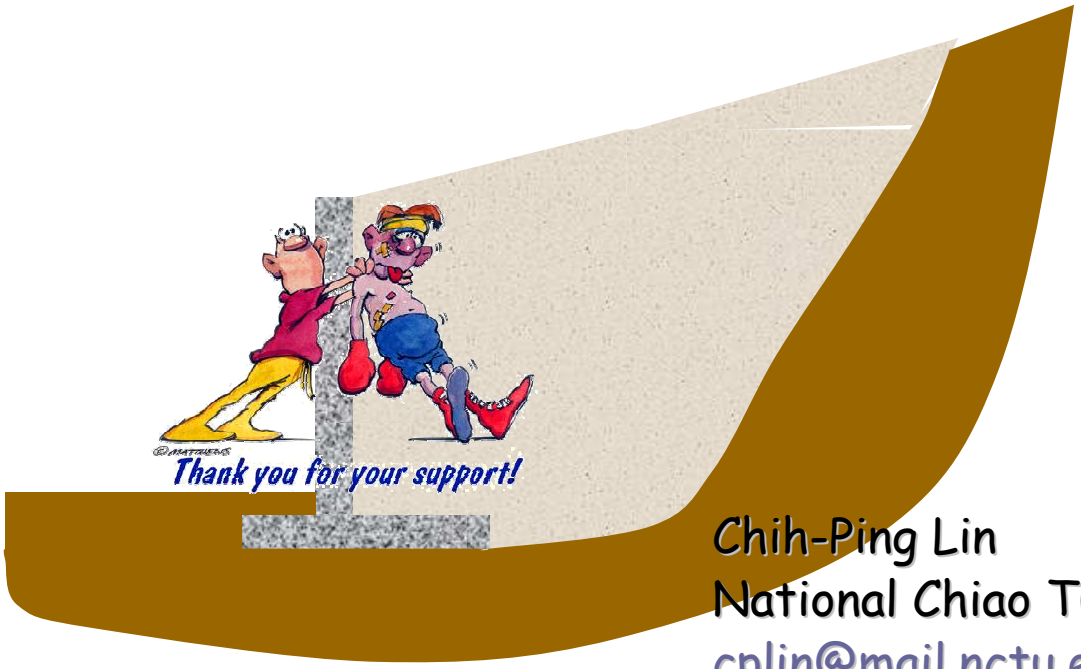
Soil Mechanics – **Lateral Earth Pressure**



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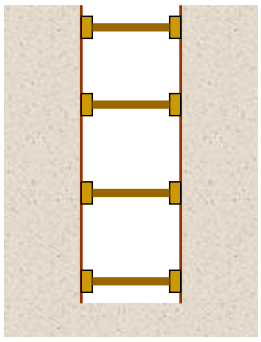
Outline

- Geotechnical applications
- K_0, active & passive states
- Rankine's earth pressure theory
- Coulomb's earth pressure theory

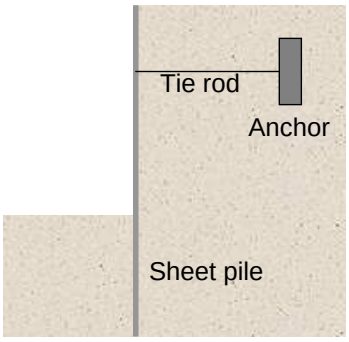
Lateral Support

In geotechnical engineering, it is often necessary to prevent lateral soil movements.

Cantilever retaining wall



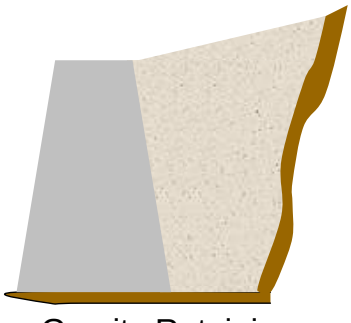
Braced excavation



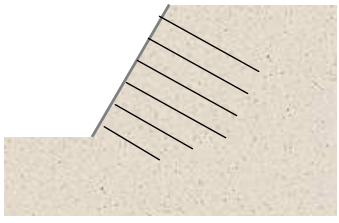
Anchored sheet pile

Lateral Support

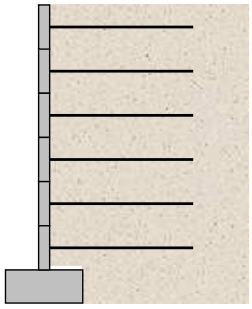
We have to estimate the lateral soil pressures acting on these structures, to be able to design them.



Gravity Retaining wall



Soil nailing



Reinforced earth wall

Soil Nailing

Sheet Pile

Sheet piles marked for driving

Sheet Pile

Sheet pile wall

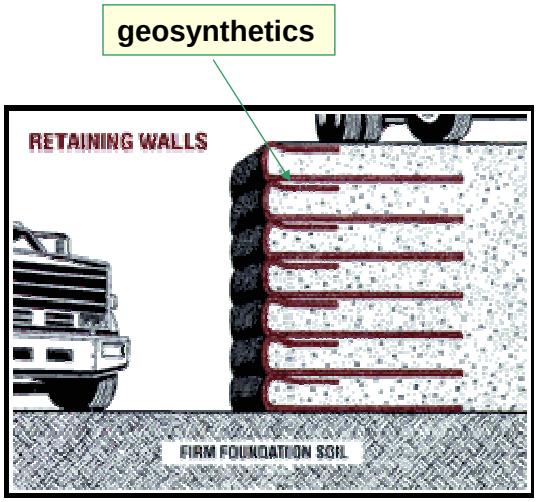
Sheet Pile

During installation

Sheet pile wall

Reinforced Earth Wall

Reinforced earth walls are increasingly becoming popular.

