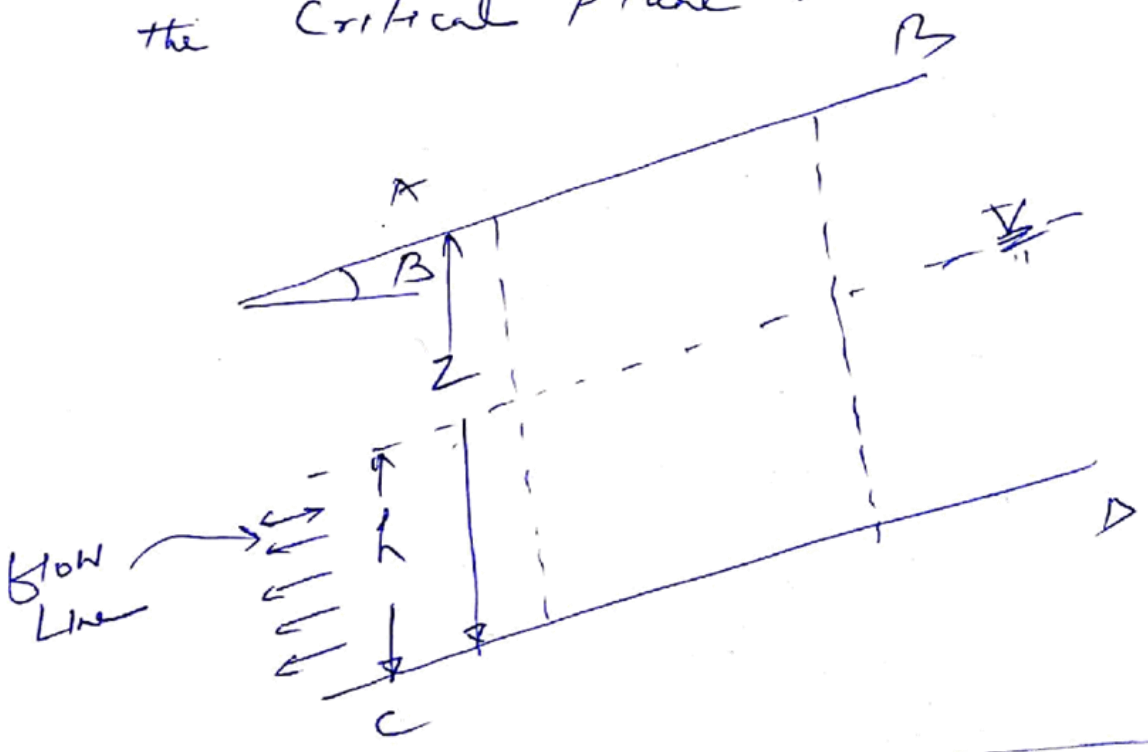
Department of Civil Engineering
Katihar Engineering College, Katihar

Subject : Soil & Rock Mechanics
Topic : Swedish Circle Method (Finite Slope)
Lecture : 03
Course Instructor : Prof. Rashid Mustafa

Case 4. Slope subjected to steady seepage and water table is at depth h above the Critical plane.



$$F_{OS} = \left(1 - \frac{\gamma_w h}{\gamma_{sat} \cdot z}\right) \frac{\tan\phi}{\tan\beta}$$

Where $\beta \rightarrow$ Slope Angle
$\phi \rightarrow$ Angle of Internal friction of soil
$h \rightarrow$ height above the Critical plane

When $h = z$

$$FOS = \left(1 - \frac{\gamma_w z}{\gamma_{sat} \cdot z}\right) \frac{\tan\phi}{\tan\beta}$$

$$\boxed{FOS = \left(\frac{\gamma_{sub}}{\gamma_{sat}}\right) \frac{\tan\phi}{\tan\beta}}$$

↳ When steady seepage parallel to slope.

We know that

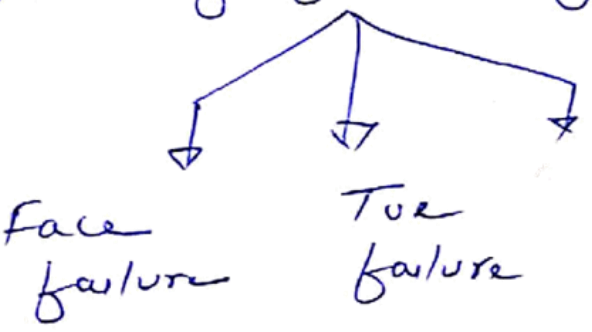
$$\gamma_{sub} \approx \frac{1}{2} \gamma_{sat}$$

$$\boxed{FOS = \frac{1}{2} \frac{\tan\phi}{\tan\beta}}$$

Note: If slope is completely submerged & steady seepage takes place parallel to the slope then factor of safety is reduced to half in comparison to factor of safety of dry or submerged slope. Hence dry and submerged condition, FOS should be always greater than 2 in order to ensure stability..

