Department of Civil Engineering
Katihar Engineering College, Katihar

Topic: Lateral Earth Pressure theory

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Lecture: 03

There are two classical theories on Lateral Earth Pressure

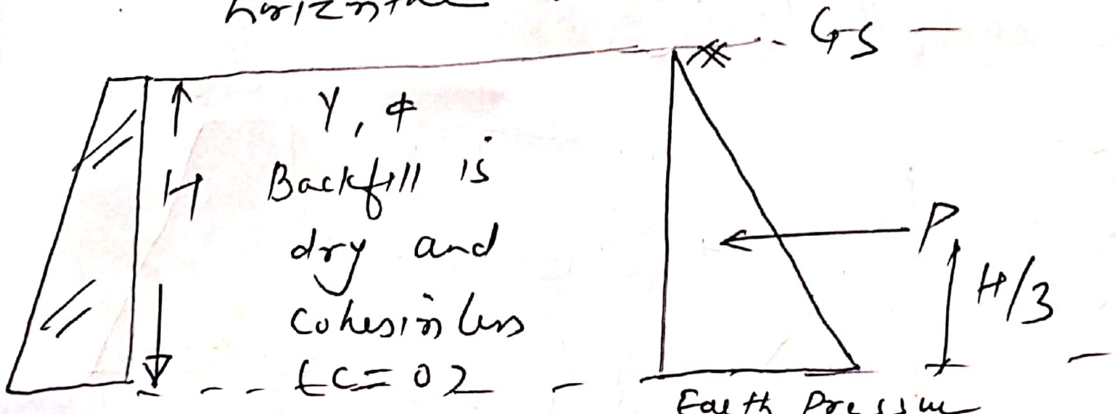
① Rankine Earth Pressure (1857)

② Coulomb's Wedge Theory (1776)

1. Rankine Earth Pressure theory (1857)

Assumptions:

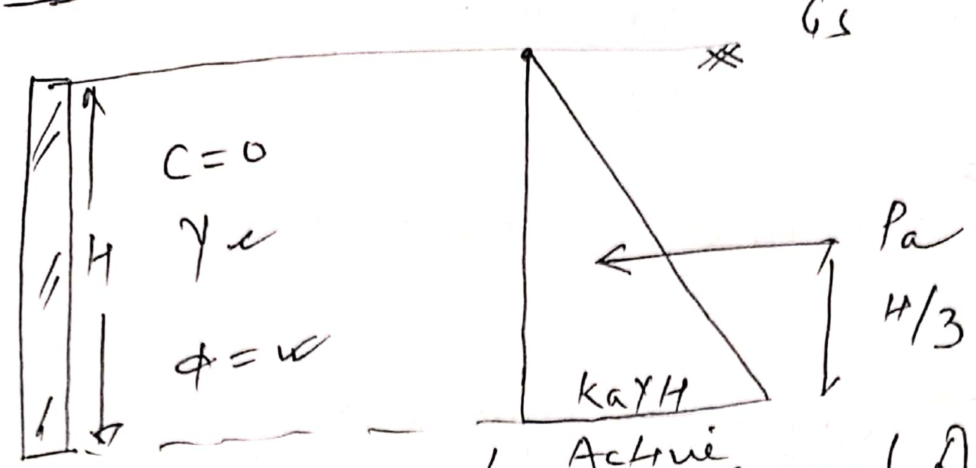
1. The soil is homogeneous, isotropic.
2. The backfill ~~of~~ is dry
3. The soil backfill is cohesionless (c=0)
4. The backface of the wall is smooth means there is no friction b/w wall and backfill
5. The Ground surface is may be horizontal or inclined.



Earth Pressure diagram

Active Case

Case 1. When Backfill is Dry



Active Earth Pressure diagram (Due to ϕ-soil)

