APPLIED GEOTECHNICAL ENGINEERING (15CV53)
SCHEME & SOLUTION IAT-2

1.(a) Define earth pressure at rest with a neat sketch.

Ans:- ***Explanation- 2marks, Fig– 1mark.***

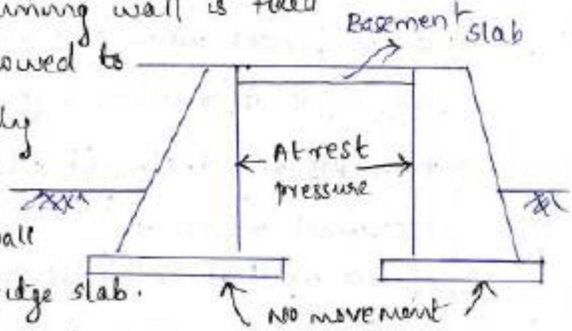
① At rest pressure

→ Soil mass is not subjected to any lateral movement

→ occurs when the retaining wall is fixed firmly on top & not allowed to rotate or move laterally

Eg ① Basement slab

② Bridge abutment wall restrained at top by bridge slab.



→ Also known as state of elastic equilibrium as no part of soil mass has failed & attained the plastic eq bm.

1.(b) Compare between Coulomb's and Rankine's theories.

Ans:- ***Comparison-4 points- 4marks***

Comparison of Coulomb's theory with Rankine's theory

Coulomb's Theory	Rankines theory
① Considers retaining wall & backfill as a system & takes into account the friction b/w wall & the backfill.	① Friction is not considered
② Backfill surface may be plane or curved	② Considers backfill to be a plane surface.

(3) Total earth thrust is first obtained & its position & direction of the earth pressure are assumed to be known. Linear variation of pressure with depth is tacitly assumed & direction is automatically obtained from the concept of wall friction.	(3) Plastic equilibrium inside a semi-infinite soil mass is considered, pressures evaluated, a retaining wall is imagined to be interposed later & the location & magnitude of the total earth thrust are established automatically.
(4) More versatile since (1) any shape of backfill surface can be accounted (2) any break in the wall face or in surface of the fill is accounted. (3) considers effects of stratification of backfill (4) effects of various kinds of surcharge on earth pressure is considered (5) effects of cohesion, adhesion & wall friction is considered. (6) Provides more reliable results from graphical solutions.	(4) Not versatile.

1.(c) A retaining wall of 9m height retains cohesionless backfill with e=0.6, Φ=33◦ and G=2.68. The surface is level with the top of the wall. The water table is at a depth of 3 m from the ground surface. Obtain pressure distribution diagram and determine the total active pressure and its point of application. Take γ_w = 10 kN/m^3

Ans:- Pressure distribution diagram **– *1.5 mark***

Ka = 1-sin33/ 1+sin33 = 0.295 **– *0.5 mark***

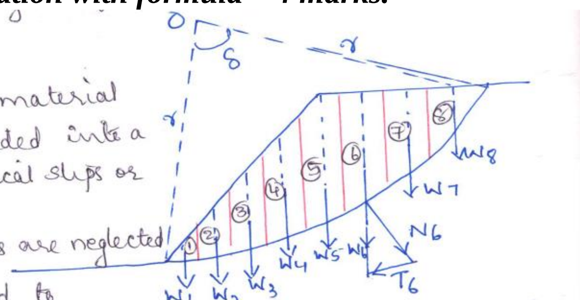
$\gamma_d = G\gamma_w/1+e$ = 16.75 kN/m^3 **– *0.5 mark***

