# CE 4780 Hurricane Engineering II

# Section on Flooding Protection: Earth Retaining Structures and Slope Stability

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Fall 2002

# Table of Content

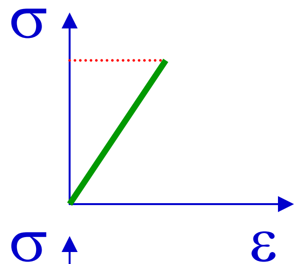


- Three weeks of classes

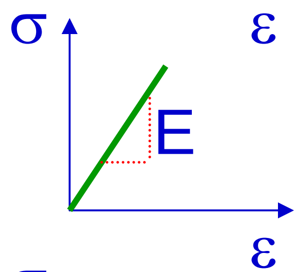
# Shear Strength of Soils

## Important Concepts

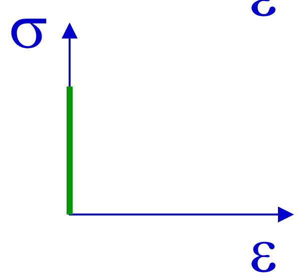
Strength



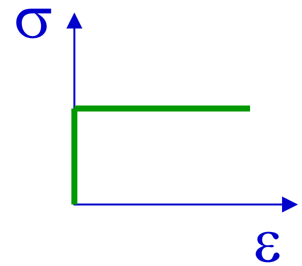

Stiffness




Rigid




Plastic




Hardness (bearing capacity)

Effective Stress!!

# Shear Strength of Soils

Factors controlling the shear strength

- Void ratio e
- Confining stress $\sigma'_o$
- Shear strength $\tau$
- Stiffness M, E, G
- Saturation and capillary effects
- Cementation
- Permeability k

# Shear Strength of Soils

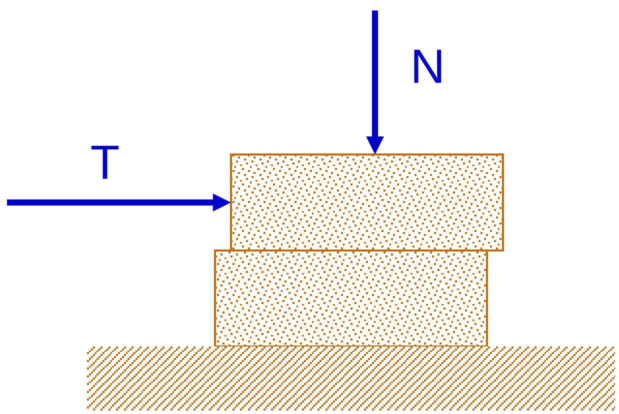
Factors controlling the shear strength

- Friction between particles
- Dilation
- Capillary forces
- Cementation

# Shear Strength of Soils

Factors controlling the shear strength

– Friction between particles




Amonton’s law are valid

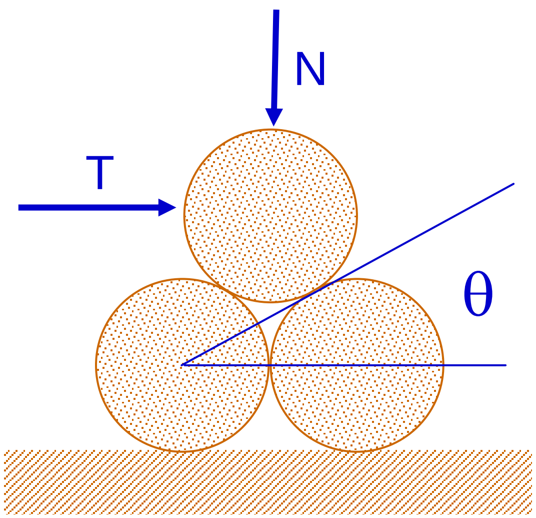
$$T = \mu N$$

# Shear Strength of Soils

Factors controlling the shear strength

- Dilation (compatibility of deformation)

