPUTATIONS

Field



Average vertical strain, $\varepsilon_f = \dfrac{\Delta H}{H_o}$

Laboratory



$\therefore$ Average vertical strain, $\varepsilon_L = \dfrac{\Delta e}{1+e_o}$

For an undisturbed soil specimen.

$$\varepsilon_f = \varepsilon_L$$

$$\frac{\Delta H}{H_o} = \frac{\Delta e}{1+e_o}$$

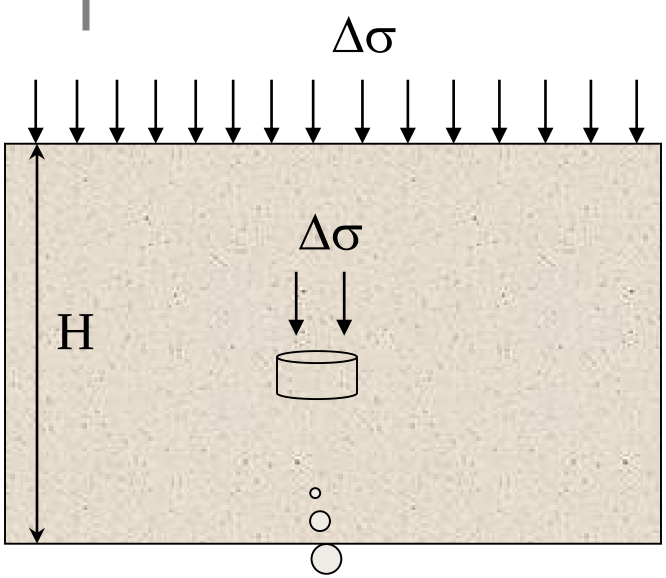
$$\boxed{S_C = \Delta H = H_o \cdot \frac{\Delta e}{1+e_o}}$$

where,

S_C = Consolidation settlement in the field

SETTLEMENT COMPUTATIONS

Ways to estimate consolidation settlement:



