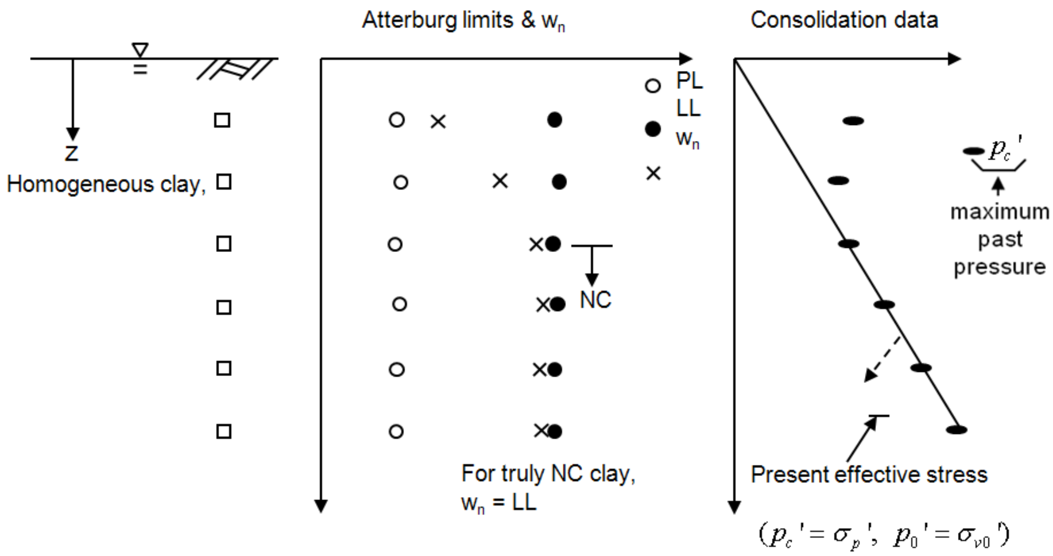
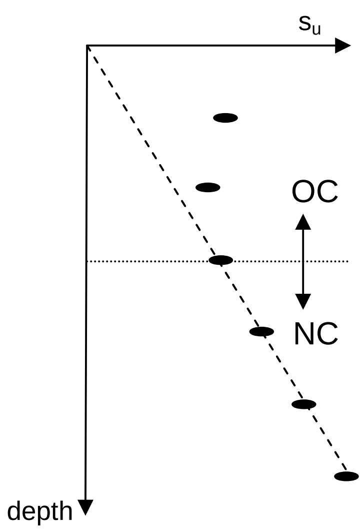
(2) Undrained Strength

- **Sophistication for selecting s_u**



- **Triaxial or field tests**



* s_u varies with depth and stress history

For truly N.C. clays,

$$s_u / p_o' = s_u / \sigma_{vc}' = s_u / p_c' = \text{const.}$$

Vertical consolidation stress (for σ_{vc}')

→ For the same OCR, $s_u / p_o' = \text{const.}$

- **To determine $s_u / p_o' = s_u / \sigma_{vc}'$ (→ Determining s_u)**

1) Based on w_n, LL or PL

For example, if $w_n \approx$ LL → NC

$\therefore s_u / p_o' = \text{const.}$ is valid

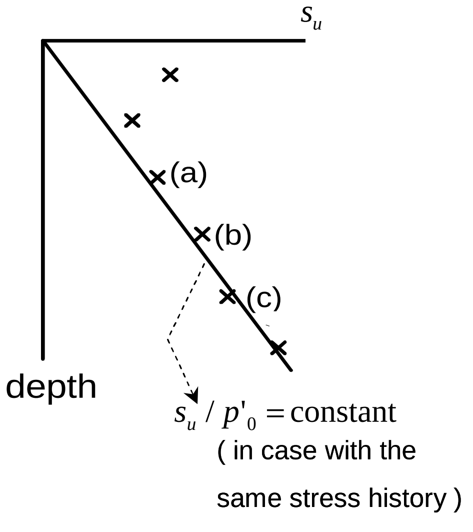
→ Skempton, $s_u / p_o' = 0.11 + 0.0037(PI)$