- Assume smooth particles

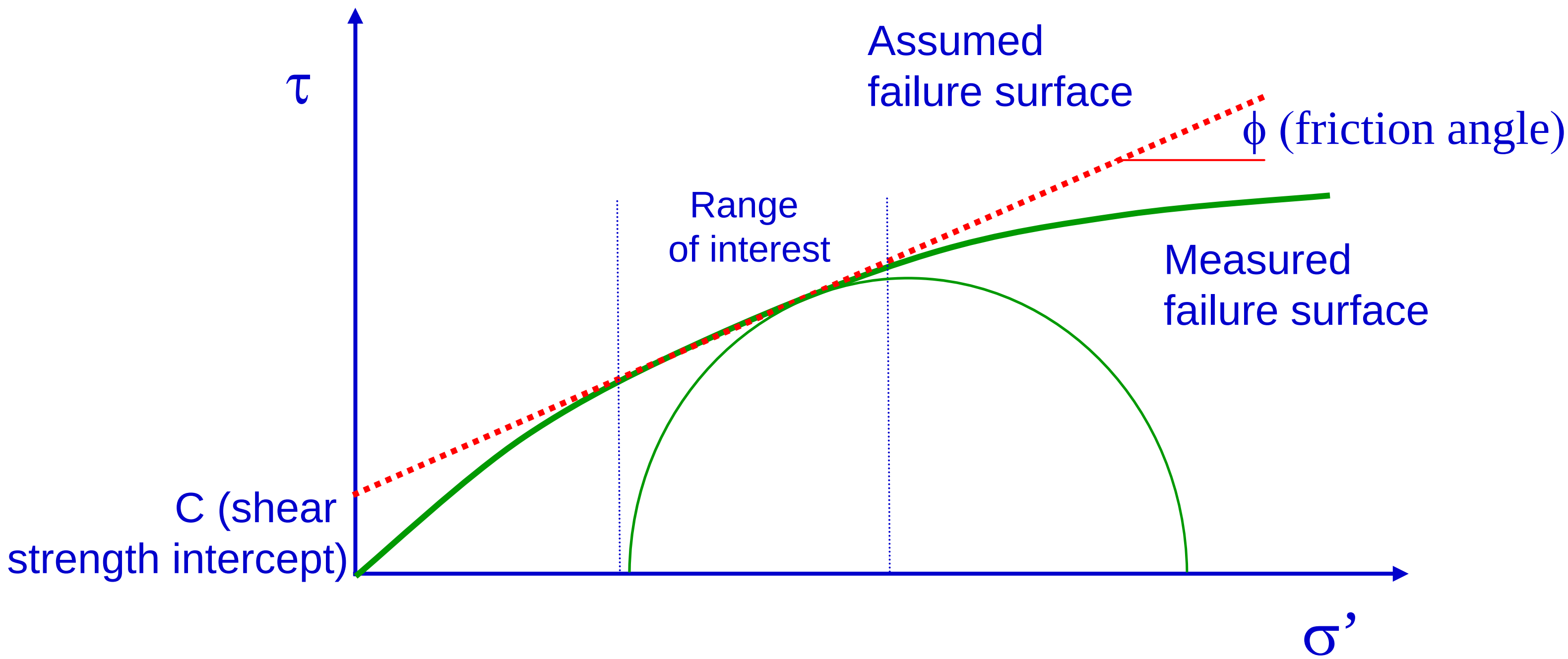



$$T = N \tan(\theta)$$

# Shear Strength of Soils

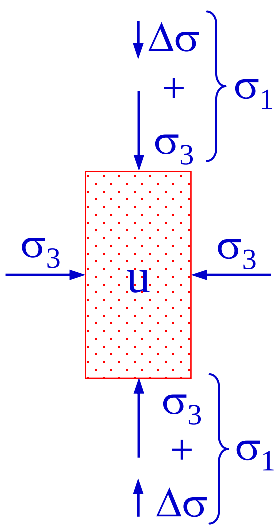
Factors controlling the shear strength

- Friction between particles and dilation: Mohr's circle and Coulomb's failure criteria

