Department of Civil Engineering
Katihar Engineering College, Katihar

Subject : Soil & Rock Mechanics
Topic : Stability of Slopes (Infinite Slope)
Lecture : 02
Course Instructor : Prof. Rashid Mustafa

Case b. Submerged Slope : (Cohesionless Soil)

$$\sigma_z = \gamma' z \cos\beta$$

$$\sigma_n = \gamma' z \cos^2\beta$$

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

Shear strength $= \sigma_n \tan\phi = \gamma' z \cos^2\beta \cdot \tan\phi$

Factor of safety (FoS) $= \dfrac{\tau_f}{\tau} = \dfrac{\gamma' z \cdot \cos^2\beta \cdot \tan\phi}{\gamma' z \cos\beta \cdot \sin\beta}$

$$\boxed{FoS = \frac{\tan\phi}{\tan\beta}}$$

→ FoS of dry/Moist slope is same as that of submerged slope.

→ The change in depth of critical section causes change in value of Normal stress & Shear stress acting on it. but ratio of the stresses remains const.

Case 3. For $c-\phi$ soil

$$FOS = \frac{\tau_f}{\tau} = \frac{c + \sigma_n \tan\phi}{\tau}$$

$$\sigma_n = \gamma z \cos^2\beta.$$
$$\tau = \gamma z \cos\beta . \sin\beta.$$

$$\text{Factor of safety } (FOS) = \frac{c + \gamma z \cos^2\beta . \tan\phi}{\gamma z \cos\beta . \sin\beta}.$$

↳ For $c-\phi$ soil

Where
- $c \rightarrow$ cohesion of the soil
- $\gamma \rightarrow$ Unit wt of soil
- $\beta \rightarrow$ Slope angle
- $\phi \rightarrow$ Angle of internal friction.

Let H_c be the critical height of the slope (the height for which factor of safety is equal to one i.e

$$FOS = 1 \quad (\tau_f = \tau)$$

$$1 = \frac{c + \gamma H_c \cos^2\beta . \tan\phi}{\gamma H_c \cos\beta . \sin\beta}.$$

$$\gamma H_c \cos\beta \cdot \sin\beta - \gamma H_c \cos^2\beta \cdot \tan\phi = c$$

$$H_c = \frac{c}{\gamma \cos\beta (\sin\beta - \cos\beta \cdot \tan\phi)}$$

$$H_c = \frac{c}{\gamma \cos^2\beta (\tan\beta - \tan\phi)} \quad -(2)$$

Where $H_c \rightarrow$ Critical height ($FOS = 1$ or $\tau_f = \tau$)

From (2)

$$\gamma H_c = \frac{c}{\cos^2\beta (\tan\beta - \tan\phi)}$$

$$\frac{c}{\gamma \cdot H_c} = \cos^2\beta (\tan\beta - \tan\phi)$$

Where $\frac{c}{\gamma H_c} = S_n =$ Dimensionless quantity known as stability number.

$$\text{Stability Number } (S_n) = \frac{c}{\gamma H_c} = \cos^2\beta (\tan\beta - \tan\phi)$$

If a factor of safety F_c is applied to the cohesion such that mobilised cohesion at a depth H.

$$C_m = \frac{C}{FOS}$$

where $C_m \rightarrow$ Mobilised cohesion

$$S_n = \frac{C_m}{\gamma H} = \frac{C}{FOS \cdot \gamma \cdot H}$$

It can be also written as

$$S_n = \frac{C}{\gamma H_c} = \frac{C}{F_c \cdot \gamma H}$$

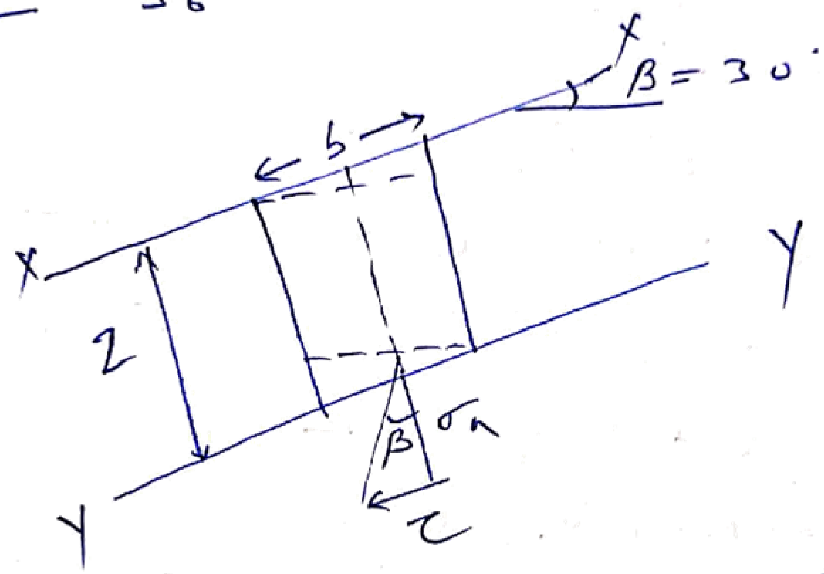
$$F_c = \frac{H_c}{H}$$

$$FOS = F_c = \frac{H_c}{H} = F_H$$

where $F_c \rightarrow$ Factor of safety w.r.t cohesion

$F_H \rightarrow$ Factor of safety w.r.t height.

P-1. A slope of infinite extent is made in a dense layer at an angle of 30° to the horizontal. Determine the factor of safety of the slope against shear failure if the angle of internal friction of the soil to be 36°.



Vertical stress on Y-Y $= \sigma_z \cos\beta$

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

$\sigma_n = \gamma z \cos^2\beta$.

Shear stress $(\tau) = \gamma z \sin\beta \cdot \cos\beta$.

Let τ_f be the shear strength of soil

$\tau_f = c^0 + \sigma_n \tan\phi$

$\tau_f = \sigma_n \tan\phi$

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

Factor of safety $= \dfrac{\tau_f}{\tau} = \dfrac{\gamma z \cos^2\beta \cdot \tan\phi}{\gamma z \cos\beta \cdot \sin\beta}$

$$FOS = \frac{\tan\phi}{\tan\beta} = \frac{\tan 36}{\tan 30}$$

$$\boxed{FOS = 1.258} > 1$$

Slope is safe.

P-2. A Vertical cut is made in a clay deposit having $C = 30\ kN/m^2$ & $\phi = 0$, $\gamma = 16\ kN/m^3$. Find the maximum height of the cut which can be temporarily supported.

Take For $\phi = 0$, $S_n = 0.261$.

Soln

~~Tab~~ Stability Number $(S_n) = \frac{C}{F_c \cdot \gamma \cdot H}$

For Critical condition, $F_c = 1$.

$$S_n = \frac{C}{\gamma \cdot H_c}$$

$$0.261 = \frac{30}{16 \times H_c}$$

$$H_c = \frac{30}{16 \times 0.261}$$

$$\boxed{H_c = 7.18\ m}$$

HAPPY LEARNING