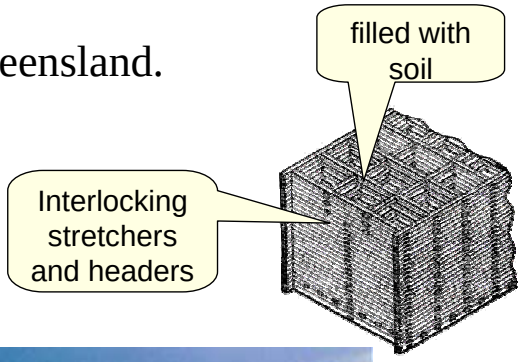


Crib Wall

Crib walls have been used in Queensland.

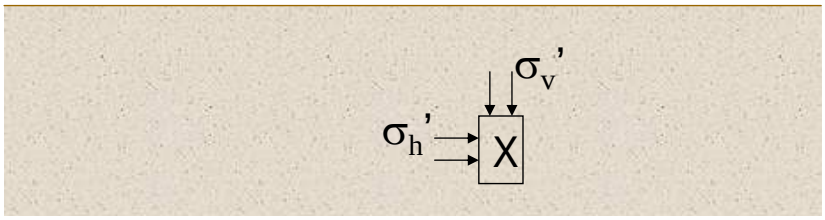
Good drainage & allow plant growth.

Looks good.



Earth Pressure at Rest

In a homogeneous natural soil deposit,



the ratio σ_h'/σ_v' is a constant known as coefficient of earth pressure at rest (K_0).

$$K = \frac{\sigma_h'}{\sigma_v'}$$

Importantly, at K_0 state, there are no lateral strains.

Estimating K_0

For normally consolidated clays and granular soils,

$$K_0 = 1 - \sin \phi'$$

For overconsolidated clays,

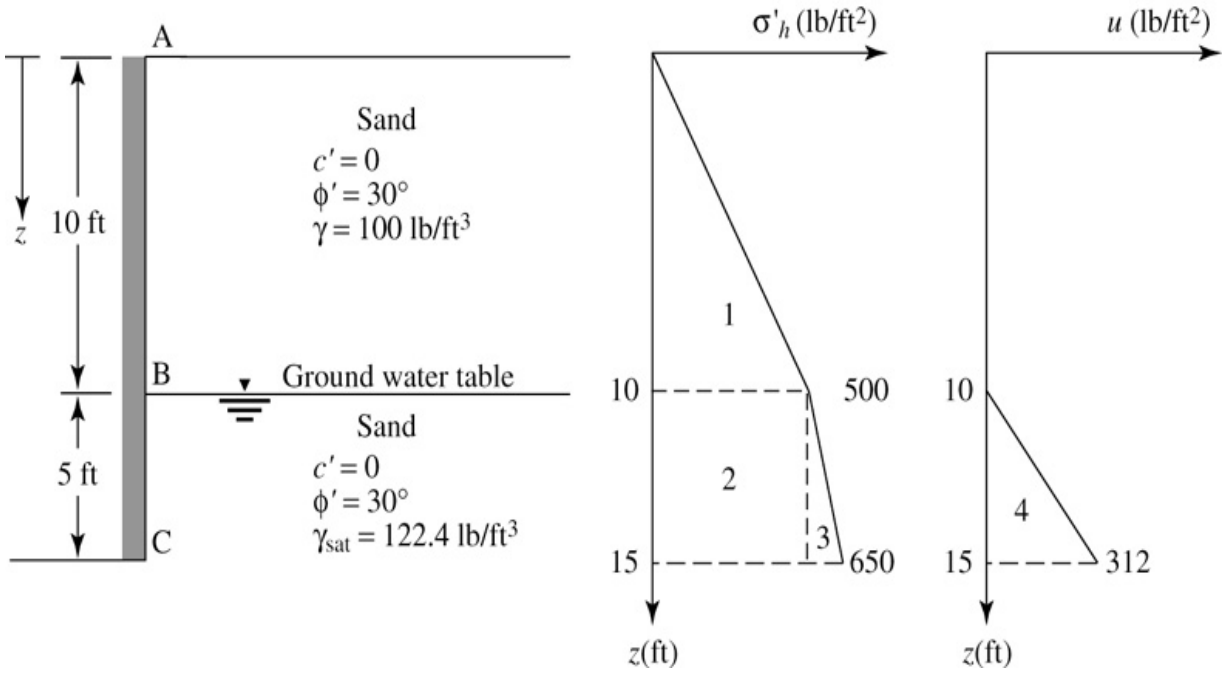
$$K_{0,\text{overconsolidated}} = K_{0,\text{normally consolidated}}\ OCR^{0.5}$$

