APPLIED GEOTECHNICAL ENGINEERING (17CV53)
SCHEME & SOLUTION – IAT3

1 (a) Explain with a neat sketch, Rebhann's construction for active pressure.

Ans:- ***Explanation- 4marks, Fig– 4marks.***

Rebhann's Construction for active Pressure

→ Graphical method for the determination of the total active pressure according to Coulomb's theory.

→ Based on Poncelet's solution & also known as Poncelet's method.

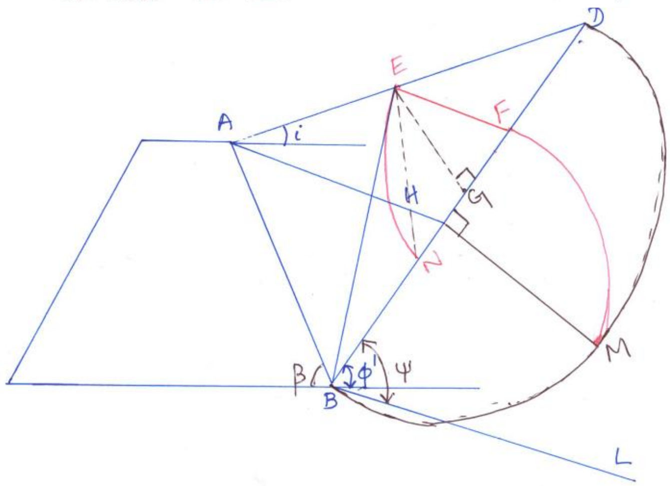
Procedure

1. Line BD is drawn at an angle ϕ' to the hzl.
2. Line BL, drawn at an angle ψ with line BD, is known as the earth pressure line. $\psi = \beta - \delta$.
3. With BD as diameter, a semi circle is drawn.
4. Draw a line AH parallel to BL, intersecting the line BD at H.
5. A perpendicular HM is drawn at H, so as to intersect the semi circle at M.
6. With B as center & BM as radius, drawn an arc MF, intersecting BD at F.
7. Line FE is drawn such that EF is parallel to BL, intersecting the ground at E.
8. With F as centre & FE as radius, draw an arc to meet BD at N.

g) Line BE represents the critical failure plane.

$P_a = \frac{1}{2} \times \gamma_x$ (Area of Δ^{le} NEF) $= \gamma_x \frac{1}{2}$ (NF $\times x$)

where $x = \perp^{ar}$ distance EG b/w E & BD



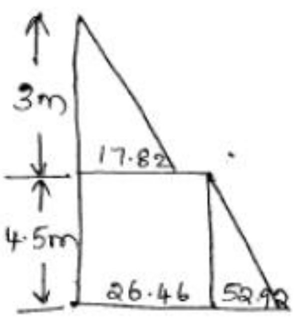
1 (b) A retaining wall retains a cohesionless backfill with a height of 7.5 m. The top 3m of the backfill has a unit weight of 18 kN/m^3 and Φ=30◦. Lower 4.5m of the backfill has a unit weight of 24 kN/m^3 and Φ=20◦. Obtain pressure distribution diagram and determine the total active pressure and its point of application.

Ans:- ***Calculation of total Pa - 4marks, determination of point of application – 2 marks pressure distribution diagram– 2marks.***

Ans:

$$K_{a_1} = \frac{1-\sin 30^\circ}{1+\sin 30^\circ} = 0.33$$

$$K_{a_2} = \frac{1-\sin 20^\circ}{1+\sin 20^\circ} = 0.49$$



$$p_1 = K_{a_1} \gamma_1 H_1 = 0.33 \times 18 \times 3 = 17.82 \text{ kN/m}^2$$

$$p_2 = K_{a_2} \gamma_1 H_1 = 0.49 \times 18 \times 3 = 26.46 \text{ kN/m}^2$$

$$p_3 = K_{a_2} \gamma_2 H_2 = 0.49 \times 24 \times 4.5 = 52.92 \text{ kN/m}^2.$$

$$P_1 = \frac{1}{2} \times 17.82 \times 3 = 26.73 \text{ kN/m}$$

$P_2 = 26.46 \times 4.5 = 119.07$ kN/m

$P_3 = \frac{1}{2} \times 52.92 \times 4.5 = 119.07$ kN/m.

Total active pressure $= P_1 + P_2 + P_3 = \underline{264.87}$ kN/m

$$\bar{x} = \frac{26.73\left(4.5 + \frac{3}{3}\right) + \left(119.07 \times \frac{4.5}{2}\right) + \left(119.07 \times \frac{4.5}{3}\right)}{264.87}$$

$= \underline{2.24\text{m}}$ from base

2 (a) Explain briefly the types of slope failure.