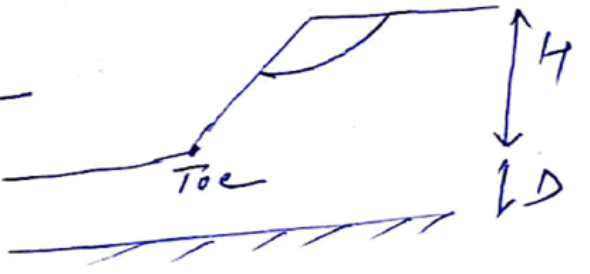
⇒ Stability Analysis of Finite slope.

⇒ Types of failure of finite slope



(1) Face failure:

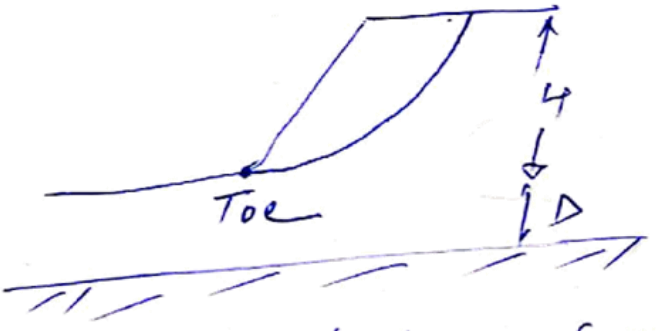
It is defined as when failure surface or failure occurs above the toe then such type of failure is called face failure.



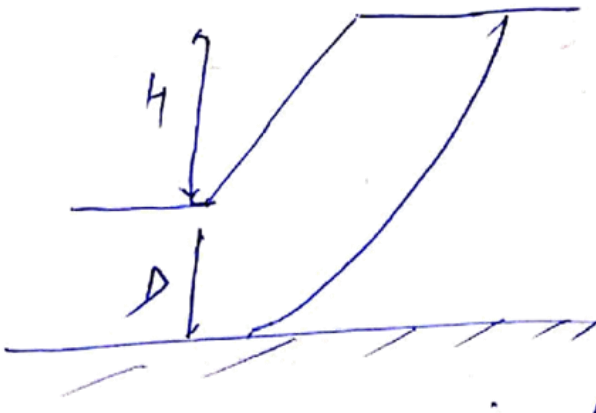
Face failure

(2) Toe failure

It is defined as when failure surface passes through the toe of the slope then such type of failure is called Toe failure.



(3) Base failure: If failure surface passes below the toe then such type of failure is called base failure.



Note: Depth factor: It is defined as the ratio of total depth (H+D) to the depth of slope (H) is called Depth factor.

$$\text{Depth factor } (D_f) = \frac{H+D}{H}$$

→ In case of face failure the value of depth factor is less than 1.

→ In Case of Toe failure, $D_f = 1$

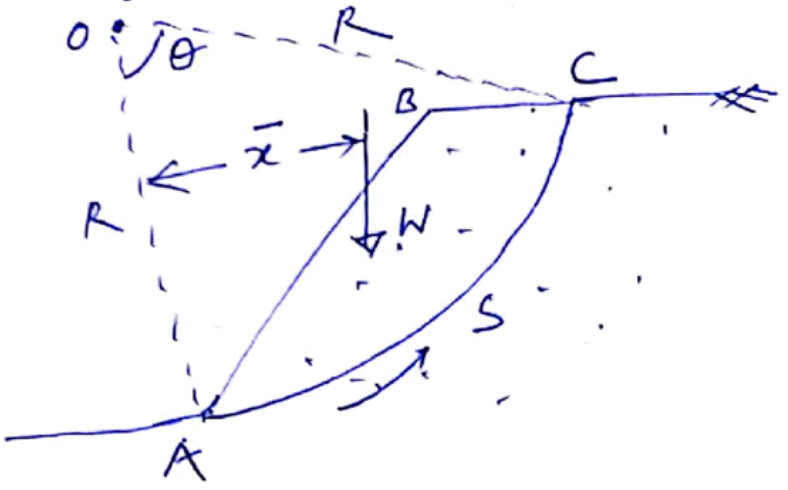
→ In case of Base failure, $D_f > 1$

⇒ Analysis of finite slope

- Swedish Circle Method
  - $\phi_u = 0$ Analysis (For Pure Clay)
  - c-ϕ Soil
- Friction Circle Method
- Taylor stability chart

① Swedish Circle Method :

Case I For $\phi_u = 0$ Analysis (For Pure clay)



Let AB represents slope whose stability to be investigated.

Let ASC be the trial slip Circle with Centre O.

