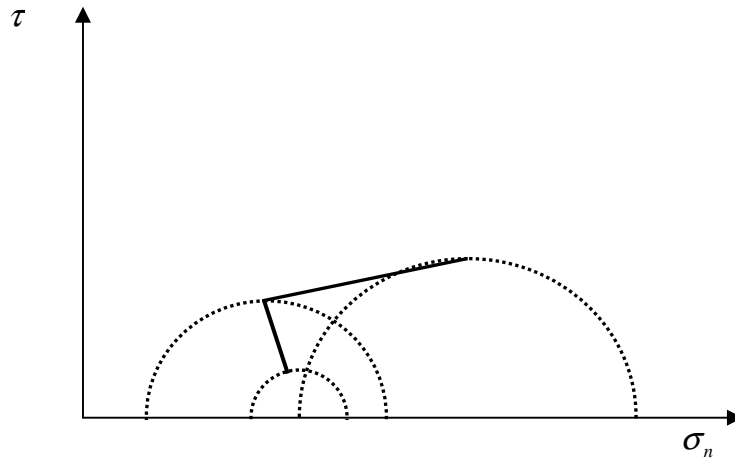


(3) Stress Paths

● **Definition**

“Locus of maximum shear stress for any loading history”

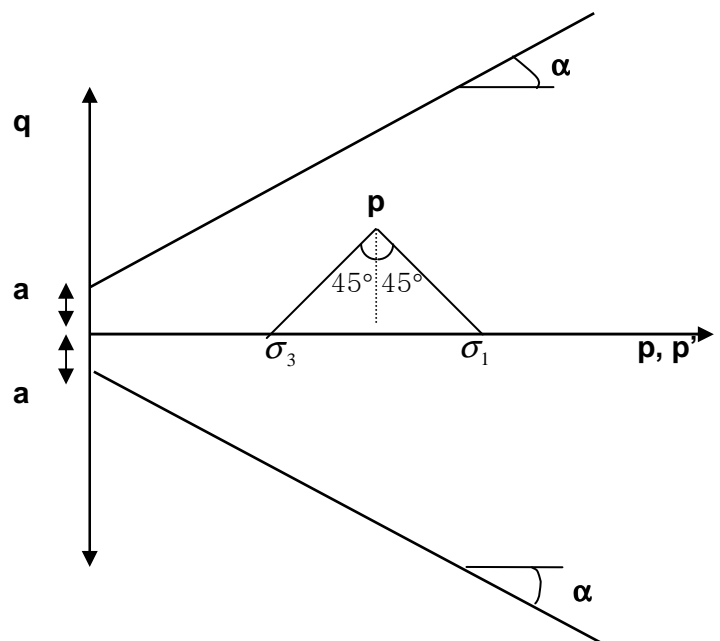


● **Lamb's stress space**

$$q = \frac{\sigma_1 - \sigma_3}{2} = \frac{\sigma'_1 - \sigma'_3}{2}$$

$$p = \frac{\sigma_1 + \sigma_3}{2}$$

$$p' = \frac{\sigma'_1 + \sigma'_3}{2}$$

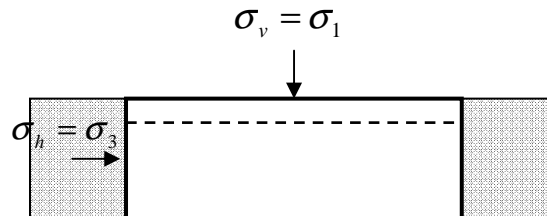


$$\sin \phi' = \tan \alpha$$

$$c' \cos \phi' = a$$

● Examples of Stress Paths

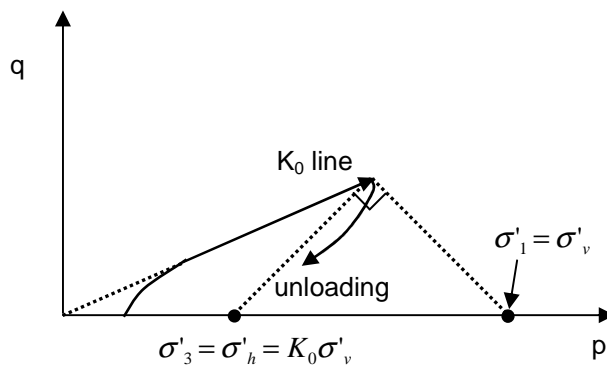
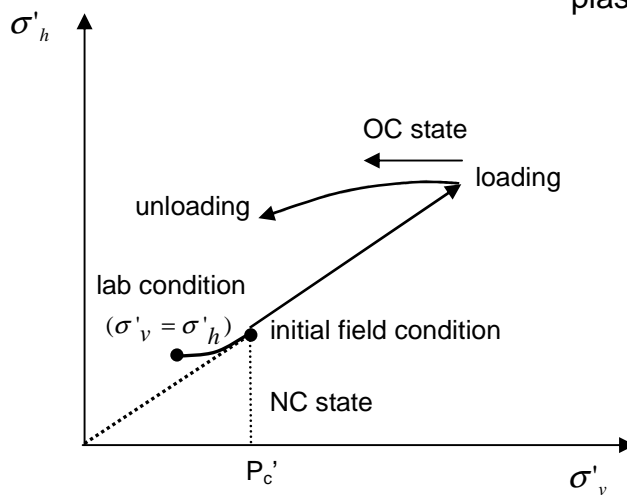
1) 1-Dimensional compression (Drained)