γ_{sub} =(G-1)γ_w/1+e = 10.5 kN/m^3 – ***0.5 mark***
p_1 = 0.295*16.75*3 = 14.823 KN/m^2 – ***0.5 mark***
p_2 = 0.295*16.75*3 = 14.823 KN/m^2 – ***0.5 mark***
p_3 = 0.295*10.5*6 = 18.585 KN/m^2 – ***0.5 mark***
p_4 = 10*6 = 60 KN/m^2 – ***0.5 mark***
P_1 = 0.5* p_1 *3 = 22.23 KN/m – ***0.5 mark***
P_2 = p_2 *6 = 88.94 KN/m – ***0.5 mark***
P_3 = 0.5* p_3 *6 = 55.575 KN/m – ***0.5 mark***
P_4 = 0.5* p_4 *6 = 180 KN/m – ***0.5 mark***
P= P_1 + P_2 + P_3 + P_4 = 346.925 KN/m – ***1.0 mark***
Point of application = 2.577 m – ***1.0 mark***

2.(a) Explain the Swedish Circle method of stability analysis for a C-Φ soil.

Ans:- ***Figure- 3 marks, Explanation with formula – 4 marks.***

② c – φ analysis



→ Trial ○le is drawn, & material above slip circle is divided into a convinient no. of vertical slips or slices.
→ The forces b/w the slices are neglected.
→ Each slice is assumed to act independently as a column of soil of unit thickness & width b.
→ Weight 'W' of each slice can be resolved into normal 'N' & tangential 'T' components.
'N' passes through centre of rotation 'O' & hence do not cause any driving moment on the slice.

$N = W\cos i$ & $T = W\sin i$.

Driving moment, $M_D = T \times r = W\sin i \times r$
$= r \times \Sigma T$.

Resisting moment, $M_R = r\left[c\,\Sigma\Delta L + \Sigma N\tan\phi\right]$
where $\Sigma\Delta L = \hat{L} = \frac{2\pi r\delta}{360°}$ = length AB of slip ○le.

$\therefore$ $\boxed{\text{FOS against sliding} = \frac{c\hat{L} + \Sigma N\tan\phi}{\Sigma T}}$

A no. of trial ○les are chosen & FOS in each case is computed
○le giving min FOS is the critical slip circle.

2.(b) Explain the Fellinious method of locating the center of critical slip circle.

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

In case of slopes in homogeneous cohesive soil deposits, the centre of a critical circle can be directly located by using Fellenius direction angles.

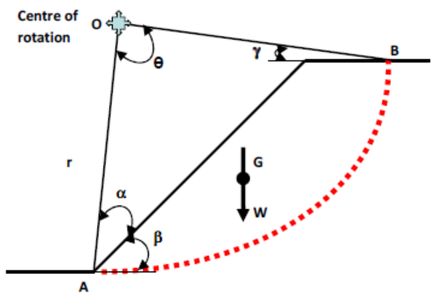
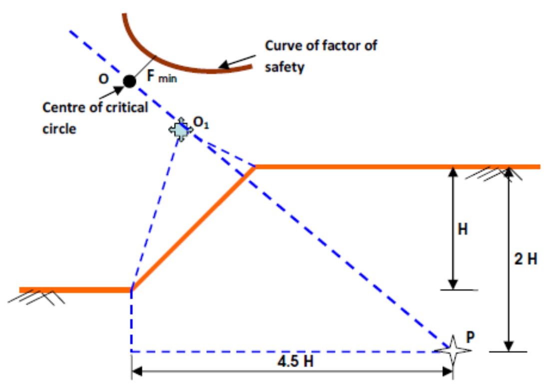


Table 2: Fellenius direction angles for locating critical slip circle

Slope	Angle α	Angle γ
1:1	28º	37º
1:1.5	26º	35º
1:2	25º	35º
1:3	25º	35º
1:5	25º	37º

For any given slope the corresponding direction angles a and g are set out from the base and the top as shown in figure. The point of intersection of these two lines is the centre of critical circle. In case of c-f soils the procedure for locating critical slip surface is slightly different and is as given below:



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) A 6 m deep canal is to be excavated through a soil with C = 15 kN/m², Φ = 20◦, e = 0.65 & G = 2.6. The side slope is 1:1. If Sn = 0.06, determine the FOS wrt cohesion when the canal runs full. What will be the FOS if the canal is rapidly emptied? Take Taylor's stability no: for this condition as 0.114.