$$K_a = \frac{\sigma_a'}{\sigma_v'}$$

$$\sigma_a' = k_a \sigma_v' = k_a \gamma z$$

Active Earth Pressure $(p_a) = k_a \gamma H$

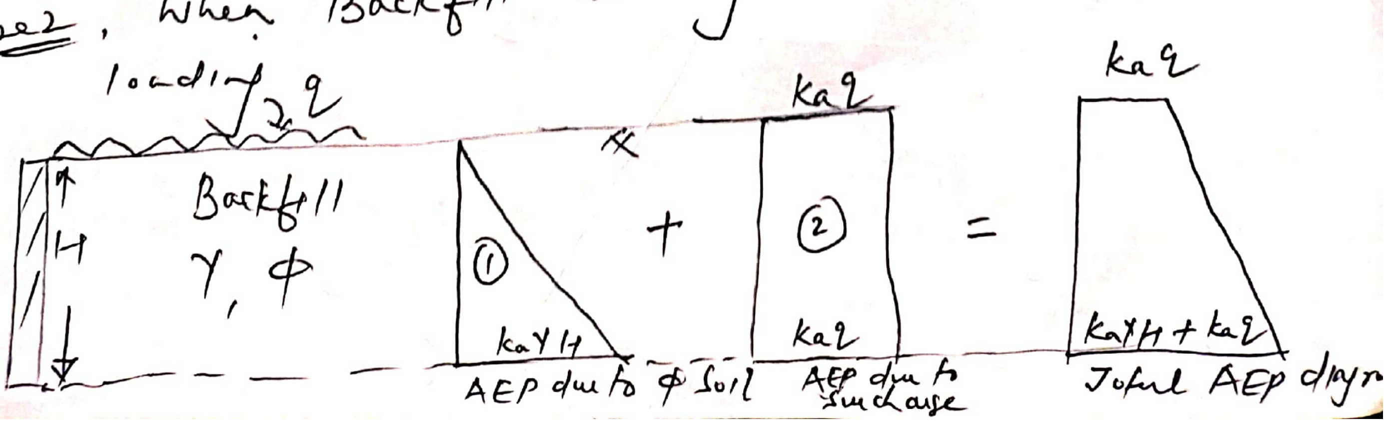
Total Active thrust $(P_a) = \int_0^H (p_a)\,dz$

$$= \frac{1}{2} k_a \gamma H^2$$ acting at H/3 from base of the wall

Where k_a = Active EP coefficient

$$= \frac{1-\sin\phi}{1+\sin\phi}$$

Case 2. When Backfill is dry and Effect of surcharge loading, q



So we know that

$$K_a = \frac{\sigma_h'}{\sigma_v'} = \frac{\sigma_h}{\sigma_v} = \frac{\sigma_h}{q}$$

$$\sigma_h = K_a \cdot q$$

When $Z = 0$, $\sigma_a = K_a q$

When $Z = H$, $\sigma_a = K_a q$

Active Earth Pressure due to ϕ-soil $(p_{a_1}) = K_a \gamma H$

Total active thrust due to ϕ-soil $(P_{a_1}) = \frac{1}{2} K_a \gamma H^2$ acting as $\frac{H}{3}$ from base of the wall

Active Earth Pressure due to surcharge loading q $(p_{a_2}) = K_a q$

Total Active thrust due to surcharge loading q $(P_{a_2}) = (K_a q) H$ acting as $\frac{H}{2}$ from base of the wall

Total Active thrust due to ϕ-soil and surcharge loading (q) $(P_a) = P_{a_1} + P_{a_2}$