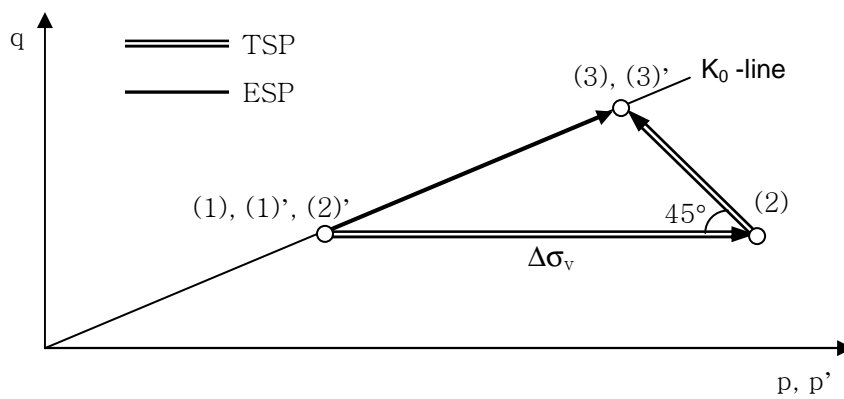
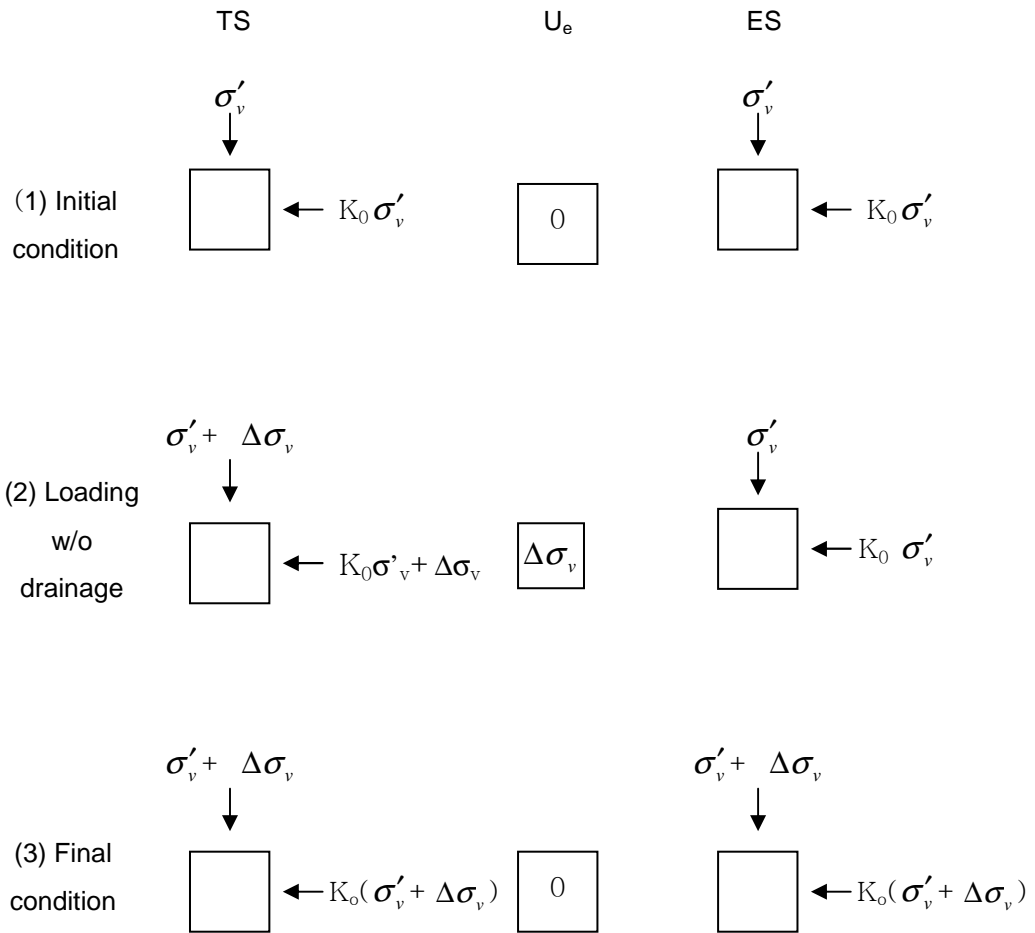
- Drained loading and unloading (when $K_{0(NC)} < 1$).

