CE394M: Stress paths and invariants

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Overview

Stresses / strains

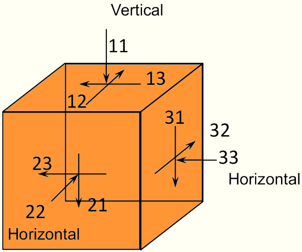
1D consolidation / simple shear

- Zero lateral strain ($\varepsilon_{22} = \varepsilon_{33} = 0$)
- Stresses: σ and τ
- Strains: $\varepsilon_{11} = \varepsilon_v$ and γ

2D plane strain

- Zero lateral strain ($\varepsilon_{22} = \gamma_{12} = \gamma_{23} = 0$)
- Stresses: s and t
- Strains: ε_v and ε_γ

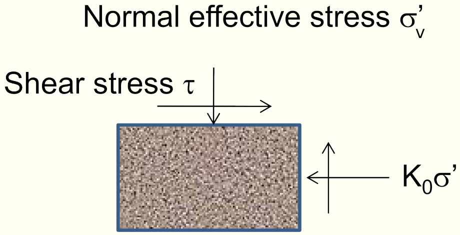
3D general (axi-symmetric as a special case)

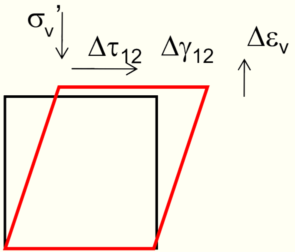


- Stresses: p and q
- Strains: ε_v and ε_s

1D simple shear

1. No lateral strain
2. Constant normal effective stress σ'_v
3. Increasing shear strain γ
4. Measure shear resistance τ
5. Measure volumetric strain ε_v or void ratio $e = e_0 - (1 + e_0)\varepsilon_v$
6. **No information for the lateral direction**





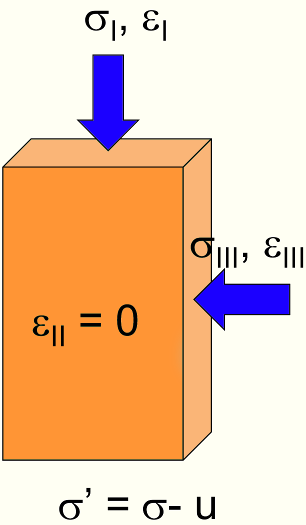
2D plane strain / Mohr-Coulomb model

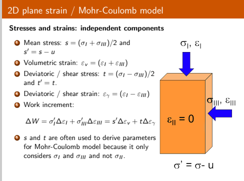
Stresses and strains: independent components

1. Mean stress: $s = (\sigma_I + \sigma_{III})/2$ and $s' = s - u$
2. Volumetric strain: $\varepsilon_v = (\varepsilon_I + \varepsilon_{III})$
3. Deviatoric / shear stress: $t = (\sigma_I - \sigma_{III})/2$ and $t' = t$.
4. Deviatoric / shear strain: $\varepsilon_\gamma = (\varepsilon_I - \varepsilon_{III})$
5. Work increment:

$$\Delta W = \sigma'_I \Delta\varepsilon_I + \sigma'_{III}\Delta\varepsilon_{III} = s'\Delta\varepsilon_v + t\Delta\varepsilon_\gamma$$

6. s and t are often used to derive parameters for Mohr-Coulomb model because it only considers σ_I and σ_{III} and not σ_{II}.

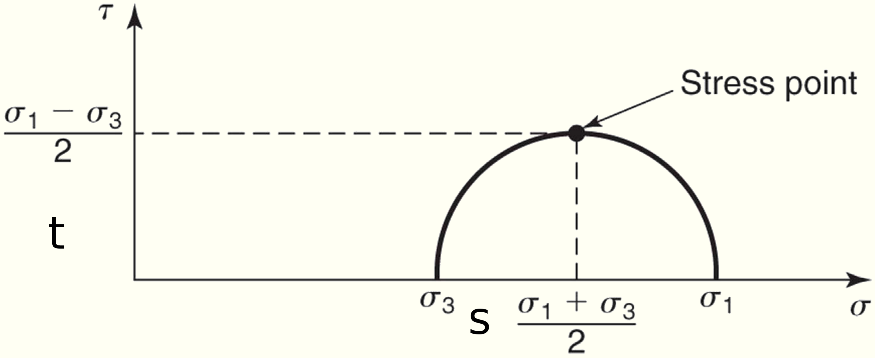




Principal stresses $\sigma_I > \sigma_{II} > \sigma_{III}$. This equation holds good and is the definition of σ in principal stress notations, i.e., $I > II > III$.

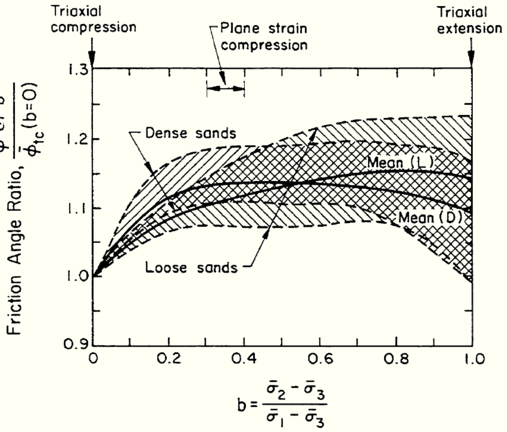
No shear stresses on these planes.

2D Mohr circle



Effect of σ_{II}

Bishop (1966) defined **b-value**: $b = (\sigma_{II} - \sigma_{III})/(\sigma_I - \sigma_{III})$, where $\sigma_I > \sigma_{II} > \sigma_{III}$. Triaxial compression $b = 0$, triaxial extension $b = 1$. Typically $\phi'_{ps} = (1.05 - 1.15)\phi'_{tx}$.



Ladd et al., (1975)

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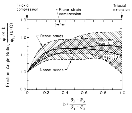

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σ_{II} do have an effect on soil behavior. For example, the friction angle depends on the loading condition: triaxial compression, plane-strain, triaxial extension and others . . . .