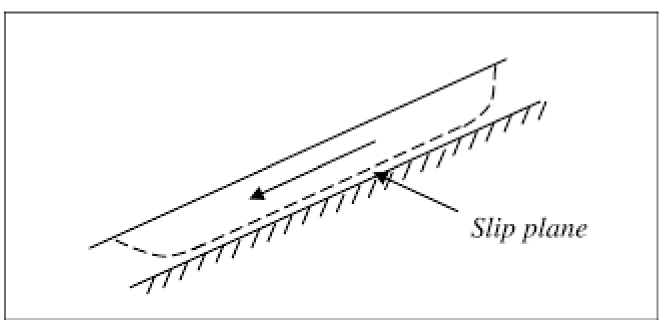
Ans:- ***Explanations with figure - 6mark***

The types of slope failures are

1. Translational Failure
2. Rotational Failure
3. Wedge Failure
4. Compound Failure

Translational Failure

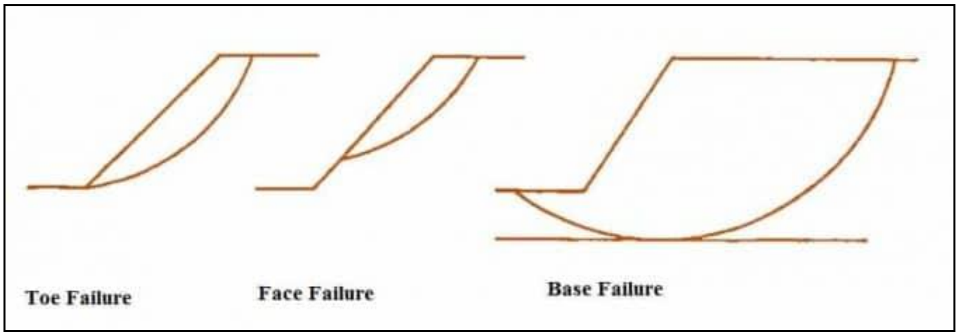
- Translation failure occurs in the case of infinite slopes and here the failure surface is parallel to the slope surface.
- This type of failure can be observed in slopes of layered materials or natural slope formations.



Rotational Failure

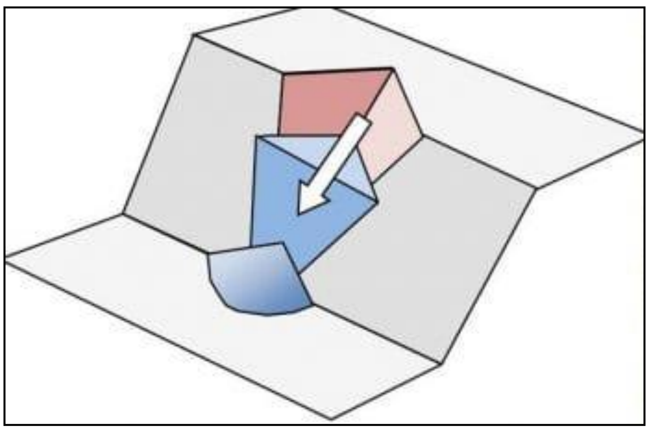
- In the case of rotational failure, the failure occurs by rotation along a slip surface and the shape thus obtained in slip surface is curved. Failed surface moves outwards and downwards.
- In homogeneous soils, the shape is circular while in case of non-homogeneous soils it is non-circular.
- Rotational failure may occur in three different ways :
  - ✓ Face failure or slope failure

- ✓ Toe failure
- ✓ Base failure



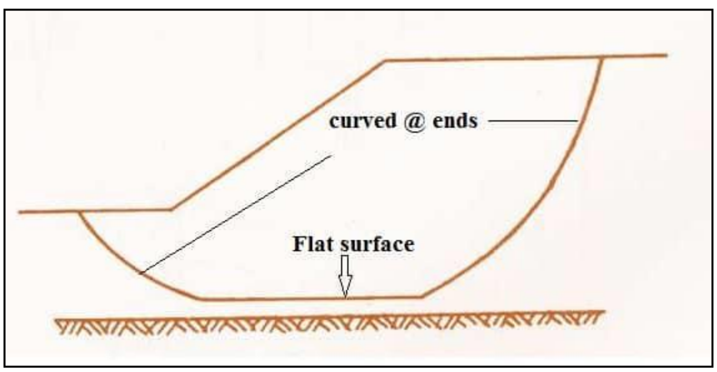
Wedge Failure

- Wedge failure, also known as block failure or plane failure, generates a failure plane that is inclined.
- This type of failure occurs when there are fissures, joints, or weak soil layers in slope, or when a slope is made of two different materials.
- It is more similar to translational failure but the difference is that translational failure only occurs in case of infinite slopes but wedge failure can occur in both infinite and finite slopes.



