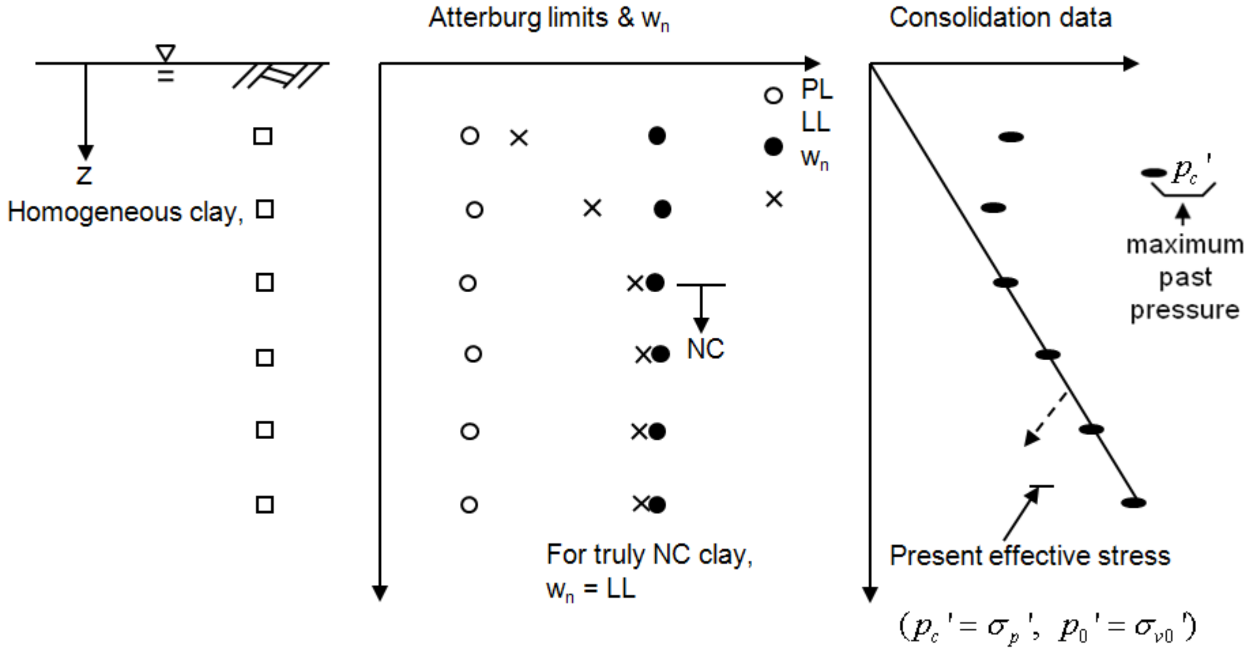
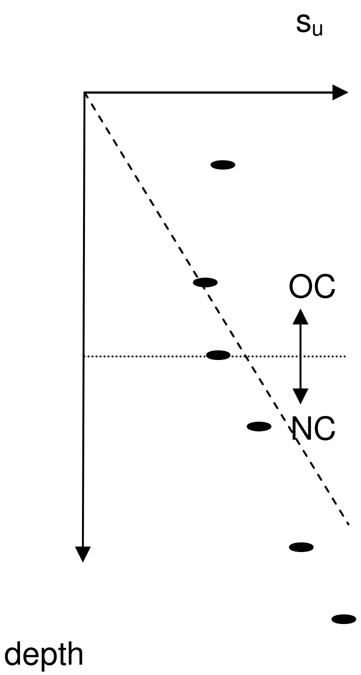
# (2) Undrained Strength

## ● Sophistication for selecting $s_u$.



## ● Triaxial or field tests.




* $s_u$ varies with depth and stress history.

For truly N.C. clays,

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

Vertical consolidation stress

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

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

1) <u>Based on $w_n$, LL or PL.</u>

   For example, if $w_n \approx$ LL → NC.