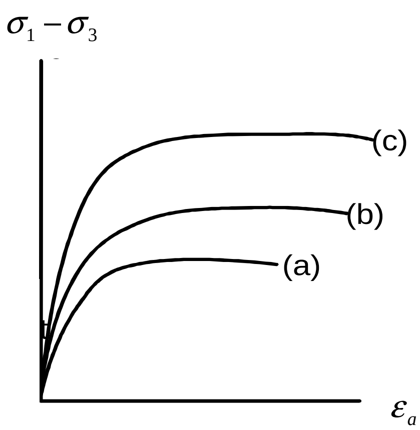
2) Run consolidation tests

Ladd, $s_u / p_o' = (0.23 \pm 0.04)(OCR)^{0.8}$

Mesri, $s_u / p_c' = 0.22$

3) Run a series of UU tests





4) Run a series of CU (CIU or CK_0U) tests

→ Directly get s_u / σ_{vc}'

- **Considerations required for Lab Testing on Undrained Shearing Behavior of Clays**

  - Representing the in-situ field conditions before shearing and during shearing

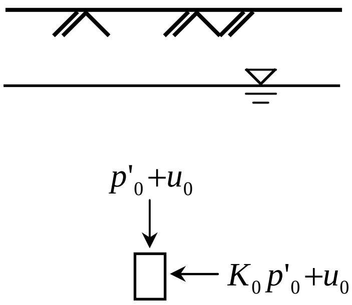
1) <u>In-situ field conditions before shearing</u>

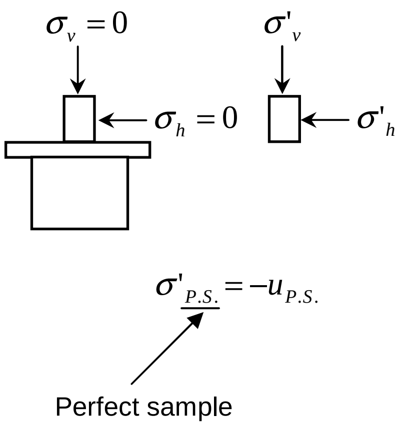
a) Sample disturbance

$\rightarrow$ Changes in stresses and strains during sampling, transportation, extrusion, and trimming

* Perfect sample (No change in water content and volume)

In filed in lab





- Based on pore pressure parameters suggested by Skempton,

$$\Delta u = B\Delta\sigma_3 + D(\Delta\sigma_1 - \Delta\sigma_3)$$

Assumptions → starting with good sample
no change in w_n as a saturated sample (no change in volume) → undrained condition

$$\Delta u = \Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3) \quad \leftarrow \text{(B=1)}$$

$$\Delta u = -K_0 p_0' - u_0 + A_u(-p_0' - u_0 + K_0 p_0' + u_0)$$
$$= -K_0 p_0' - u_0 - A_u(p_0' - K_0 p_0')$$

$$u_{ps} = u_0 + \Delta u$$
$$\therefore \sigma'_{ps} = -u_{ps} = -u_0 - \Delta u$$
$$= K_0 p_0' + A_u(p_0' - K_0 p_0')$$
$$= \{K_0 + A_u(1 - K_0)\} p_0'$$