Compound Failure

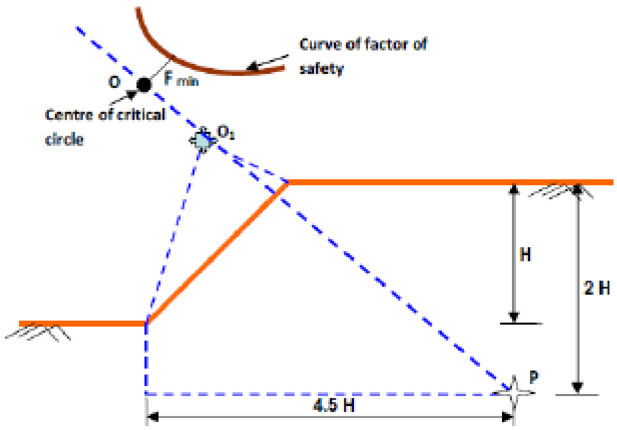
- A Compound failure is a combination of translational slide and rotational slide.
- In this case, the slip surface is curved at two ends like rotational slip surface and flat at central portion like in translational failure.
- The slip surface becomes flat whenever there is a hard soil layer at a considerable depth from toe.



2 (b) Explain the Fellinious method of locating the center of critical slip circle for c-φ soil.

Ans:- ***Explanation - 3mark, Figure - 2mark***

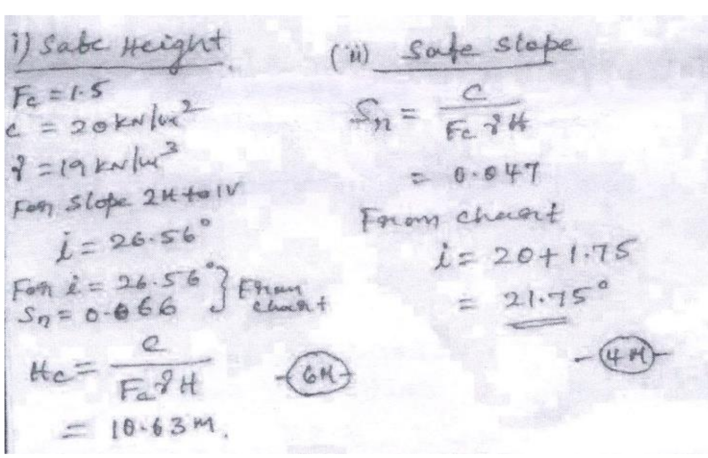
Locate point O1 the centre of Fellenius circle. Locate point P at 2H below the top surface of the slope and 4.5H from the toe of the slope. Extend backwards the line PO1 beyond O1. Construct trial slip circles with centres located on the extended portion of the line PO1. For each of these trial slip circles find the F.S by the method of slices. Plot the F.S for each of these trial slip circles from their respective centre and obtain a curve of factor of safety. Critical slip circle is the one that has a minimum F.S.



2(c) An embankment is to be constructed with a soil having C=20 kN/m², φ= 10◦ and γ=19 kN/m³. The desired factor of safety with respect to cohesion as well as friction is1.5. Determine (1) safe height of the desired slope if slope is 2H to 1V (2) Safe angle of slope if the desired height is 15m. For φ=10◦ Taylor's stability numbers are as follows:

Stability No:	**0.04**	**0.08**
Slope angle(i)	**20**	**30**

Ans:-



i) Safe Height

$F_c = 1.5$

$c = 20\ kN/m^2$

$\gamma = 19\ kN/m^3$

For slope 2H to 1V

$i = 26.56°$

For $i = 26.56°$, $S_n = 0.066$ } From chart

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

$= 10.63\ m.$ (6M)

(ii) Safe slope

$S_n = \frac{c}{F_c \gamma H}$

$= 0.047$

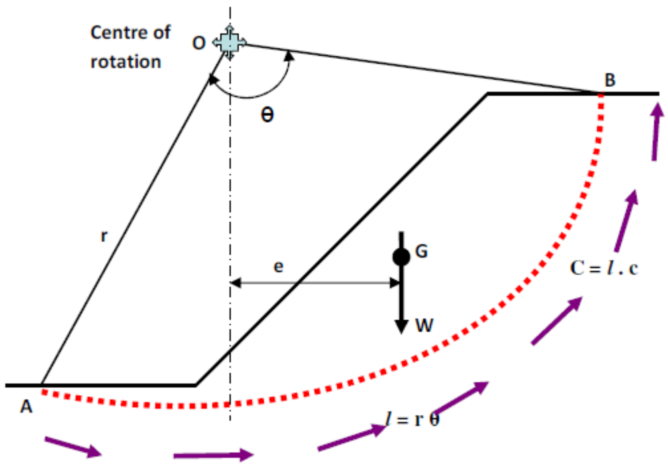
From chart

$i = 20 + 1.75$

$= 21.75°$ (4M)

3 (a) Explain the Swedish Circle method of stability analysis for a purely cohesive soil.