(a) Using m_v

Consolidation settlement, $S_c = m_v \,.\, \Delta\sigma \,.\, H$

$$m_V = \frac{a_V}{1+e}$$

e_o, σ_{vo}', C_c, C_r, σ_p', m_v

oedometer test

(b) Using *e-log* σ_v' plot

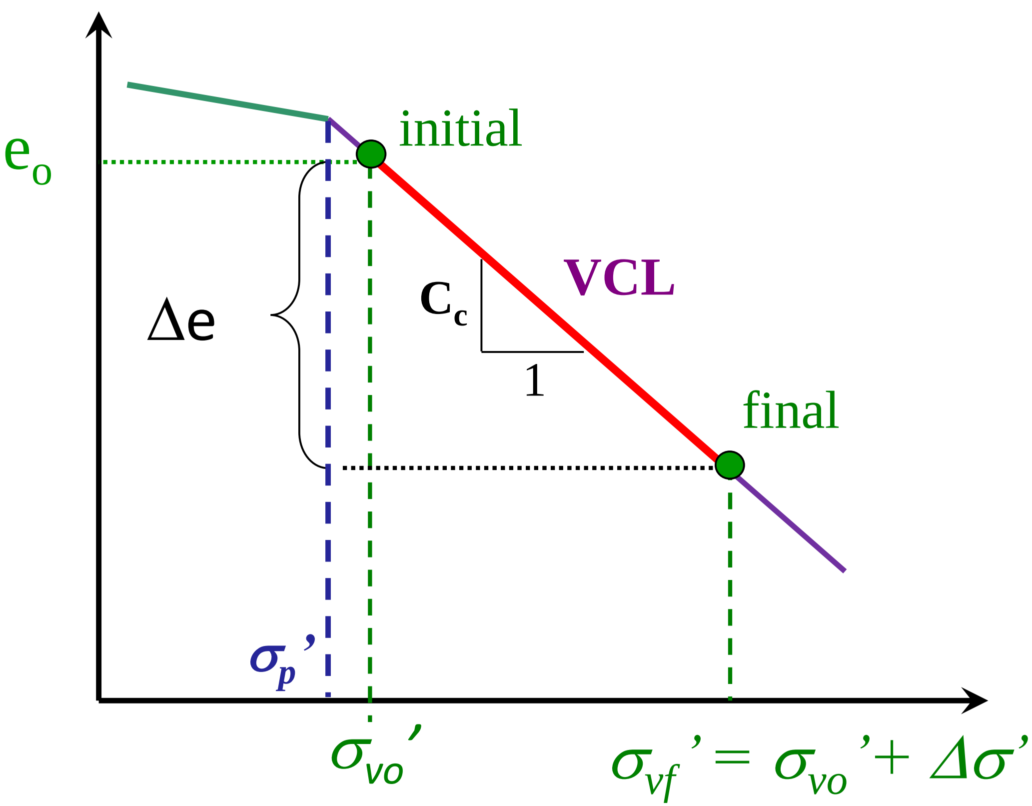
next slide

$$settlement = S_c = \frac{\Delta e}{1+e_o} H$$

SETTLEMENT COMPUTATIONS

CASE I: $\sigma'_p < \sigma'_{vo} < \sigma'_{vf}$

If the clay is *normally consolidated*, the entire loading path is along the *VCL*.



$$C_C = \frac{\Delta e}{\log \left((\sigma_{vo}' + \Delta\sigma) \big/ \sigma_{vo}' \right)}$$

$$\Delta e = C_c \log \frac{\sigma_{vo}' + \Delta\sigma'}{\sigma_{vo}'}$$

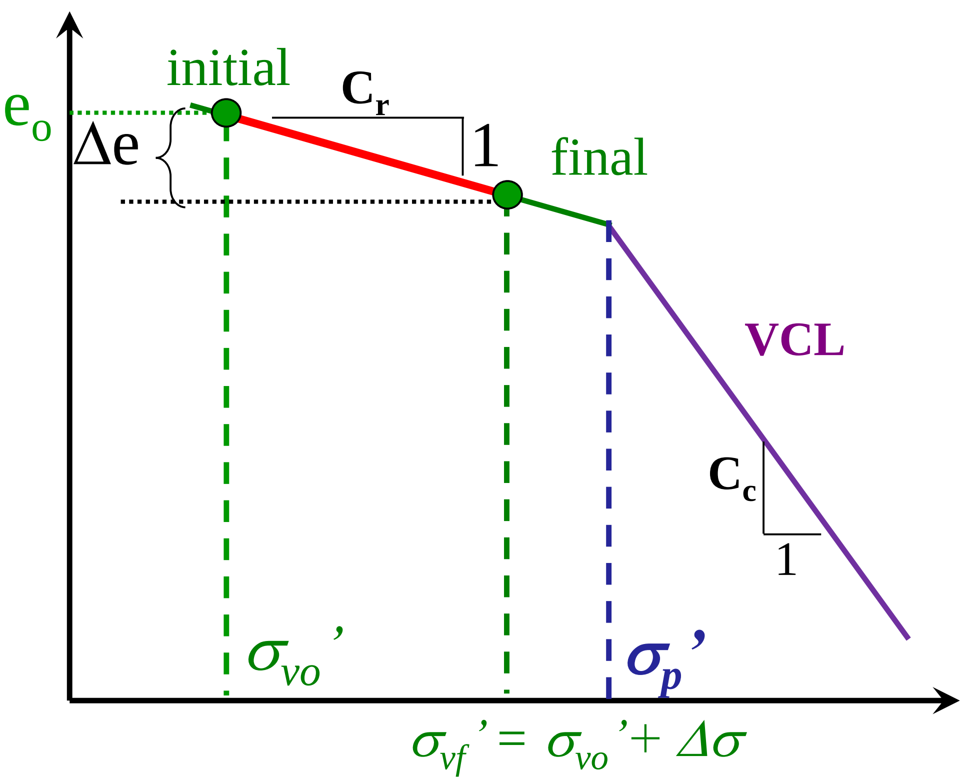
$$S_c = \frac{\Delta e}{1 + e_o} H$$

$$\boxed{S_c = H \left(\frac{C_c}{1 + e_o} \right) \left(\log \frac{\overbrace{\sigma_{vo}' + \Delta\sigma'}^{\sigma'_{vf}}}{\sigma_{vo}'} \right)}$$