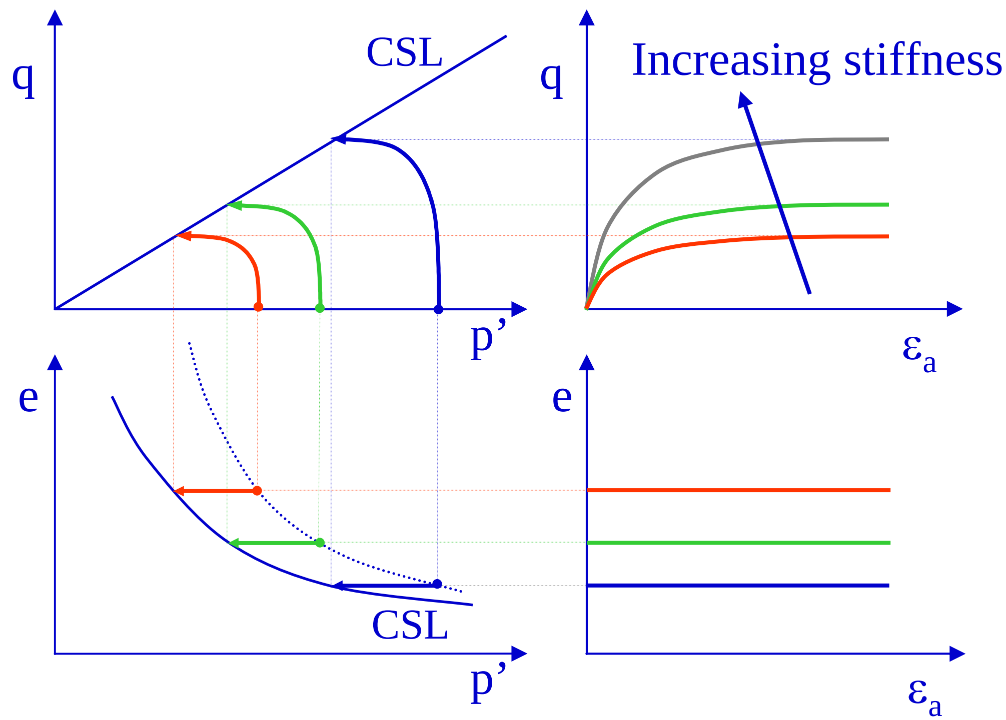


# Soil Behavior

- p,q,e plots – Effect of water – undrained tests

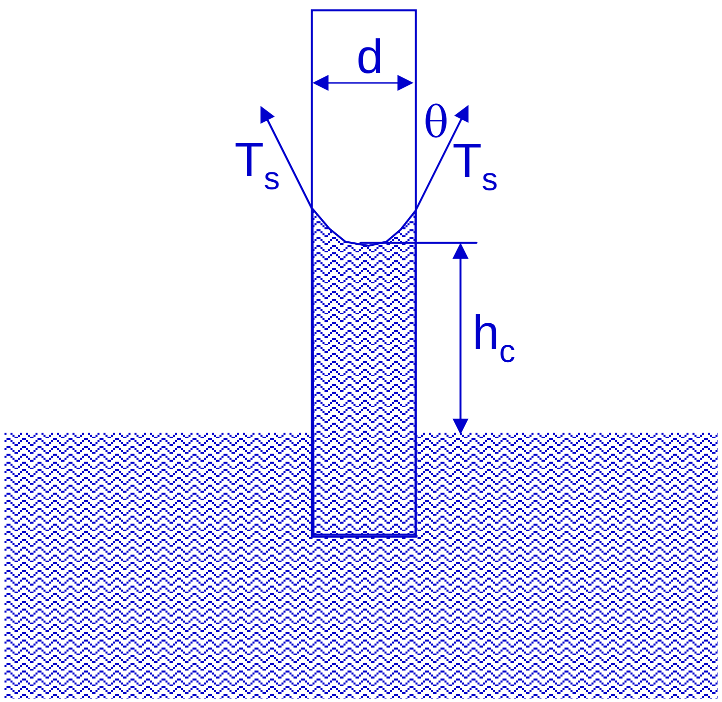



$$p' = \frac{\sigma'_1 + \sigma'_3}{2} \qquad q = \frac{\sigma_1 - \sigma_3}{2}$$



# Shear Strength of Soils

- Capillarity




Equilibrium equation in the y-direction:

$$\pi d T_s \cos(\theta) = \pi \frac{d^2}{4} h_c \gamma_w$$

Capillary height:

$$h_c = \frac{4 T_s \cos(\theta)}{d \gamma_w}$$