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

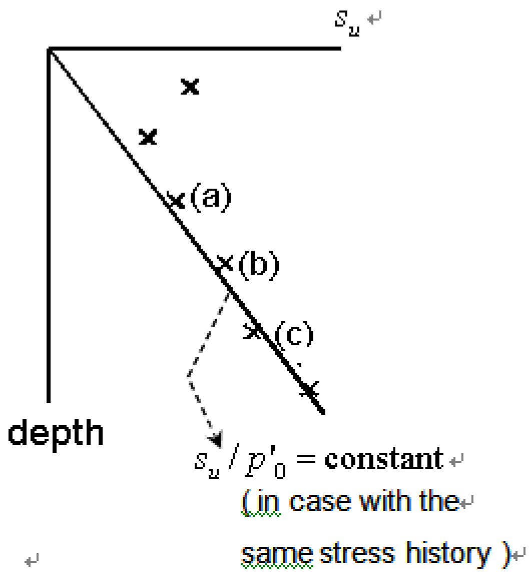
   → Skempton, $s_u / p_o^{'} = 0.11 + 0.0037(PI)$

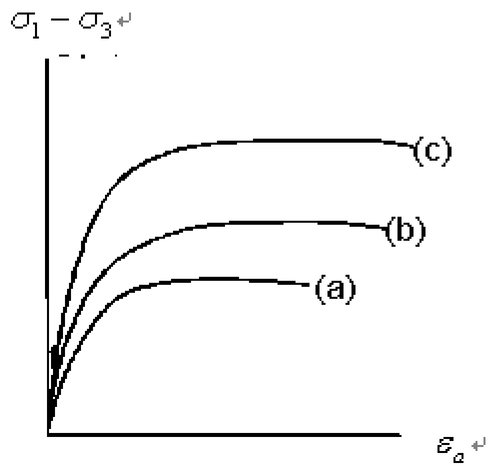
2) <u>Run consolidation tests.</u>

   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.

$\rightarrow$ Directly get $s_u / \sigma'_{vc}$ .

## ● Considerations required for Lab Testing on Undrained Shearing Behavior of Clays.

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

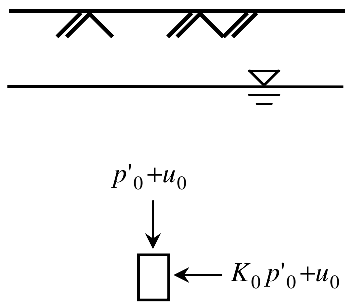
1) <u>In-situ field conditions before shearing.</u>

a) Sample disturbance.

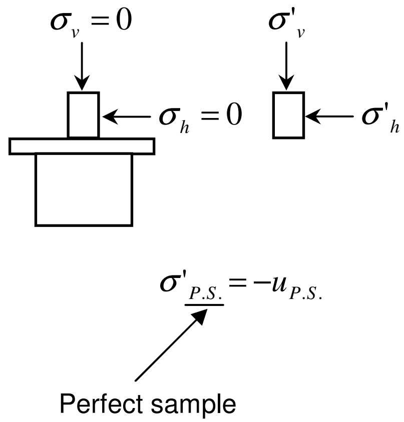
→ Changes in stresses and strains during sampling, transportation, extrusion, and trimming.

## ∗ Perfect sample (No change in water content and volume)

In filed




in lab



- Based on pore pressure parameters suggested by Skempton,

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

Assumption. $\rightarrow$ starting with good sample.

no change in $w_n$ as a saturated sample (no change in volume) $\rightarrow$ undrained condition.

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

$$\begin{aligned}\Delta u &= -K_0 p_0^{'} - u_0 + A_u(-p_0^{'} - u_0 + K_0 p_0^{'} + u_0) \\ &= -K_0 p_0^{'} - u_0 - A_u(p_0^{'} - K_0 p_0^{'})\end{aligned}$$