SETTLEMENT COMPUTATIONS

CASE II: $\sigma'_{vo} < \sigma'_{vf} < \sigma'_p$

If the clay is *over-consolidated*, and remained so by the end of consolidation.



$$Cr = \frac{\Delta e}{\log (\sigma_{vo}'+\Delta\sigma) / \sigma_{vo}'}$$

$$\Delta e = C_r \log \frac{\sigma_{vo}'+\Delta\sigma'}{\sigma_{vo}'}$$

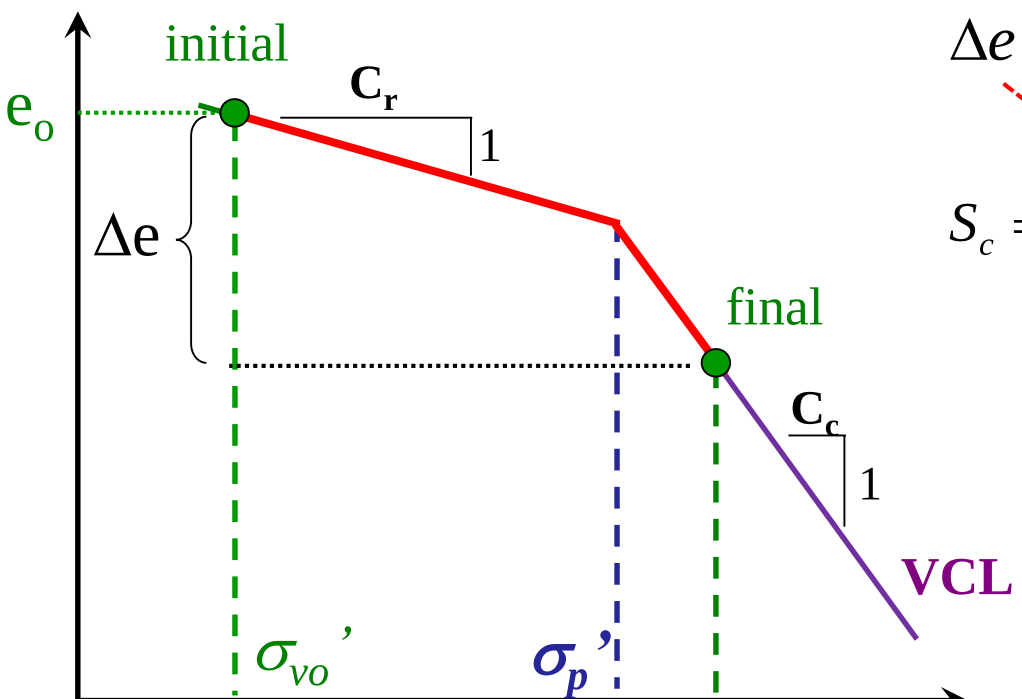
$$S_c = \frac{\Delta e}{1+e_o} H$$

$$\boxed{S_c = H\left(\frac{C_r}{1+e_o}\right)\left(\log \frac{\overbrace{\sigma_{vo}'+\Delta\sigma'}^{\sigma'_{vf}}}{\sigma_{vo}'}\right)}$$

SETTLEMENT COMPUTATIONS

CASE III: $\sigma'_{vo} < \sigma'_p < \sigma'_{vf}$

If the *over-consolidated*, soil becomes normally consolidated by the end of consolidation.



$$\Delta e = C_r \log \frac{\sigma_p'}{\sigma_{vo}'} + C_c \log \frac{\overbrace{\sigma_{vo}' + \Delta\sigma'}^{\sigma'_{vf}}}{\sigma_p'}$$

$$S_c = \frac{\Delta e}{1+e_o} H$$

$$\boxed{S_c = H\left(\frac{C_r}{1+e_o}\right)\left(\log \frac{\sigma_p'}{\sigma_{vo}'}\right) + H\left(\frac{C_c}{1+e_o}\right)\left(\log \frac{\sigma_{vo}' + \Delta\sigma'}{\sigma_p'}\right)}$$

CONCLUDED