Department of Civil Engineering
Katihar Engineering College, Katihar

Subject : Soil & Rock Mechanics
Topic : Stability of Slopes (Infinite Slope)
Lecture : 01
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Stability of Slopes

→ Slopes for embankments are provided in roadways, railways, earthen dam or river draining work.

→ Failure of which takes place due to the following forces.

(i) Gravity force
(ii) Seepage force.
(iii) Earthquake
(iv) Sudden drawdown in water table
(v) Erosion due to water

→ Types of slopes

- Infinite Slope
- Finite Slope

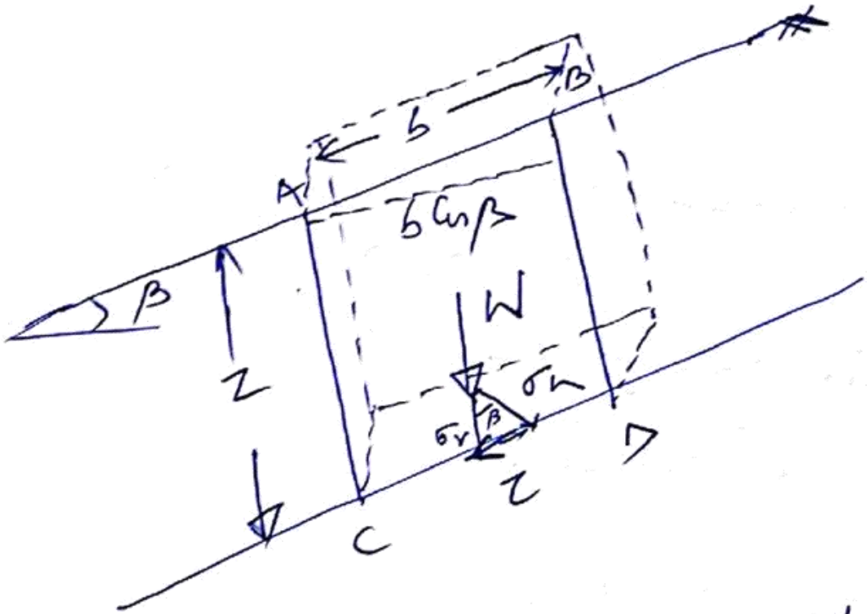
(I) Infinite Slope

. If the slope represents the boundary surface of semi-infinite soil mass then properties of soil at all the similar depth below the surface will be same then the slope is termed as infinite slope.

→ Failure of infinite slope takes place due to sliding & failure is parallel to ground surface slope.

Ex. ~~[struck out]~~ Mountain slope.

⇒ Stability analysis of infinite slope:



Let AB represents infinite slope having slope angle of β with the horizontal. Failure of which takes place along the critical plane CD it means parallel to Ground slope and at the depth of z from the surface

$$\text{Area of } ABCD = (b \cos\beta) z$$
$$= bz \cos\beta$$

Volume of ABCD = $(b z \cos\beta) \times 1$

Weight of ABCD = $\gamma \times b z \cos\beta$

$= \gamma b z \cos\beta$.

Vertical stress $(\sigma_z) = \frac{W}{A}$

$= \frac{\gamma b z \cos\beta}{(b \times 1)}$

$= (\gamma z \cos\beta)$

Normal stress on the Critical plane $= \sigma_n = \sigma_z \cos\beta$

$$\boxed{\sigma_n = \gamma z \cos^2\beta}$$

Tangential stress on the Critical plane $(\tau) = \sigma_z \sin\beta$

$$\boxed{\tau = \gamma z \cos\beta . \sin\beta}$$

Note: The tangential is also termed as shear stress that induces failure along Critical plane CD by sliding which is being resisted by shear strength of soil.

Factor of safety (F.O.S) = Shear strength of soil / Shear stress on that plane

$$FOS = \frac{\tau_f}{\tau}$$

Case 1 (a). Cohesionless soil slope. Dry / Moist

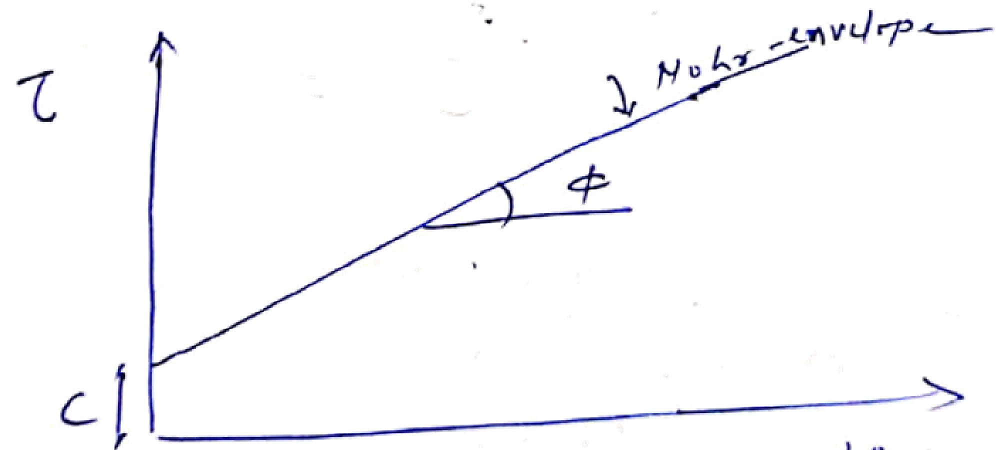
A/c to Mohr - Coulomb Equation.

