CE 4780 Hurricane Engineering II

Section on Flooding Protection: Earth Retaining Structures and Slope Stability

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- Seepage Analysis
- Methods of Slope Stability Analysis
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- Example Problems

- Three weeks of classes

Introduction

- There are two types of earth retaining structures
  - Embankments (slope stability analysis)
  - Retaining walls (rigid - gravity - and flexible walls)

Basic Concepts of Lateral Earth Pressures

- At Rest or K_o Condition
  - The horizontal strain is zero

$$\sigma_{AV} = \gamma z_w + \gamma_{sat}(z_A - z_w)$$

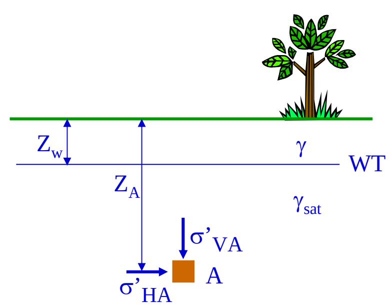
$$u_A = \gamma_w (z_A - z_w)$$

$$\boxed{\sigma'_{AV} = \sigma_{AV} - u_A}$$

$$\boxed{\sigma'_{AH} = K_o \sigma'_{AV}}$$

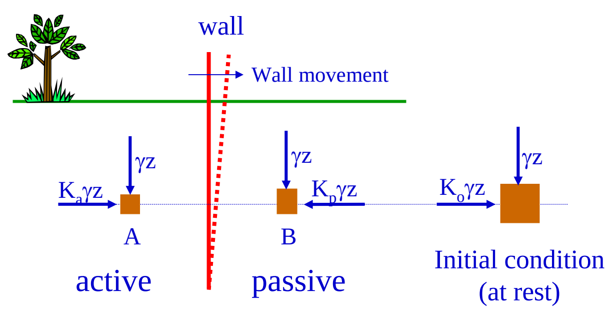
$$K_o = 1 - \sin(\phi) \quad \text{(for NC soils)}$$

$$\sigma_{AH} = \sigma'_{AH} + u_A$$



Basic Concepts of Lateral Earth Pressures

- Active K_A and Passive K_P Conditions
  - There is horizontal deformation

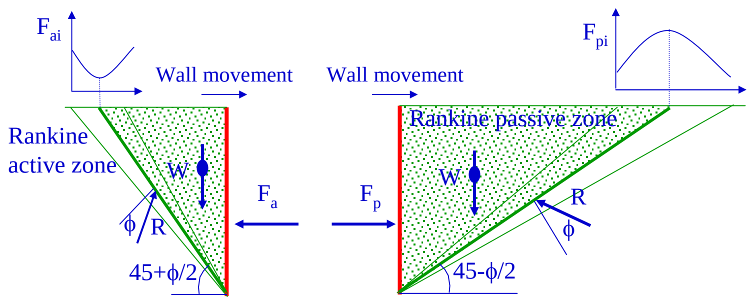


Basic Concepts of Lateral Earth Pressures

- Active K_A and Passive K_P Conditions
  - Limit equilibrium analysis
  - Coulomb (1776): upper bound theorem
  - Rankine (1857): lower bound theorem
  - Assumptions:
    - The earth retaining wall is vertical
    - The wall earth interface is frictionless (no shear stresses)
    - The soil surface is horizontal (no shear stresses)
    - The wall is rigid and the soil is dry, homogeneous and isotropic
    - The soil is loose and initially at rest

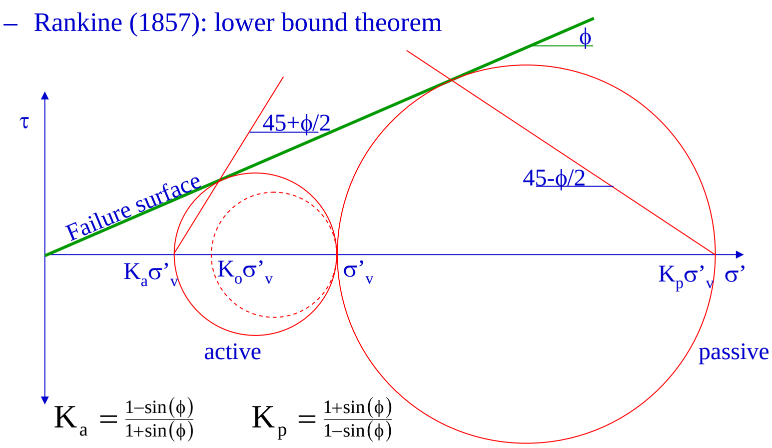
Basic Concepts of Lateral Earth Pressures