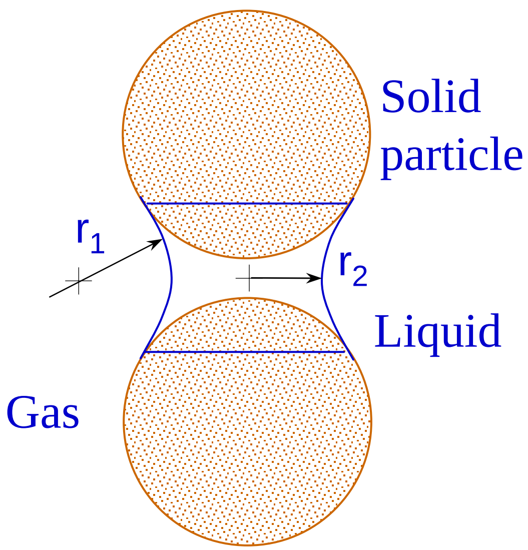
$$h_c \propto \frac{1}{d}$$

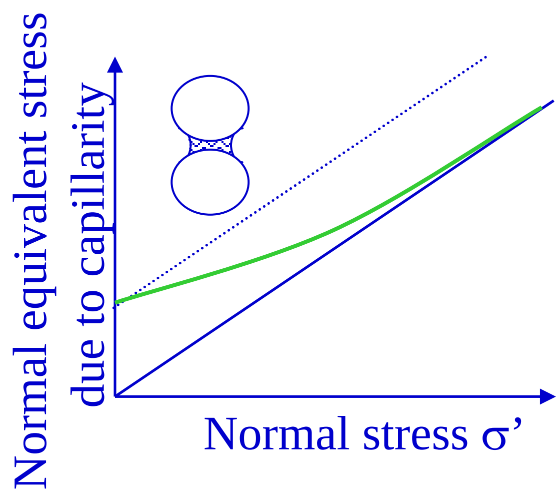
# Shear Strength of Soils

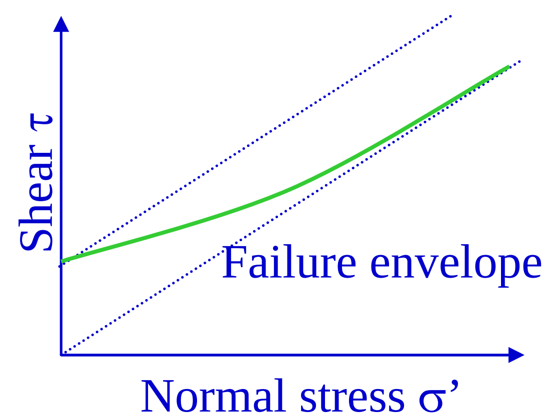
- Capillarity

Increase in strength and stiffness; e.g., most deposits

$$\Delta u = T_s\left(\frac{1}{r_1} + \frac{1}{r_2}\right) \qquad \sigma'_{eq} = \frac{\pi T_s}{4R}\left[2 - \left(\frac{8}{9} G_s w\right)^{\frac{1}{4}}\right]$$



