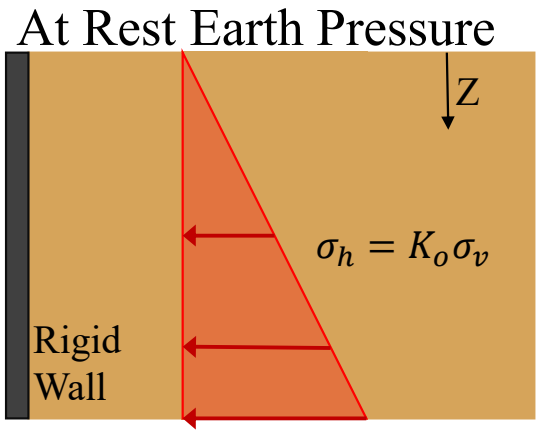
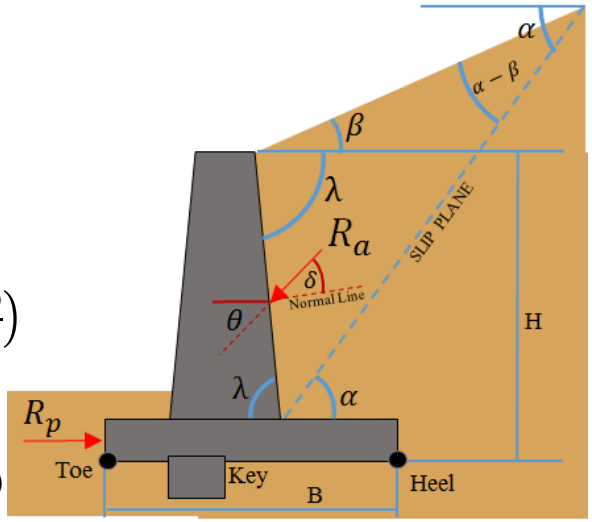
Lateral Pressure and Retaining Structures



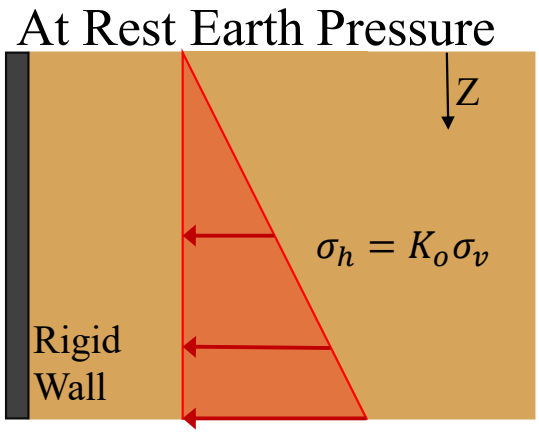
Active & Passive Earth Pressure

General Considerations: CERM 37 & Essentials-McCarthy (719)

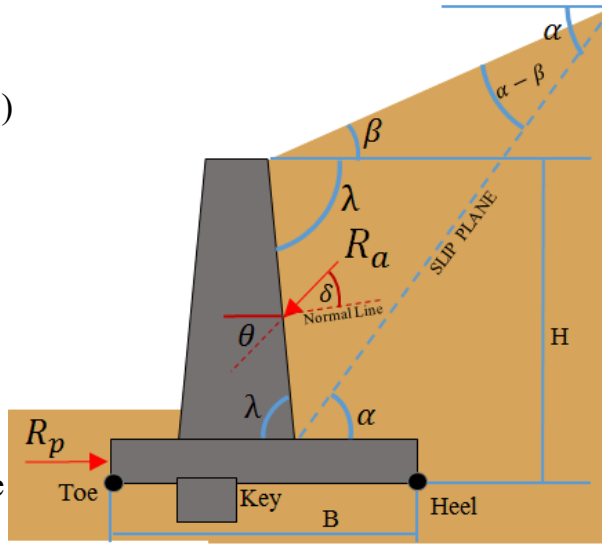
- Earth Pressure Types
  - **AT REST**: When homogenous isotropic soil, vertical principal stress is = to the overburden
    - or $\sigma_v = \gamma_{soil} Z$
    - The horizontal pressure is related to vertical pressure by $\frac{\sigma_h}{\sigma_v} = \frac{v}{1-v} = 1 - \sin(\phi')$
      - Where: ϕ' is the effective stress angle of internal friction.
      - This is valid for OCR = 1. For greater OCR use $\sigma_h = \sigma_v[1 - \sin(\phi')\,]OCR^{\sin(\phi')}$
    - Pressure per unit length of wall = $P_0 = \frac{1}{2}K_o\gamma_t H^2$
    - When submerged, intergranular (effective) stress σ_v'
      - $\sigma_v' = \sigma_v - u$
  - **ACTIVE:** Wall and soil movement pushing the wall out (away from the soil mass)
    - General Active horizontal earth pressure w/ level backfill: $p_a = p_v K_a - 2c\sqrt{K_a}$
      - This potentially allows the cohesion to cause tension cracking **at the top**.
    - General equation for $K_a = \dfrac{sin^2(\lambda+\phi)}{sin^2\lambda\, sin(\lambda-\delta)\left(1+\sqrt{\frac{sin(\phi+\delta)sin(\phi-\beta)}{sin(\lambda-\delta)sin(\lambda+\beta)}}\right)^2}$ see figure ➔ for symbols
      - **This equation is modified by geometry, soil type, and friction theory (CERM 37-3)**
  - Common ($\beta = 0$ & $\lambda = 90^o$) for dry cohesionless Rankine (no friction δ) soil $K_a = tan^2\left(45 - \frac{\phi}{2}\right)$
    - **Total Active Resultant per unit of wall length(acting at H/3 from bottom):**
      - **DRY COHESIONLESS SOIL:** $R_a = \frac{1}{2}p_a H = \frac{1}{2}K_a\gamma H^2$
      - **INTERNAL FRICTION & COHESION:** $R_a = \frac{1}{2}K_a\gamma H^2 - 2c\sqrt{K_a}$ (essentials pg 726)