Ans:- ***Explanation – 3 marks, Figure– 2 marks***



Let AB be a trial slip surface in the form of a circular arc of radius 'r' with respect to center of rotation 'O' as shown in figure above. Let 'W' be the weight of the soil within the slip surface. Let 'G' be the position of its centre of gravity.

The exact position of G is not required and it is only necessary to ascertain the position of the line of action of W, this may be obtained by dividing the failure plane into a set of vertical slices and taking moments of area of these slices about any convenient vertical axis.

The shearing strength of the soil is C, since Φ = 0°.

The restoring moment (along the slip surface) = C*l*r

$$=C*r*\Theta = C*r^2*\Theta$$

The driving moment =W*e

Factor of safety, FS = Restoring moment /Driving moment

$$= C*r^2*\Theta/ W*e$$

3 (b) A homogeneous slope 15 m high is made of c — ϕ soil with unit weight of 18kN/m^3, unit cohesion of 50 kPa and angle of internal friction of 25°. Compute the factor of safety with respect to cohesion and the critical height of slope. Assume Sn = 0.05.

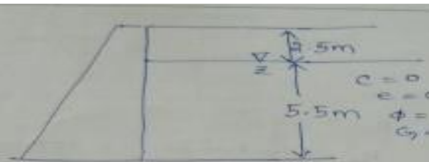
Ans:- ***Calculation of Fc – 1.5marks, Calculation of Hc – 1.5marks***

$F_c = C/ S_n*\gamma*H = 50/ 0.05*18*15 = 3.704.$

$H_c = F_c * H = 3.704*15 = 55.55$ m.

(c) A retaining wall of 8m height retains sandy material. The properties of the sand are e=0.6, Φ=30° and G=2.65. The water table is at a depth of 2.5 m from the ground surface. Draw the earth pressure diagram and determine the magnitude and point of application of total active pressure.

Ans:-

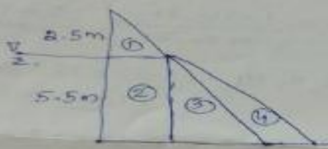


$c = 0$
$e = 0.6$
$\phi = 30^\circ$
$G = 2.65$

$\gamma_{sub} = \frac{(G-1)\gamma_w}{1+e}$
$= 10.116 \text{ kN/m}^3$

$\gamma_d = \frac{G\gamma_w}{1+e}$
$= 16.25 \text{ kN/m}^3$

$K_a = \frac{1-\sin 30^\circ}{1+\sin 30^\circ} = 0.33$



$p_1 = K_{a_1} \times \gamma_d \times 2.5$
$= 13.406 \text{ kN/m}^2$

$p_2 = K_{a_1} \times \gamma_d \times H_1 = 13.406 \text{ kN/m}^2$

$p_3 = K_{a_1} \times \gamma_{sub} \times H_2 = 0.33 \times 10.116 \times 5.5$
$= 18.36 \text{ kN/m}^2$

$p_4 = \gamma_w \times H_2 = 9.81 \times 5.5 = 53.955 \text{ kN/m}^2$

$P_1 = \frac{1}{2} \times 13.406 \times 2.5 = 16.757 \text{ kN/m}^2$

$P_2 = 13.406 \times 5.5 = 73.73 \text{ kN/m}^2$

$P_3 = \frac{1}{2} \times 18.36 \times 5.5 = 50.49 \text{ kN/m}^2$

$P_4 = \frac{1}{2} \times 53.955 \times 5.5 = 148.376 \text{ kN/m}$

$P = P_1 + P_2 + P_3 + P_4 = 289.353 \text{ kN/m}$

$P \times \bar{x} = P_1 \times \left(5.5 + \frac{2.5}{3}\right) + P_2 \times \left(\frac{5.5}{2}\right) + P_3 \times \left(\frac{5.5}{3}\right) + P_4 \times \left(\frac{5.5}{3}\right)$
$= 106.127 + 202.76 + 92.565 + 272.02$

$\bar{x} = 2.33 \text{ m from base.}$