From elastic analysis,

$$K_0 = \frac{\upsilon}{1-\upsilon}$$

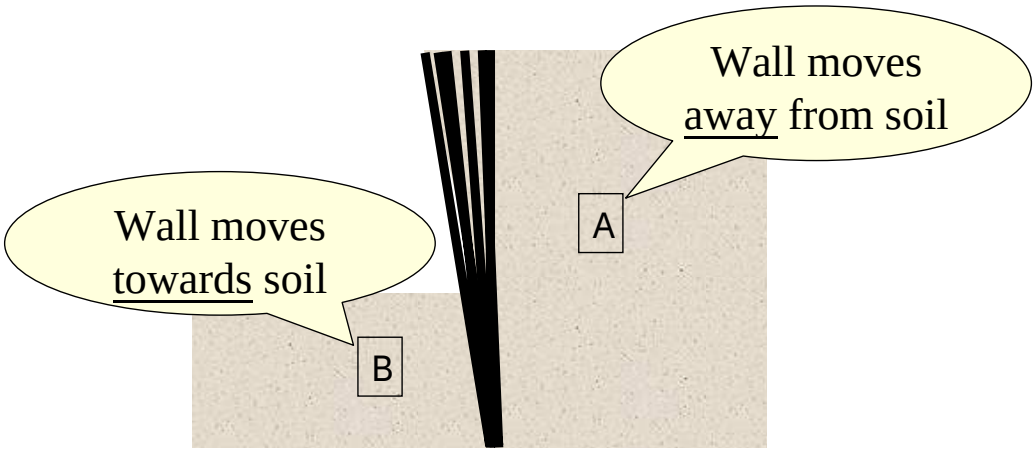
Poisson's ratio

Example 12.1



Active/Passive Earth Pressures

- in **granular** soils

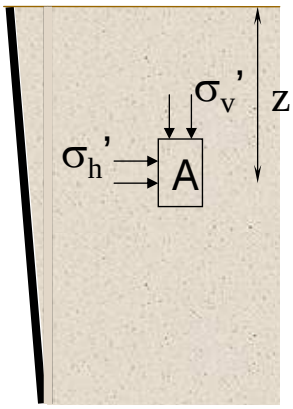


smooth wall

Let's look at the soil elements A and B during the wall movement.

Active Earth Pressure

- in **granular** soils



$\sigma_v' = \gamma z$

Initially, there is no lateral movement.

$\therefore \sigma_h' = K_0 \sigma_v' = K_0 \gamma z$

As the wall moves away from the soil,

σ_v' remains the same; and

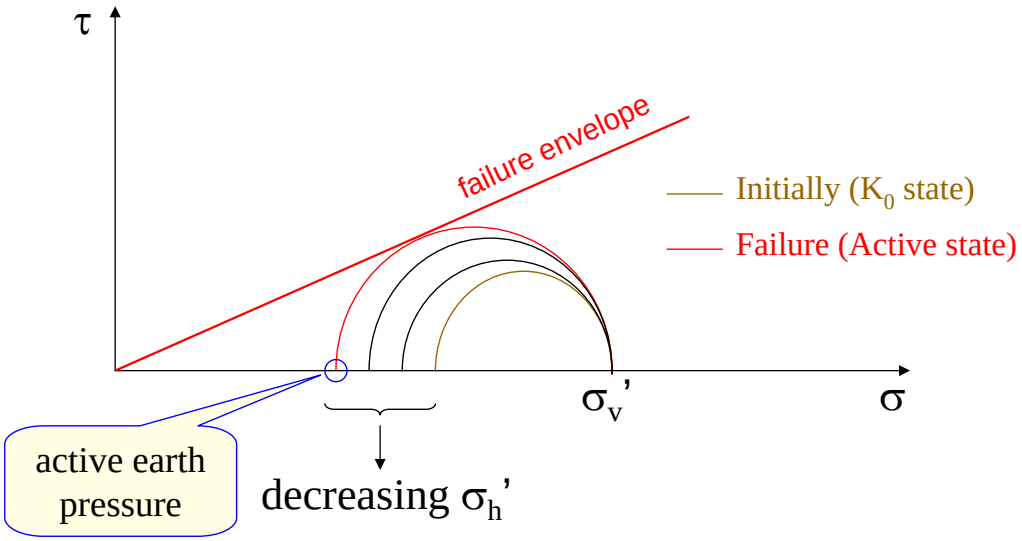
σ_h' decreases till failure occurs.

Active state

Active Earth Pressure

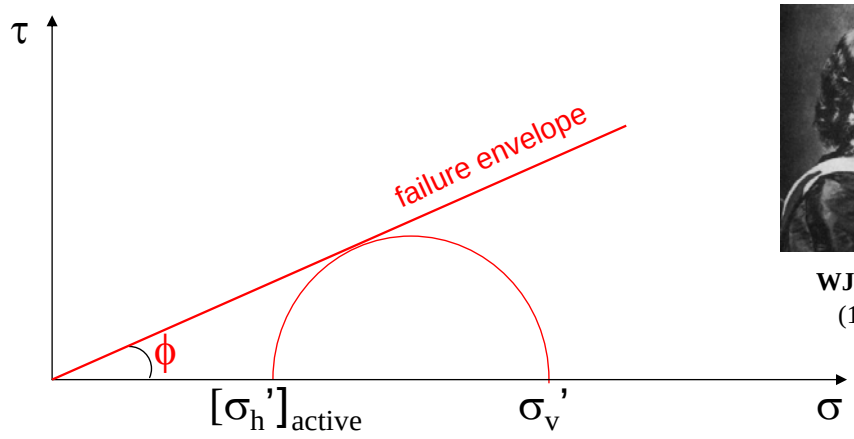
- in **granular** soils

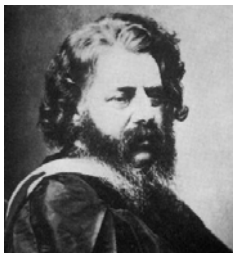
As the wall moves away from the soil,



Active Earth Pressure

- in **granular** soils





WJM Rankine
(1820-1872)