Lateral Pressure and Retaining Structures



Active & Passive Earth Pressure



<u>General Considerations: CERM 37 & Essentials-McCarthy (719)</u>

- Earth Pressure Types
  - **Passive:** Wall and soil movement pushing against the soil mass
    - General PASSIVE horizontal pressure w/ level backfill: $p_p = p_v K_p + 2c\sqrt{K_p}$
      - General equation for $K_p = \frac{sin^2(\lambda - \phi)}{sin^2\lambda\, sin(\lambda+\delta)\left(1-\sqrt{\frac{sin(\phi+\delta)sin(\phi+\beta)}{sin(\lambda+\delta)sin(\lambda+\beta)}}\right)^2}$ see figure ➔ for symbols
      - **This equation is modified by geometry, soil type, and friction theory (CERM 37-4)**
  - Common ($\beta = 0$ & $\lambda = 90^o$)for dry cohesionless Rankine (no friction δ) soil $K_p = tan^2\left(45 + \frac{\phi}{2}\right)$
    - **Total Active Resultant per unit of wall length(acting at H/3 from bottom):**
      - **DRY COHESIONLESS SOIL:** $R_p = \frac{1}{2}p_p H = \frac{1}{2}K_p\gamma H^2$
      - **INTERNAL FRICTION & COHESION:** $R_p = \frac{1}{2}K_p\gamma H^2 + 2c\sqrt{K_p}$ (essentials pg 726)

Keywords:

Level backfill ➔ $\beta = 0$

Vertical Wall ➔ $\lambda = 90^o$

Rankine Theory ➔ No wall friction ($\delta = 0$)

Granular Soil/Sand ➔ $c = 0$

Saturated Clay ➔ $\emptyset = 0$ & $K_p = K_a = 1$

Good Visuals on pg 725 & 725 of Essentials McCarthy.

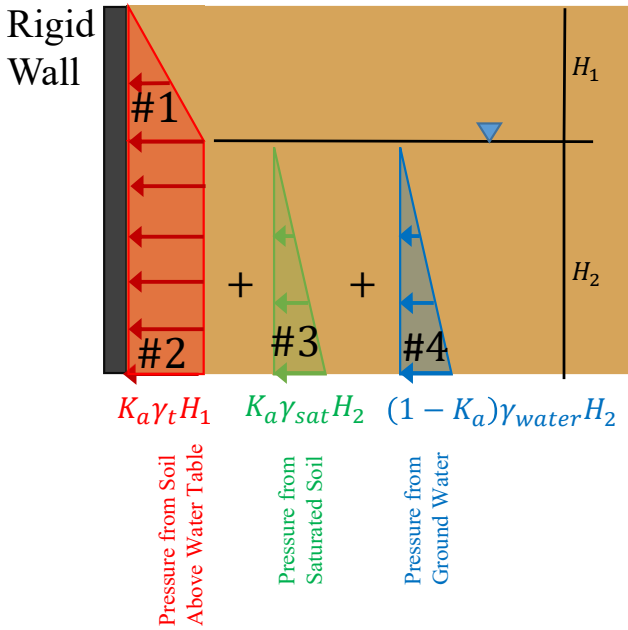
More movement/strain is required to achieve the PASSIVE state than the ACTIVE STATE

Active & Passive similar when top of wall is fixed. When the wall is going away from soil ➔ Active state

Components of R_a & R_p (See CERM 37-7)

Lateral Pressure and Retaining Structures

Lateral Pressure w/ water table behind wall



Effects of Groundwater & Freezing

- Groundwater affects the way the soil particles react to the wall
  - The general equation for pressure is a combination of loads above and below water line
    - Resulting Pressure per unit length $R_a = \#1 + \#2 + \#3 + \#4$ *or*
    - $R_a = \frac{1}{2}K_a\gamma_t {H_1}^2 + K_a\gamma_t H_1 H_2 + \frac{1}{2}K_a\gamma_{sat}{H_2}^2 + \frac{1}{2}(1-K_a)\gamma_{water}{H_2}^2$
    - Acting at a height of $h_{res} = \frac{\Sigma[R_{a(indiv)}h_{res(indiv)}]}{Total\ R_a}$

Surcharge loading Cerm 37-8 & 752 essentials.

- Depends on load type.
  - For distributed load, apply an additional pressure $R_{a(surcharge)} = K_a q H$
  - Point loads require some equations.
    - See CERM 37-8 & Essentials pg 752.

Design Considerations

- Overturning (CERM example pg 37-9)
- Sliding (CERM Example 37-9 & 37-11)
- Bearing Capacity check (CERM Example 37-9)
- General Sizing of Cantilever Retaining Walls (CERM 37-12)
- CONCRETE DESIGN (CERM 54)