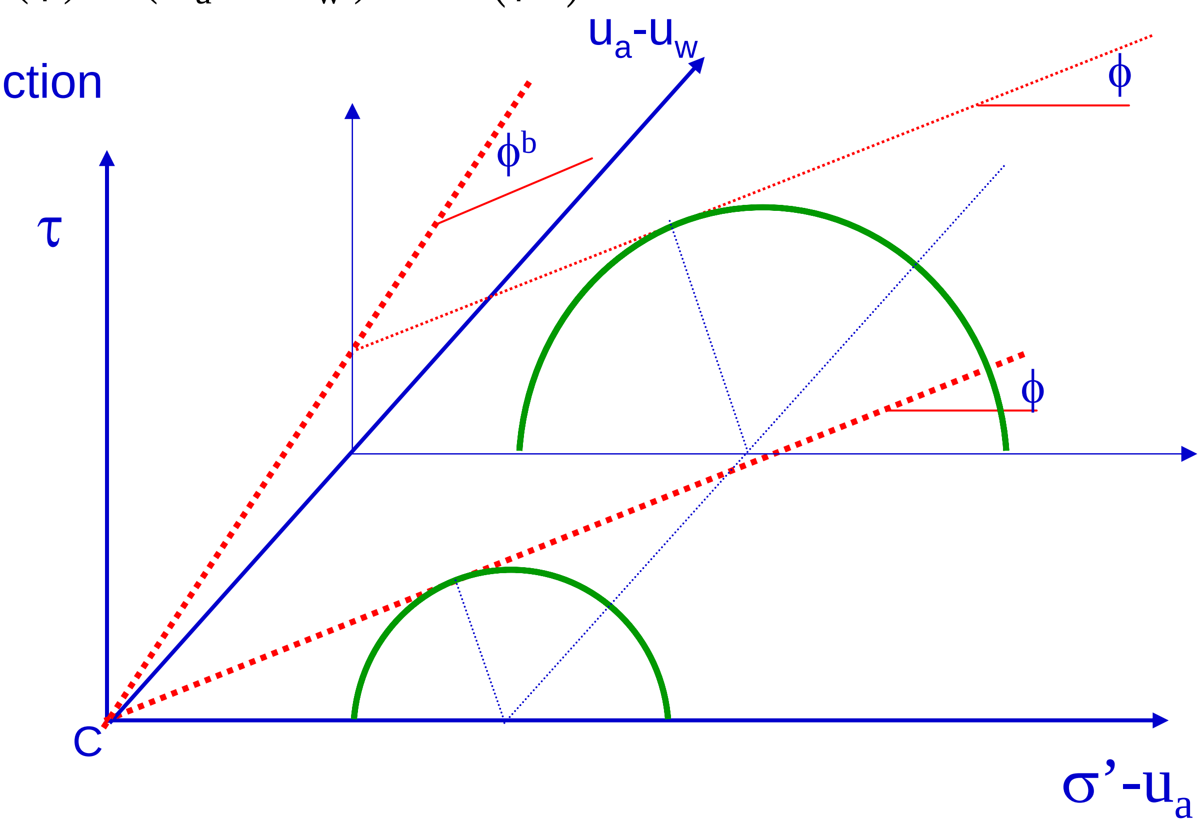
# Shear Strength of Soils

- Capillarity

Mohr-Coulomb for unsaturated soils ($S_r$<1.0)

$$\tau = (\sigma - u_a) \cdot \tan(\phi) + (u_a - u_w) \cdot \tan(\phi^b)$$

where $(u_a - u_w)$ is suction



# Shear Strength of Soils

- Cementation

Increase in stiffness E.g., loess deposits