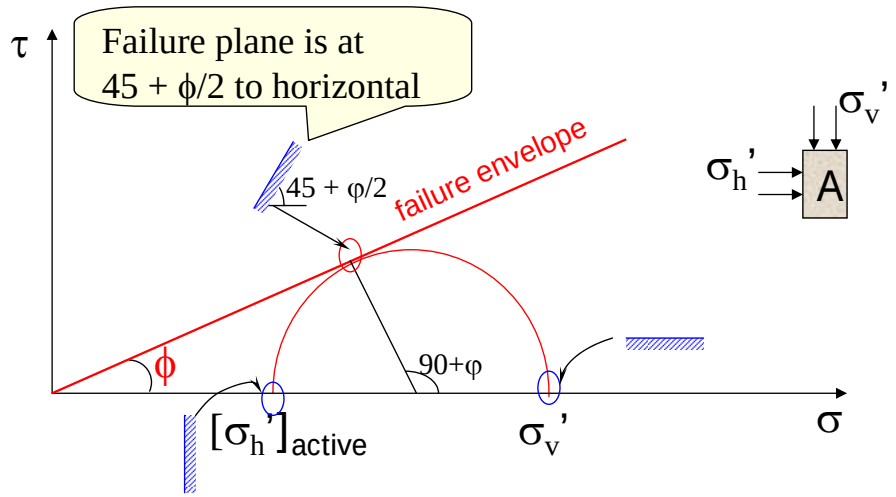
$$[\sigma_h']_{active} = K_A \sigma_v'$$

Rankine's coefficient of active earth pressure

$$K_A = \frac{1-\sin\phi}{1+\sin\phi} = \tan^2(45-\phi/2)$$

Active Earth Pressure

- in **granular** soils

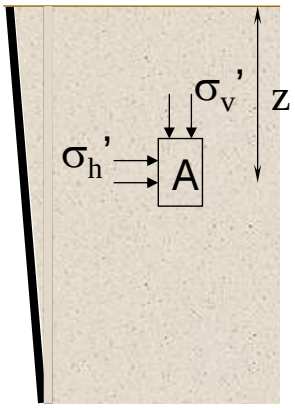


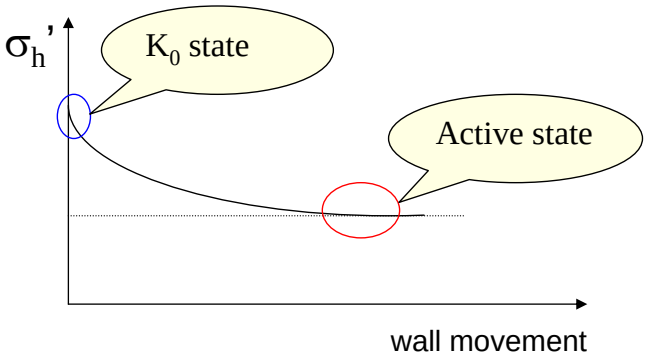
Active Earth Pressure

- in **granular** soils

As the wall moves away from the soil,

σ_h' decreases till failure occurs.





Active Earth Pressure

- in **cohesive** soils

Follow the same steps as for granular soils. Only difference is that c ≠ 0.

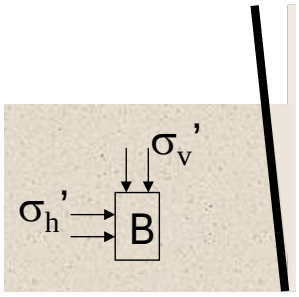
$$[\sigma_h']_{active} = K_A \sigma_v' - 2c\sqrt{K_A}$$

Everything else the same as for granular soils.

Passive Earth Pressure

- in **granular** soils

Initially, soil is in K_0 state.



As the wall moves towards the soil,

σ_v' remains the same, and

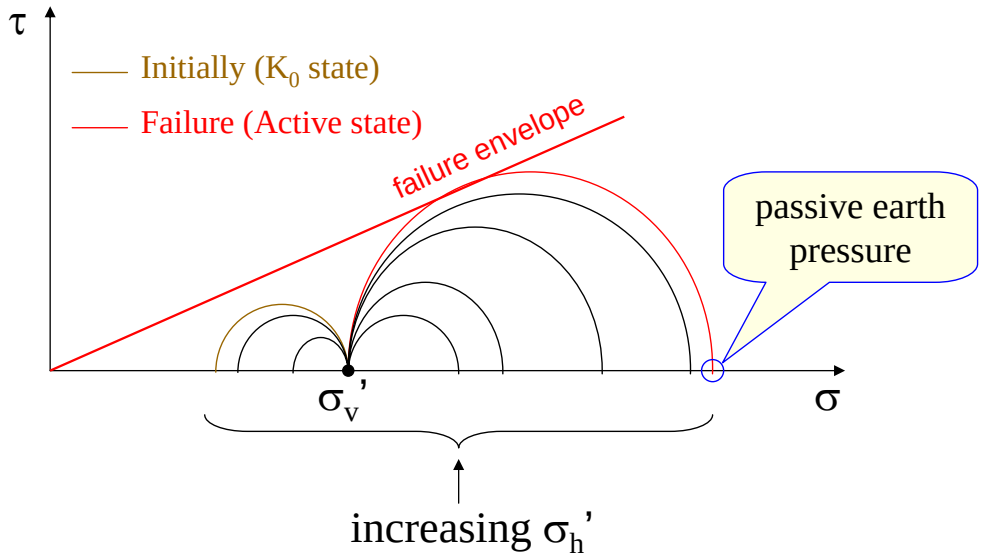
σ_h' increases till failure occurs.