$$\boxed{P_a = \frac{1}{2} K_a \gamma H^2 + K_a q H}$$

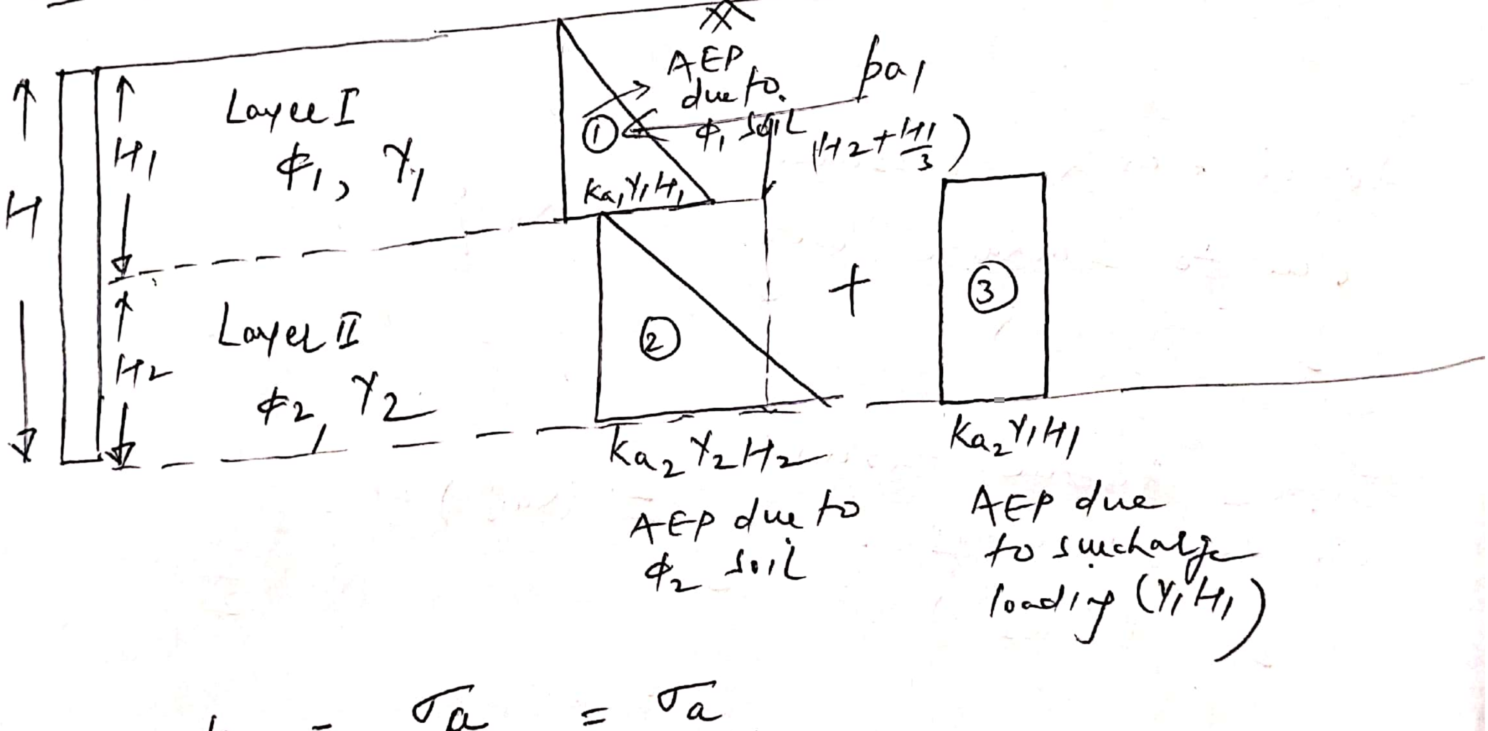
Let Z be the Line of action of Pa

$$P_a \times Z = P_{a_1} \times Z_1 + P_{a_2} \times Z_2$$

$$Z = \frac{P_{a_1} \times Z_1 + P_{a_2} \times Z_2}{P_a}$$

$$\boxed{Z = \frac{\frac{1}{2} K_a \gamma H^2 \times \frac{H}{3} + K_a q H \times \frac{H}{2}}{\frac{1}{2} K_a \gamma H^2 + K_a q H}}$$

Case 3. Layered Soil



$$K_{a_2} = \frac{\sigma_a}{\sigma_v} = \frac{\sigma_a}{\gamma_1 H_1}$$

$$\sigma_a = K_{a_2} \gamma_1 H_1$$

For Layer – I.

$$K_{a_1} = \frac{1 - \sin\phi_1}{1 + \sin\phi_1}$$

Active Earth Pressure due to ϕ_1 - Soil $(p_{a1}) = K_{a1} \gamma_1 H_1$

Active thrust due to ϕ_1 - Soil $(P_{a1}) = \frac{1}{2} K_{a1} \gamma_1 H_1^2$ acting at $\left(H_2 + \frac{H_1}{3}\right)$ from base of the wall

In Layer - II

Active Earth Pressure due to ϕ_2 - Soil $(p_{a2}) = K_{a2} \gamma_2 H_2$

Where $K_{a2} = \dfrac{1 - \sin\phi_2}{1 + \sin\phi_2}$

Active thrust due to ϕ_2 - Soil $(P_{a2}) = \frac{1}{2} K_{a2} \gamma_2 H_2^2$ acting at $\frac{H_2}{3}$ from the of the wall

Active Earth Pressure due to surcharge loading $(\gamma_1 H_1)$ $(p_{a3}) = K_{a2} \gamma_1 H_1$