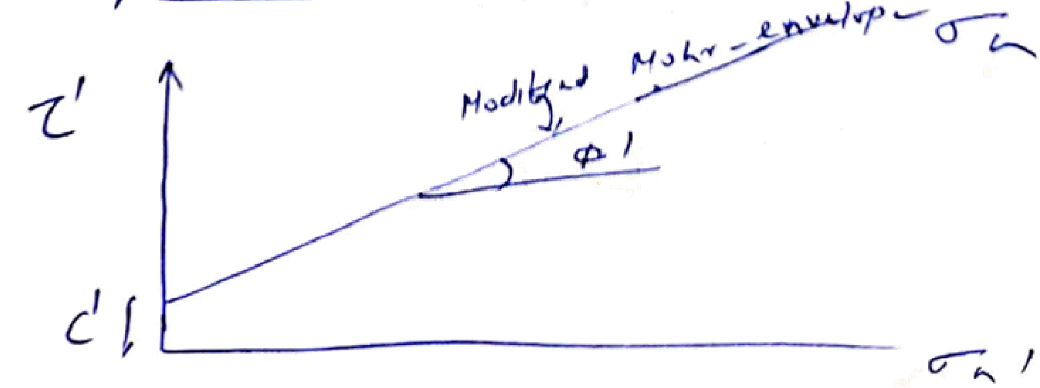
$$\tau = c + \sigma_n \tan\phi$$

where $c \rightarrow$ cohesion of soil

$\sigma_n \rightarrow$ Normal stress

$\phi \rightarrow$ Angle of internal friction





For Cohesionless soil $c = 0$.

$$\tau_f = \sigma_n \tan\phi$$

$$\boxed{\tau_f = \gamma z \cos^2\beta \cdot \tan\phi}$$

Where $\gamma \rightarrow$ Unit weight of soil

$z \rightarrow$ depth.

$\beta \rightarrow$ Slope Angle with the horizontal

$\phi \rightarrow$ Angle of internal friction of soil

$$FOS = \frac{\tau_f}{\tau} = \frac{\sigma_n \tan\phi}{\gamma z \cos\beta \cdot \sin\beta}$$

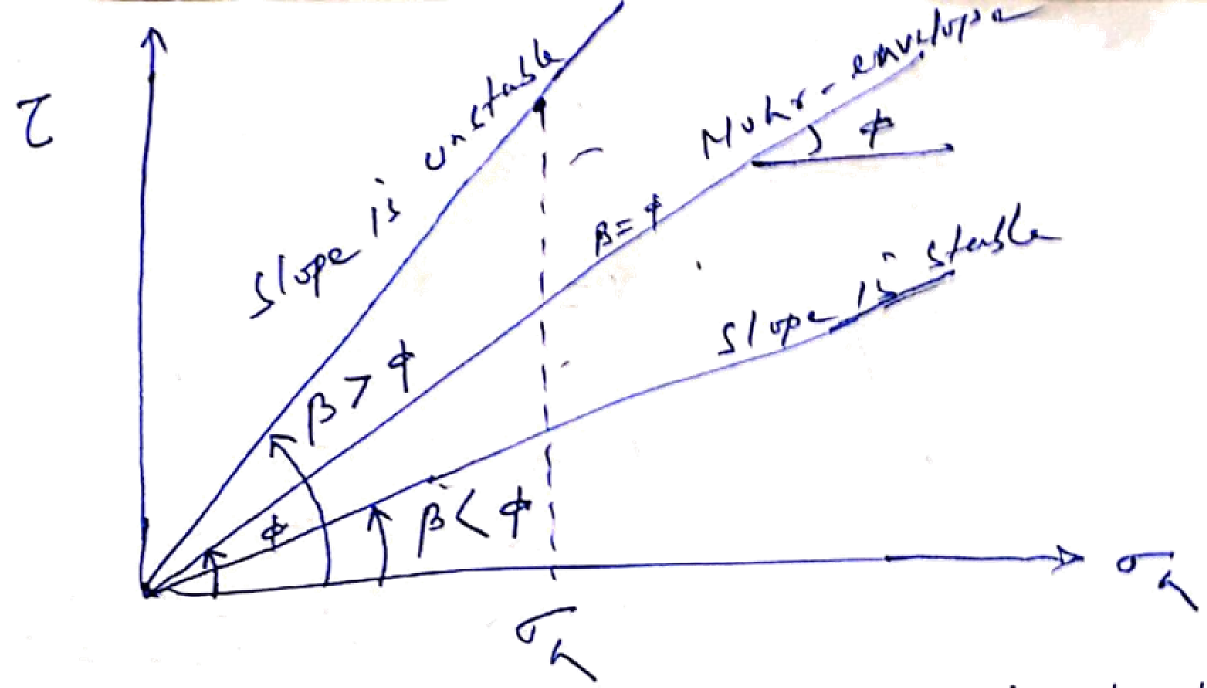
$$FOS = \frac{\gamma z \cos^2\beta \cdot \tan\phi}{\gamma z \cos\beta \cdot \sin\beta}$$

$$\boxed{FOS = \frac{\tan\phi}{\tan\beta}} \rightarrow \text{Cohesionless soil}$$

If $FOS > 1$, $\phi > \beta \rightarrow$ Slope is stable

If $FOS < 1$, $\phi < \beta \rightarrow$ Slope is Unstable

If $FOS = 1$, $\phi = \beta \rightarrow$ Slope is critical



→ If β is less than φ, slope is stable because for any given value of Normal stress, shear stress is less than the shear strength of the soil.

→ If β > φ, slope is unstable because for any given value of Normal stress, shear stress (τ) is more than shear strength (τ_f)

$$\tau = \gamma z \cos\beta \cdot \sin\beta$$

$$\tau_f = \gamma z \cos^2\beta \cdot \tan\phi$$

$$FOS = \frac{\tau_f}{\tau} < 1$$

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