Passive state

Passive Earth Pressure

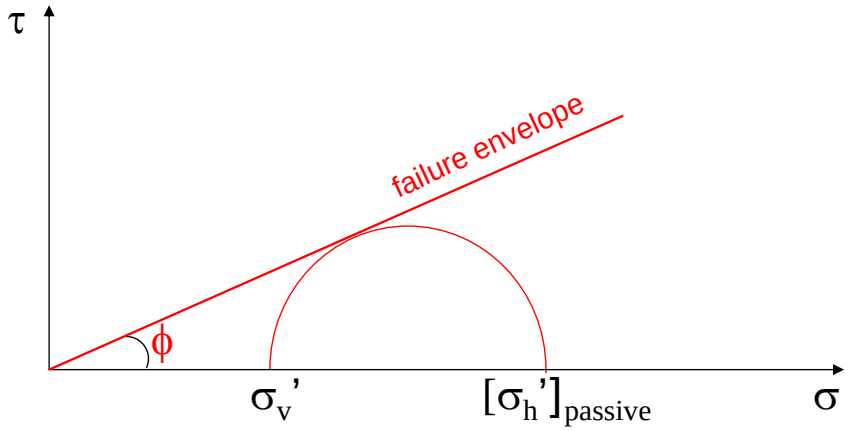
- in **granular** soils

As the wall moves towards the soil,



Passive Earth Pressure

- in **granular** soils



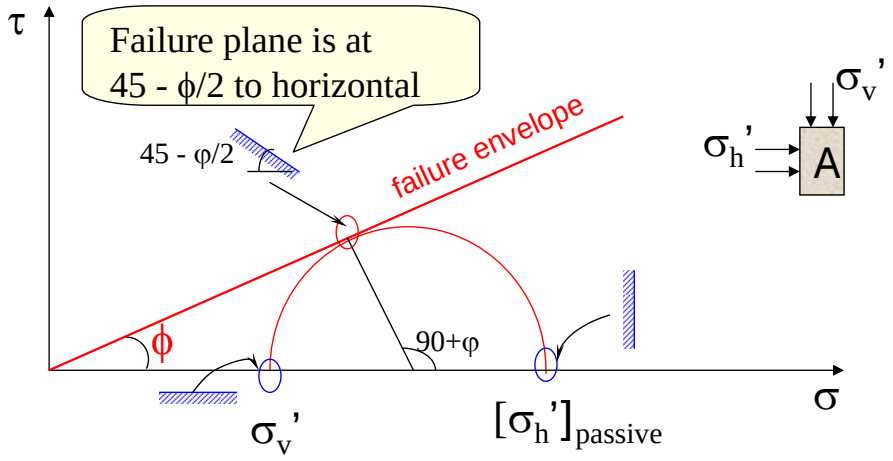
$$[\sigma_h']_{passive} = K_P \sigma_v'$$

Rankine's coefficient of passive earth pressure

$$K_P = \frac{1+\sin\phi}{1-\sin\phi} = \tan^2(45+\phi/2)$$

Passive Earth Pressure

- in **granular** soils

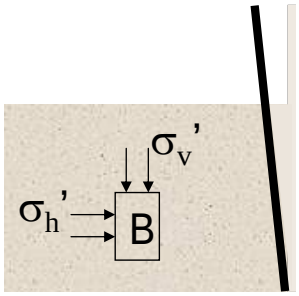


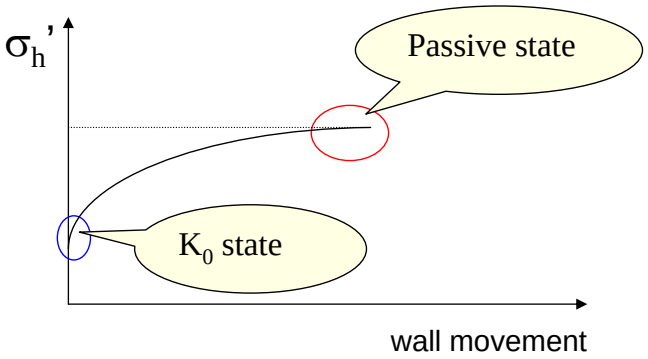
Passive Earth Pressure

- in **granular** soils

As the wall moves towards the soil,

σ_h' increases till failure occurs.