Active thrust due to surcharge loading $(\gamma_1 H_1)$ $(P_{a3}) = K_{a2} \gamma_1 H_1 H_2$ acting at $\frac{H_2}{2}$ from base of the wall

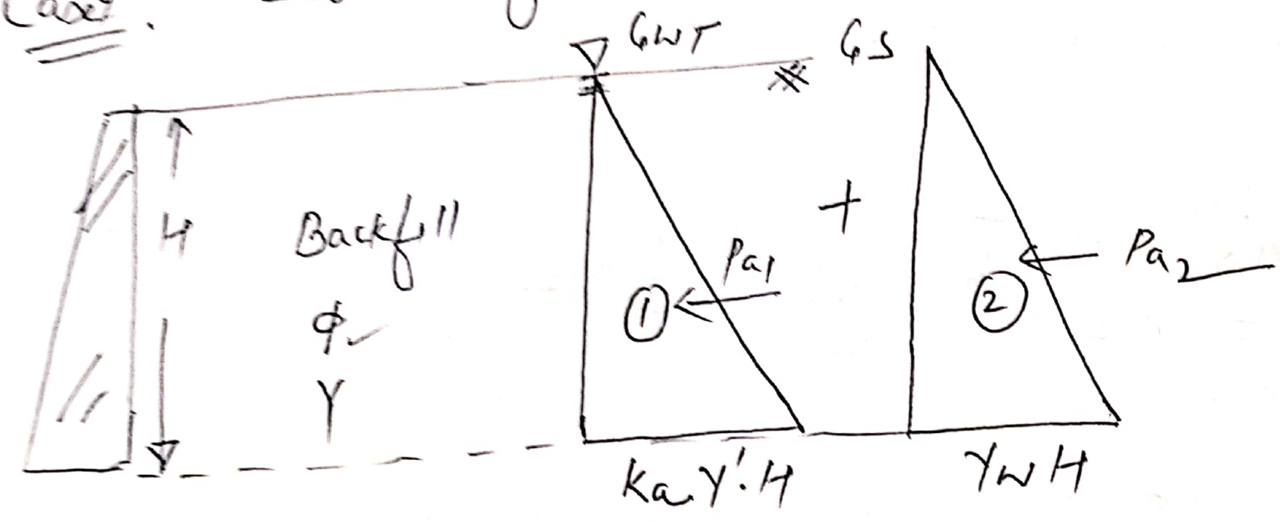
$$\boxed{\text{Total Active thrust } (P_a) = P_{a_1} + P_{a_2} + P_{a_3}}$$

Let z be the line of action

$$P_a \times z = P_{a_1} z_1 + P_{a_2} z_2 + P_{a_3} z_3$$

$$\boxed{z = \frac{P_{a_1} \times \left(H_2 + \frac{H_1}{3}\right) + P_{a_2} \times \frac{H_2}{3} + P_{a_3} \times \frac{H_2}{2}}{P_a}}$$

Case 4. Effect of water table



Active Earth Pressure due to ϕ-soil $(p_{a_1}) = K_a \gamma' H$

Where $\gamma' \rightarrow$ Submerged unit weight of soil

K_a = Active Earth Pressure Coefficient

$$= \frac{1 - \sin\phi}{1 + \sin\phi}$$

Active thrust due to ϕ-soil $(P_{a_1}) = \frac{1}{2} K_a \gamma' H^2$ acting as $H/3$ from base of the wall

Active Earth Pressure due to water table $(p_{a_2}) = \gamma_w H$

Where $\gamma_w \rightarrow$ unit weight of water

Active thrust due to presence of water table $(P_{a_2}) = \frac{1}{2}\gamma_w H^2$ acting at $H/3$ from base of the wall

$$P_a = P_{a_1} + P_{a_2}$$

$$= \frac{1}{2} k_a \gamma' H^2 + \frac{1}{2}\gamma_w H^2$$

$$\bar{z} = \frac{P_{a_1} \times \bar{z}_1 + P_{a_2} \times \bar{z}_2}{P_a}$$

$$\bar{z} = \frac{\frac{1}{2} k_a \gamma' H^2 \times \frac{H}{3} + \frac{1}{2}\gamma_w H^2 \times \frac{H}{3}}{\frac{1}{2} k_a \gamma' H^2 + \frac{1}{2}\gamma_w H^2}$$

<Happy Learning>