$\hookrightarrow K_0 = f(\text{stress history, plasticity index, friction angle...})$

$$= \frac{\sigma'_h}{\sigma'_v}$$

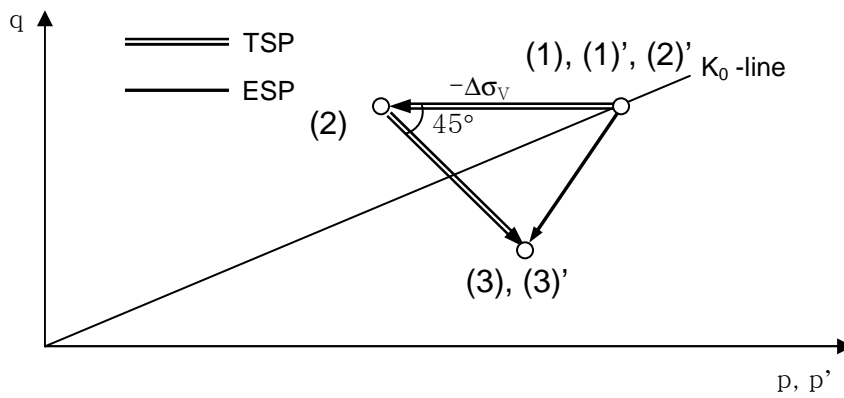
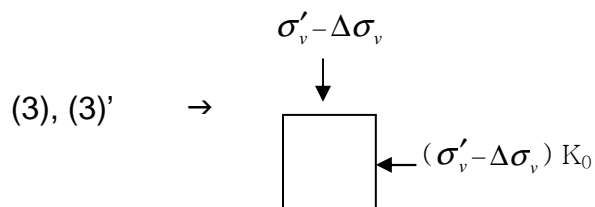


- Undrained loading + Drainage (saturated NC soils)



- Undrained unloading + Drainage (saturated OC soils)

$$K_{0(NC)} < K_0 < 1$$

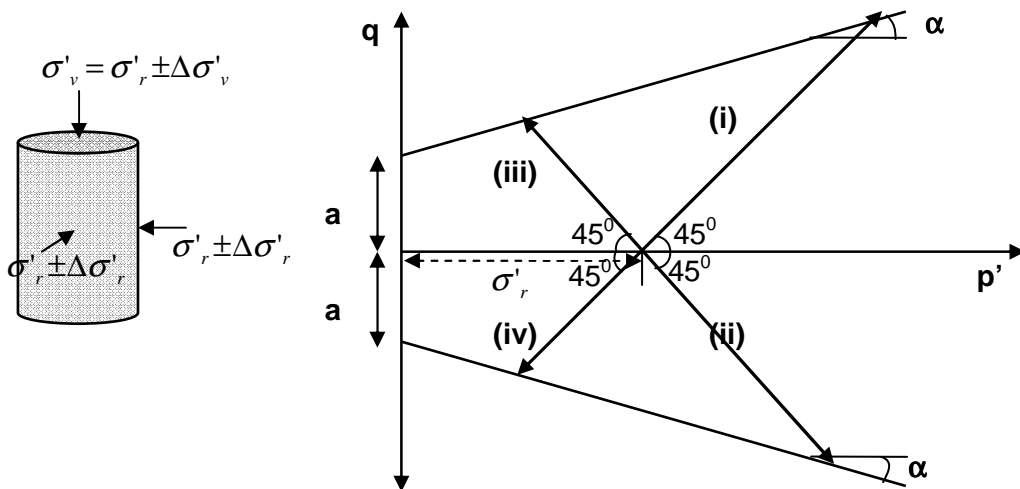


- (1) Initial condition
- (2) Unloading w/o drainage
- (3) Final condition

2) Triaxial Tests

- Drained (TSP = ESP)

$$\Rightarrow u_e = 0$$



i. **CID TXC** (σ'_v increases to failure with σ'_r constant)

Ex) Soil under center line of footing.

ii. **CID TXE** (σ'_v remains constant with σ'_r increasing to failure)

Ex) Passive resistance adjacent to toe of retaining wall (passive pressure case).