Passive Earth Pressure

- in **cohesive** soils

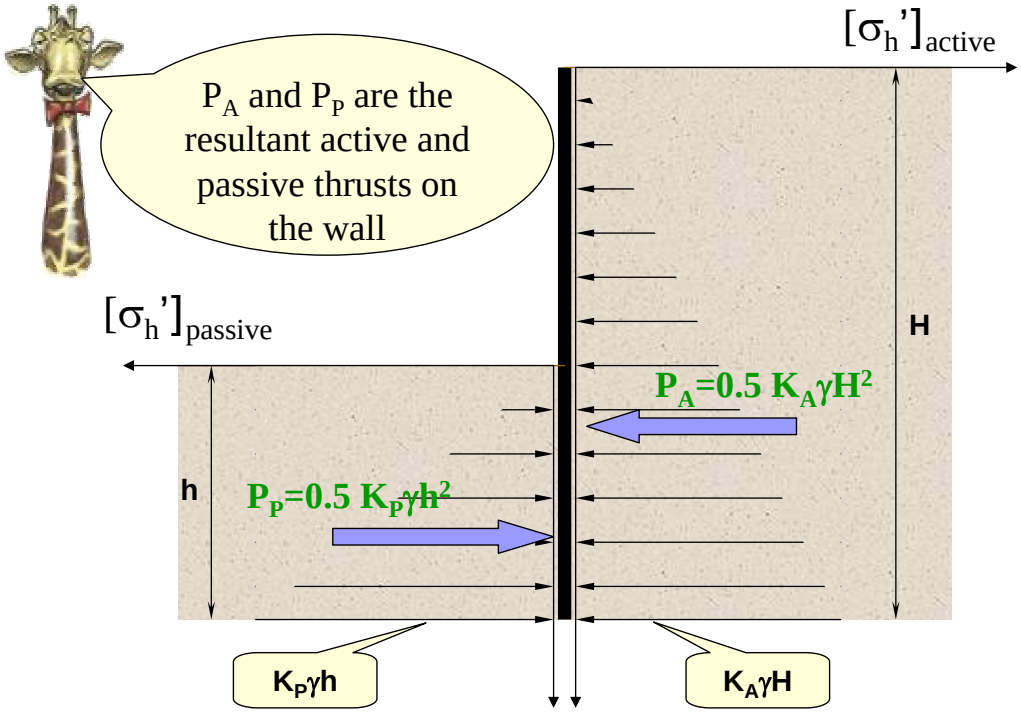
Follow the same steps as for granular soils. Only difference is that c ≠ 0.

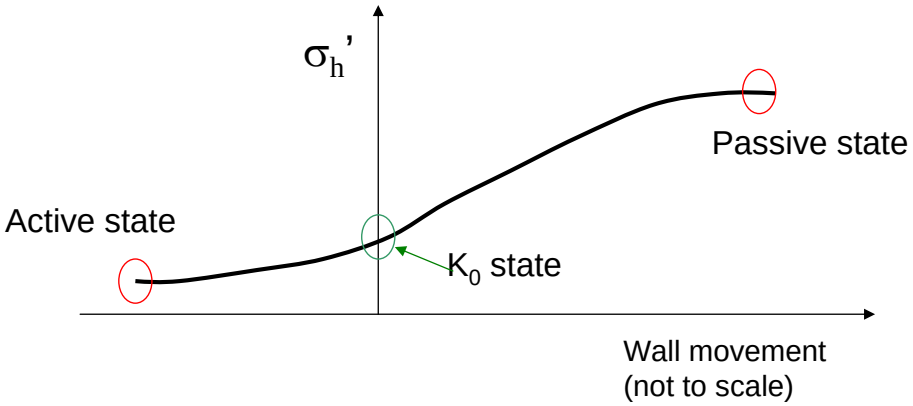
$$[\sigma_h']_{passive} = K_P \sigma_v' + 2c\sqrt{K_P}$$

Everything else the same as for granular soils.

Earth Pressure Distribution

- in **granular** soils





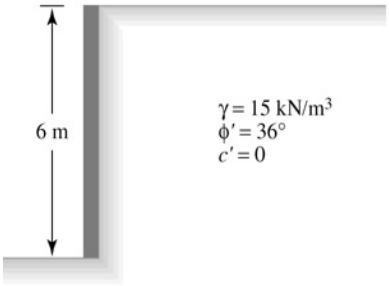
Rankine's Earth Pressure Theory

$$[\sigma_h']_{active} = K_A \sigma_v' - 2c\sqrt{K_A}$$

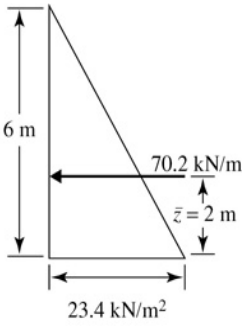
$$[\sigma_h']_{passive} = K_P \sigma_v' + 2c\sqrt{K_P}$$

- Assumes smooth wall
- Applicable only on vertical walls

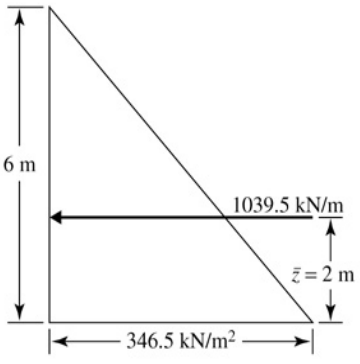
Examples 12.3



(a)

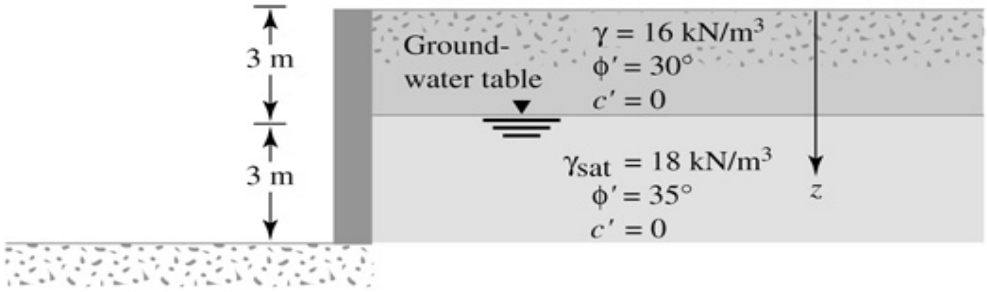


(b)