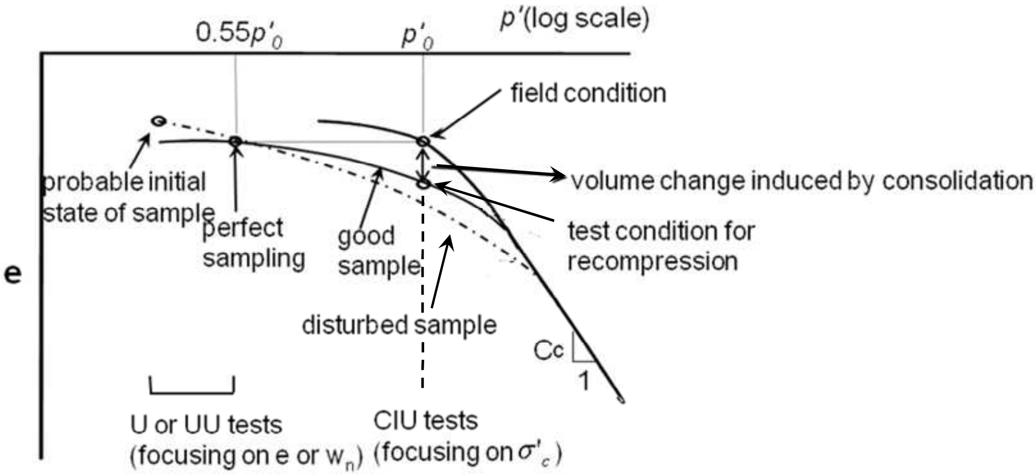
If soil is elastic and isotropic,

$$K_0 = \frac{\nu}{1-\nu} = 1 \quad \leftarrow \nu = 0.5$$

$$\sigma'_{ps} = p_0'$$

In real soils, typical values: $\left[\begin{array}{l} K_0 = 0.5 \\ A_u = 0.1 \end{array} \right]$, $\sigma'_{ps} = 0.55 p_0'$

∗ e-log p' relation on NC clays, based on recompression approach



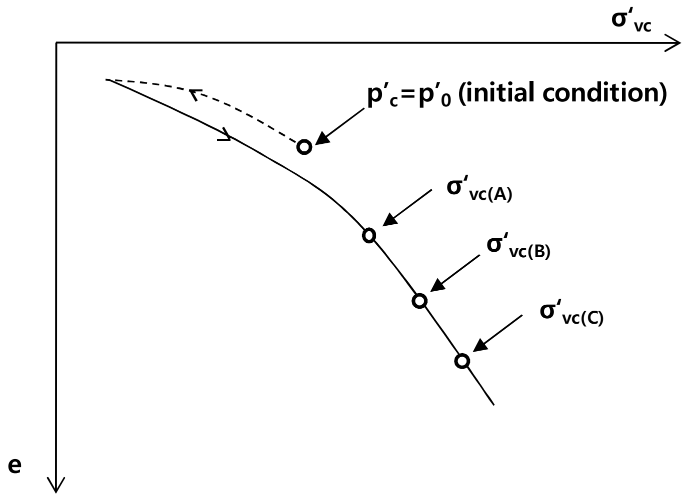
- Even in the condition of perfect sampling, volume change occurs during consolidation.
  → Increase of undrained strength
  (For N.C. or lightly overconsolidated clays, $\dfrac{\Delta V}{V} = 2 \sim 8\%$)
- To improve quality of results : The lower the $\dfrac{\Delta V}{V}$ $(or\ \Delta e)$ that occurs as loading to $(p_0^{'})_{field}$, the "better" the sample.

* Two ways to get high quality results

1. Be careful (minimize disturbance).

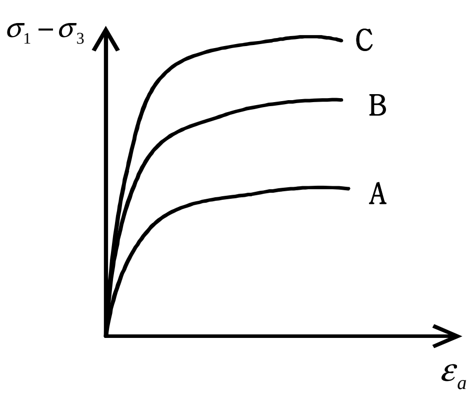
2. Normalized Strength Concept (especially, N.C. clay)

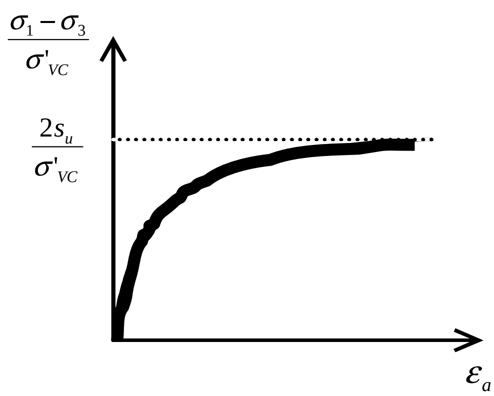
① Consolidate samples to σ'_{vc} larger than p'_c (= p'_0).



⇒ Free from sample disturbance but not in field stress condition.

② Run shear tests to get s_u. ③ Normalize the results by σ'_{vc} .





④ Back calculate s_u for any p'_0 by $\frac{s_u}{\sigma'_{vc}} \times p'_0 = s_u$.