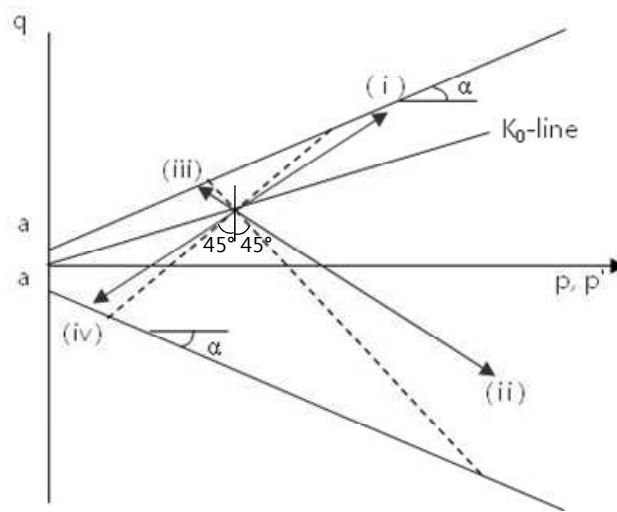
iii. **CID RTX** (σ'_v remains constant with σ'_r reducing to failure)

Ex) Soil adjacent to a retaining structure (active pressure case).

iv. **CID RTXE** (σ'_v decrease to failure with σ'_r constant)

Ex) Soil under center line of an excavation.

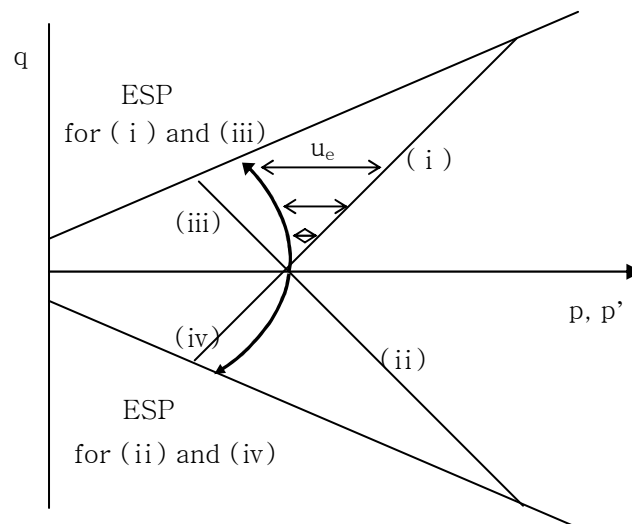
At field conditions



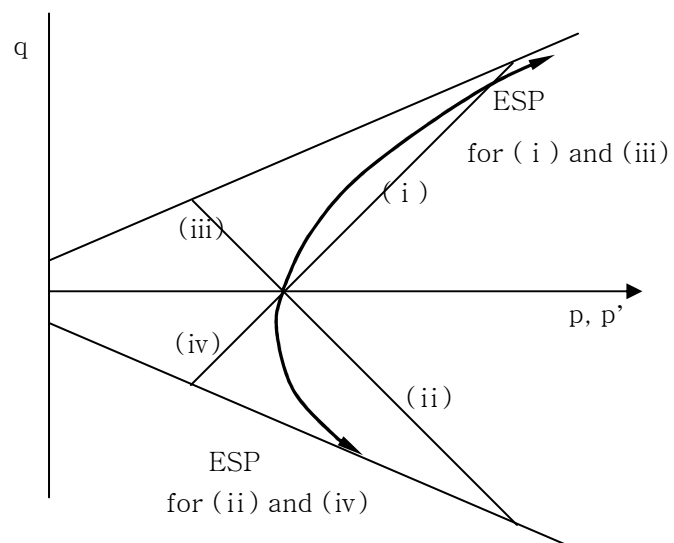
- Undrained

$\overline{CIU TX}$

loose sand
or
normally to lightly
overconsolidated
clay



dense sand
or
heavily overconsolidated
clay



Summary

1. If $\sigma_v > \sigma_h$, then q is (+).
If $\sigma_h > \sigma_v$, then q is (-).
2. Dropping lines at 45° from a point on a stress path to the p, p' axis gives the values of principal stresses.
3. If ESP is to the left of TSP, then u_e is (+).
If ESP is to the right of TSP, then u_e is (-).
4. For undrained loading, ESP's for TXC and TXE is same as those for RTXC and RTXE, respectively.

Definitions of Failure

Several common failure criteria from test results. (based on TXC test)

- ① $(\sigma_1 - \sigma_3)_{\max}$
- ② $(\sigma'_1 / \sigma'_3)_{\max}$
- ③ Limiting strain criteria.
- ④ Residual strength.
- ⑤ Critical state failure.

$$\frac{\partial(\sigma_1 - \sigma_3)}{\partial \epsilon_a} = 0 \text{ and}$$

$$\frac{\partial \sigma'_3}{\partial \epsilon_a} = 0, \frac{\partial u_e}{\partial \epsilon_a} = 0, \text{ or } \frac{\partial \epsilon_v}{\partial \epsilon_a} = 0$$