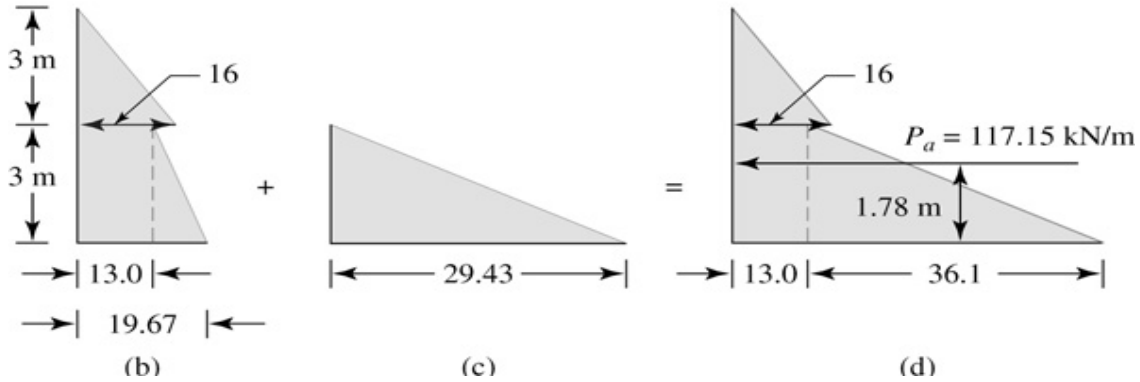


(c)

Examples 12.4

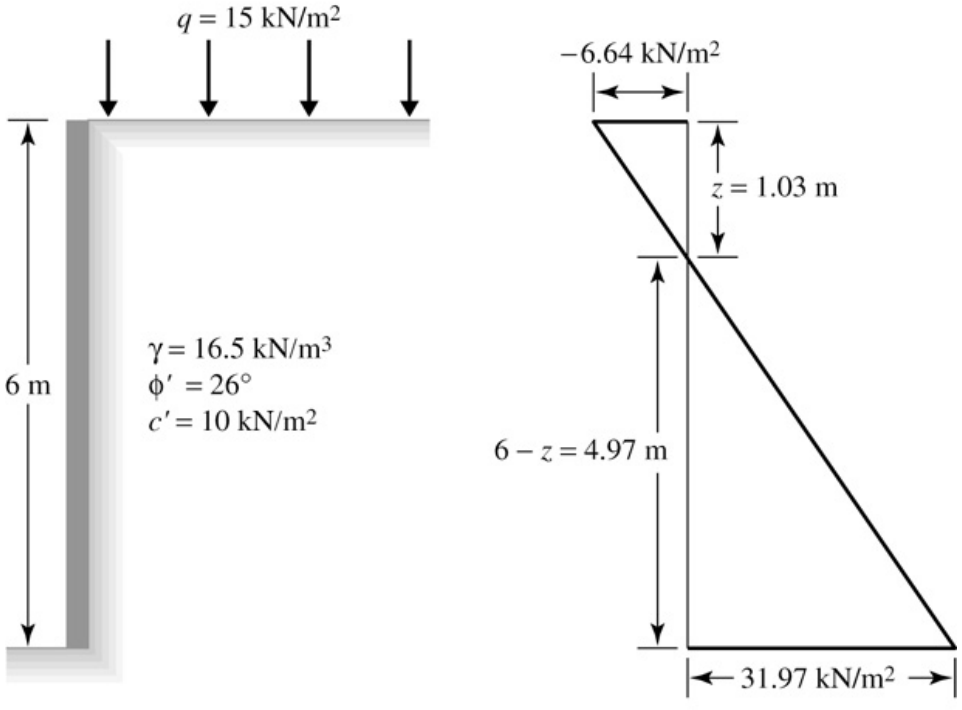


(a)



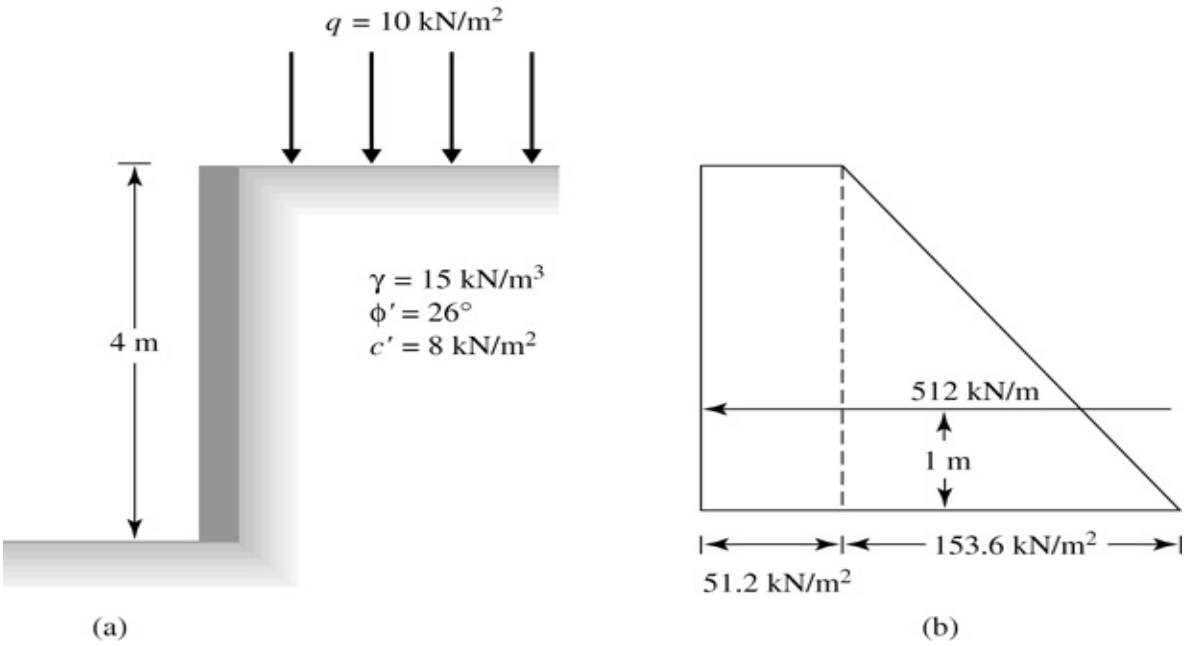
(b) (c) (d)