OA = OC = radius (R)

Let W be the weight of the soil mass ASCB and it will act at a distance of $\bar{x}$ from the Centre.

$$W = \gamma \times A \times 1$$

A → Cross sectional area of Sector ASC

γ → Unit weight of soil

Let ~~length~~ Arc length of ASC = $R \cdot \theta$

Shear resistance of ASC = $C \cdot R \cdot \theta$

Resisting Moment (MR) = Shear resistance × Lever Arm

= $CR\theta \times R = R^2 C\theta$

$$FOS = \frac{M_R}{M_D} = \frac{R^2 c\theta}{W \cdot \bar{x}}$$

Where $c \rightarrow$ cohesion of the soil

$\theta \rightarrow$ $\angle$AOC in radian

$R \rightarrow$ Radius

$W \rightarrow$ weight of soil

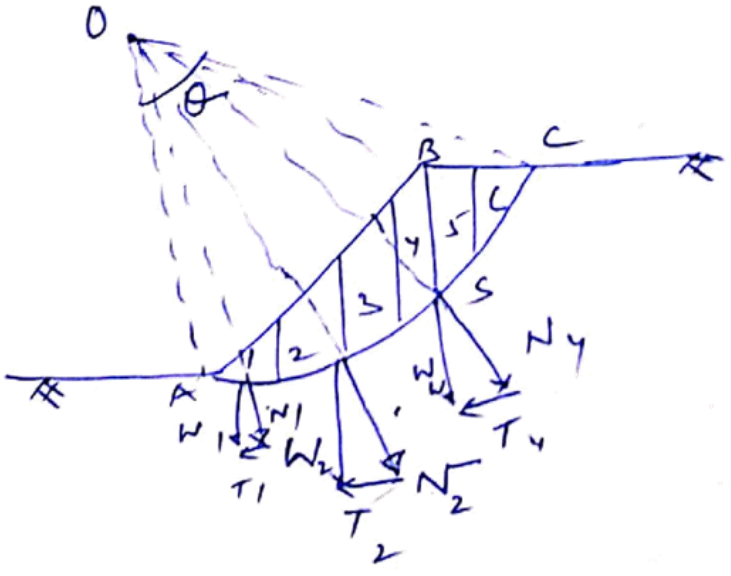
$\bar{x} \rightarrow$ Level Arm of W w.r.t to O

Case 2. For C-ϕ Soil

$$FOS = \frac{CR\theta + \Sigma N \tan\phi}{\Sigma T}$$

Where $\Sigma N =$ Sum of all Normal forces

$\Sigma T =$ sum of all shearing / Tangential forces

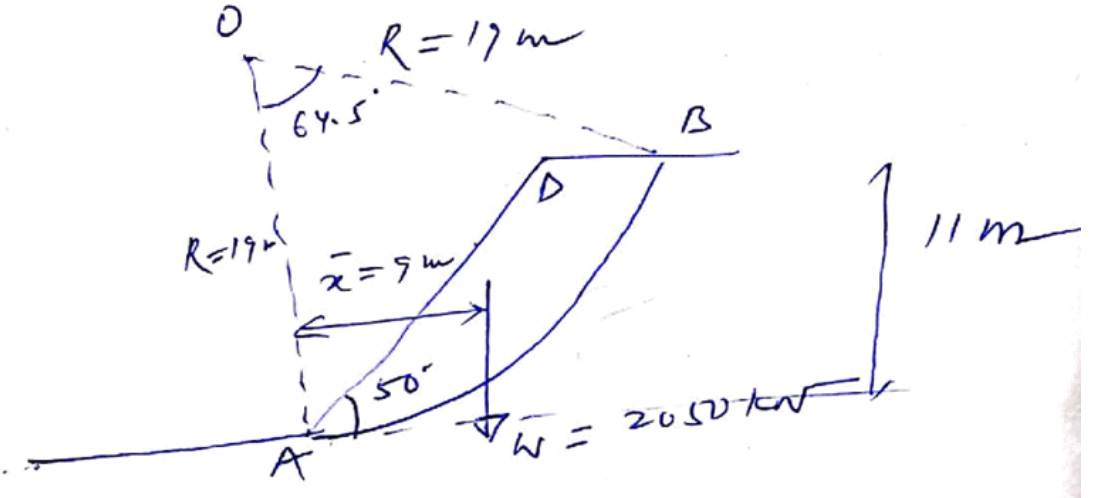


$$FOS = \frac{(CR\theta) + \Sigma(N-U)\tan\phi}{\Sigma T}$$

ΣU = Sum of all Neutral force.

P-1. Figure shows an earth slope of clayey soil having $C = 55\ kN/m^2$ & $\phi = 0$. Corresponding to a trial slip circle AB and following Data is given.

(i) Radius of slip circle = 19 m
(ii) Weight of wedge ABD = 2050 kN
(iii) Distance of W from AO = 9 m
(iv) Angle θ subtended by the arc AB at the Centre = 64.5°



$$FOS = \frac{CR^2\theta}{W \cdot \bar{x}}$$

θ in radian = $\frac{\pi}{180} \times \theta = \left(\frac{\pi}{180} \times 64.5\right)$ radian.

Resisting Moment $(M_R) = (R.\theta) \cdot C \times R$

$= CR^2\theta$

$= 55 \times 19^2 \times \frac{\pi}{180} \times 64.5$

$= 22353$ kN-m

Disturbing Moment $(M_D) = W \cdot \bar{x}$

$= 2050 \times 9 = 18450$ kN-m

$FOS = \frac{M_R}{M_D} = \frac{22353}{18450}$

$= 1.212 \ (> 1)$

Slope is safe.

HAPPY LEARNING