- Active K_A and Passive K_P Conditions
  - Coulomb (1776): upper bound theorem



Basic Concepts of Lateral Earth Pressures

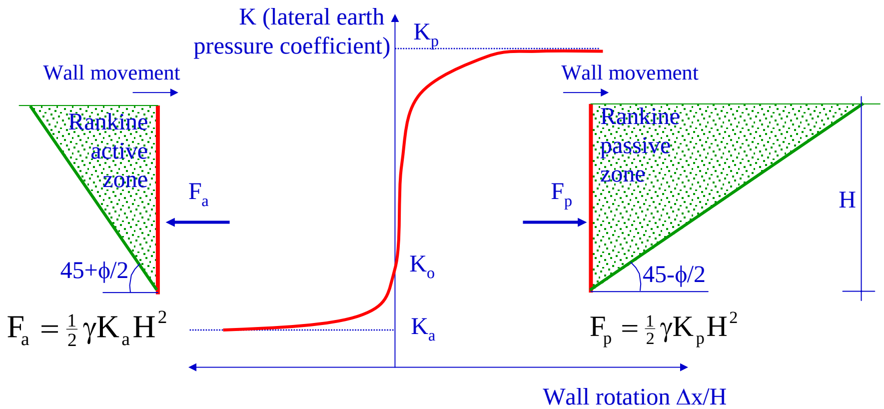
- Active K_A and Passive K_P Conditions
  - Rankine (1857): lower bound theorem



$$K_a = \frac{1-\sin(\phi)}{1+\sin(\phi)} \qquad K_p = \frac{1+\sin(\phi)}{1-\sin(\phi)}$$

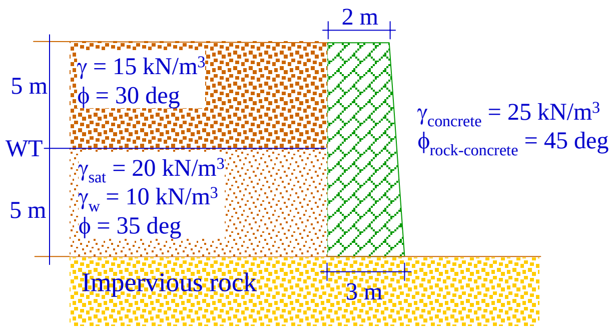
Basic Concepts of Lateral Earth Pressures

- Active K_A and Passive K_P Conditions



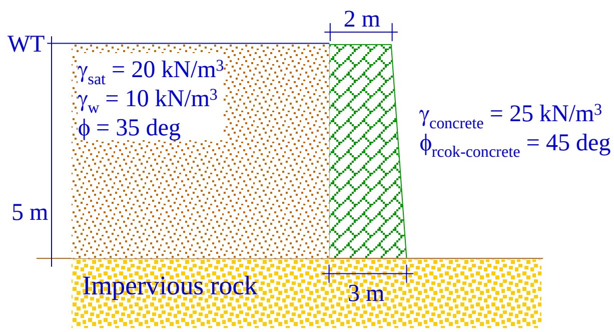
Example Problem

- Active Case
  - Determine the resultant earth force (magnitude and position) and the factors of safety against sliding and overturning



The Effect of Pore Water

- Active Case – No Drains
  - Determine the resultant earth force (magnitude and position) and the factors of safety against sliding and overturning



The Effect of Pore Water

- Active Case – Drains
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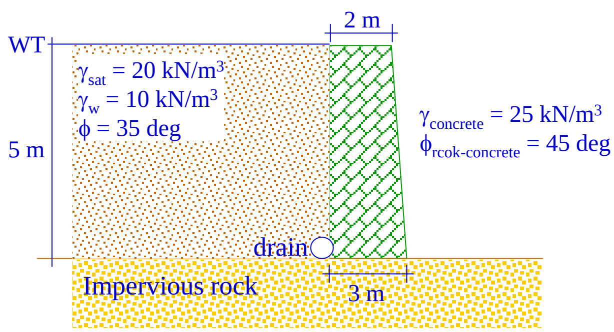
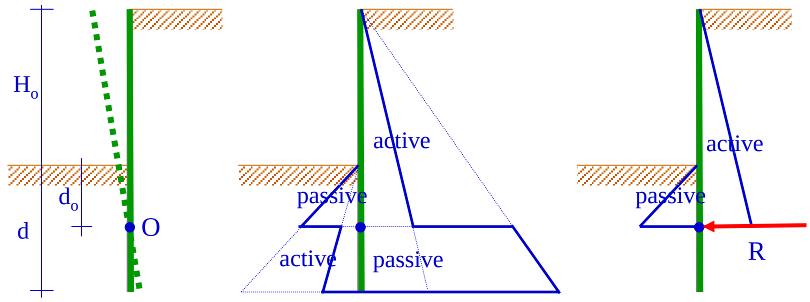


Cantilever Sheet Pile Walls

- Analysis



H_o = depth of excavation
d = depth of embedment
d_o = depth of rotation

Pressure distribution

Approximated pressure distribution

Cantilever Sheet Pile Walls

- Analysis (cont.)
  - Select a point O (arbitrary)
  - Calculate the active and passive earth pressures (reduce the strength parameters: ϕ/F_ϕ, where F_ϕ = 1.2 to 1.5)
  - Calculate the net pore water pressure and the seepage force.
  - Determine the depth d_o by summing moments about O.
  - Determine d = 1.2 to 1.3 d_o.
  - Calculate R by summing forces horizontally over the depth (H_o+d).

Cantilever Sheet Pile Walls

- Analysis (cont.)
  - Determine net passive resistance between d_o and d.
  - Check that R is greater than net passive resistance. If not extent the depth of embedment and determine new R.
  - Calculate the maximum bending moment M_{max} over H_o-d_o.
  - Determine the section modulus: $S = M_{max}/\sigma_{allow}$

References and Bibliography

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