Examples 12.5

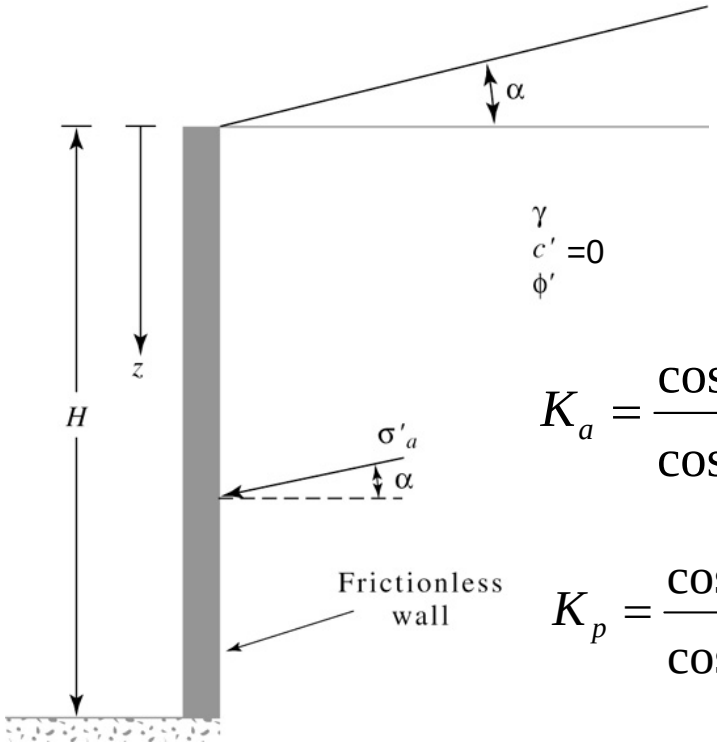


(a) (b)

Examples 12.6



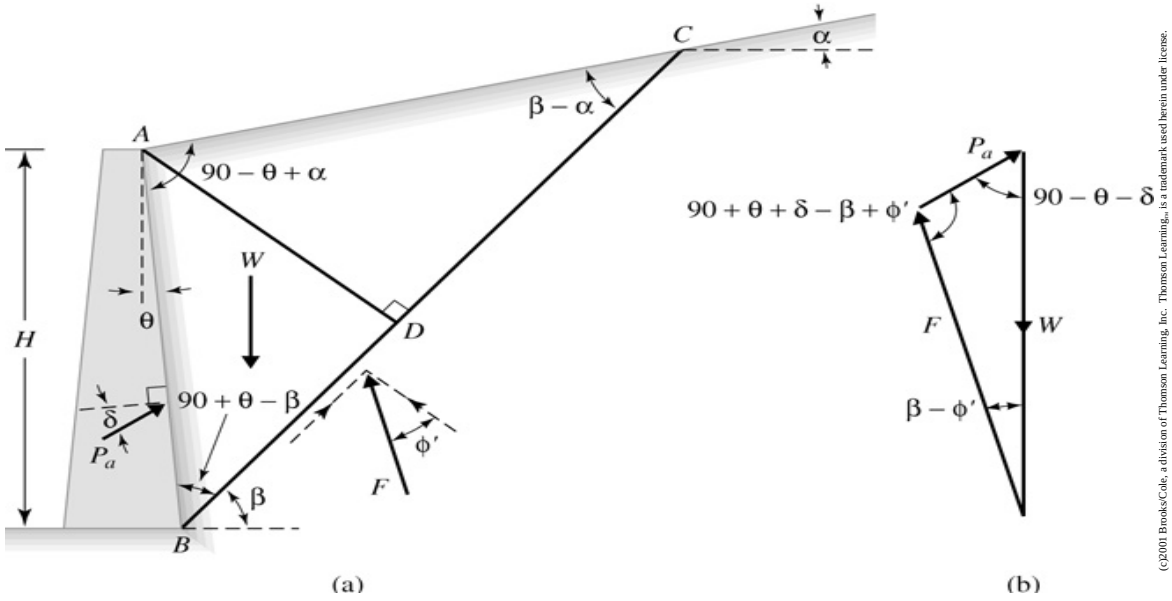
Rankine's Theory w/ Sloping Backfill



$$K_a = \frac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}$$

$$K_p = \frac{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}$$

Coulomb's Active Pressure



Coulomb's Passive Pressure