$$u_{ps} = u_0 + \Delta u$$

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

If soil is elastic and isotropic,

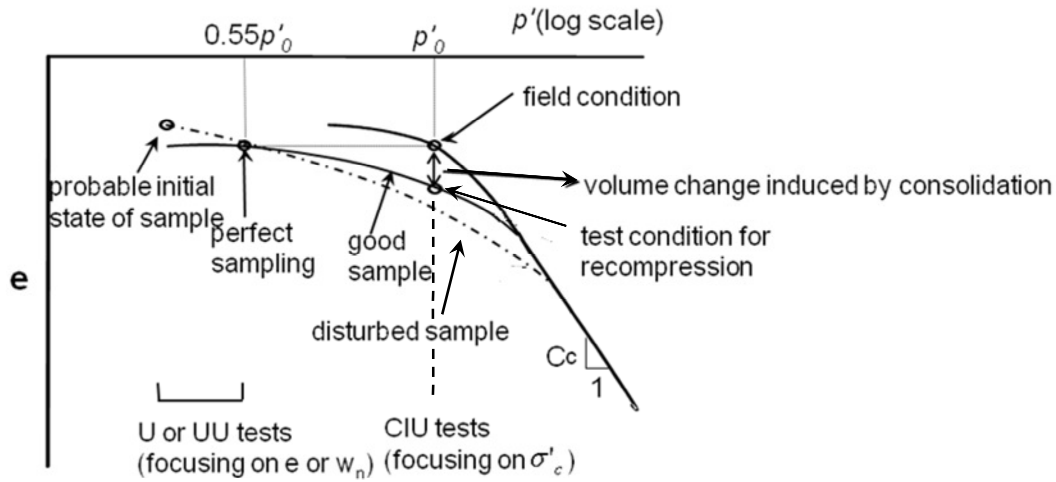
$$K_0 = \frac{\nu}{1-\nu} = 1$$

$$\nu = 0.5$$

$$\sigma'_{ps} = p'_0$$

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.

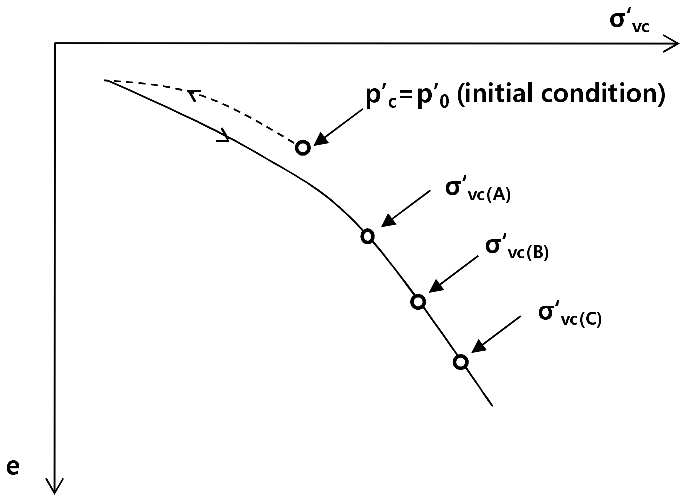
  → Increase of undrained strength (For N.C. or lightly overconsolidated clays, $\frac{\Delta V}{V} = 2 \sim 8\%$ )

- To improve quality of results: The lower the $\frac{\Delta V}{V}$ $(or\ \Delta e)$ that occurs as loading to $(p_0^{'})_{field}$, the "better" the sample.

* Two ways to get high quality results.

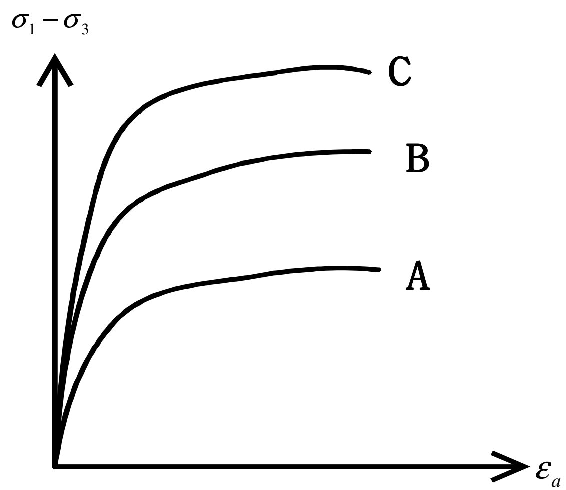
1. Be careful (minimize disturbance).
2. Normalized Strength Concept (especially, N.C. clay)

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

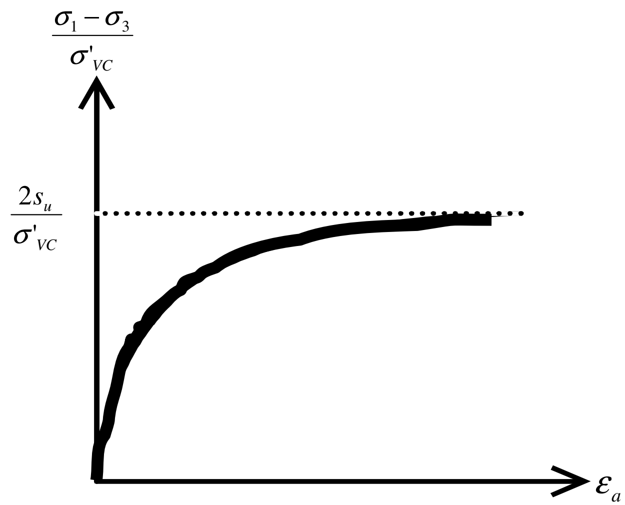



⇒ Free from sample disturbance but not in field stress condition.

② Run shear tests to get $s_u$.




③ Normalize the results by $\sigma'_{vc}$ .




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