Ans:- $\gamma_{sub} = (G-1)\gamma_w/1+e = 9.697$ kN/m^3 ***– 1.0 mark***

$F_c = C/ S_n \gamma H = 4.29$ ***– 1.0 mark***

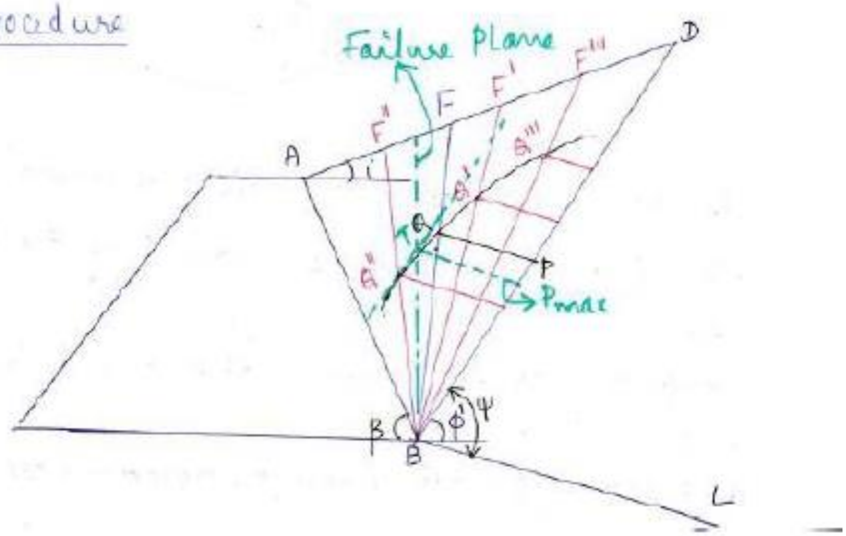
$\gamma_{sat} = (G-e)\gamma_w/1+e = 19.69$ kN/m^3 ***– 1.0 mark***

$F_c = C/ S_n \gamma H = 1.11$ ***– 1.0 mark***

3.(a) Explain with a neat sketch, Culmann's construction for active pressure.

Ans:- ***Figure – 3 marks, Explanation – 5 marks***

Procedure



From B, a line BD is drawn at an angle φ' to the h...
As the weight of the wedge is plotted along this line, ...
is also known as the weight line.

A line BL is drawn at an angle ψ with the line BD, ... that ψ = β - δ

A failure surface BF is assumed & the weight W of the failure wedge ABF is computed.

(4) The weight (W) of the wedge is plotted along BD such that BP = W.

(5) From P, draw a line PG parallel to BL to intersect the failure surface BF at G.

(6) The line PG represents the magnitude of Pa required to maintain equilibrium for the assumed failure plane.

(7) Similarly several other failure planes BF'', BF', BF''' etc are assumed & the procedure is repeated & thus the points

Q'', Q', Q''' etc are located.

(8) A smooth curve is drawn joining the points Q'', Q, Q', Q'''. This curve is called culmann's line.

(9) A line (shown dotted) is drawn tangential to the culmann line & parallel to BD. Point T is the point of tangency.

(10) The magnitude of the largest value (P_{max}) of P_a is measured from the tangent point T to the line BD and parallel to BL. It is equal to Coulomb's active pressure (P_a).

(11) The actual failure plane passes through the point T.

3.(b) Explain briefly the types of slope failure.

Ans:- ***Explanation- 3 marks, figure- 3 marks.***

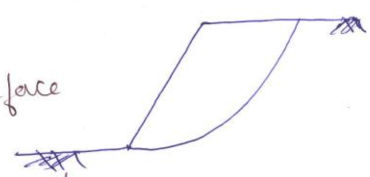
Broadly slope failures are classified into 5 types as:

(1) Rotational Failure – Caused by the rotation along a slip surface by downward & outward movement of the soil mass.

→ Slip surface – circular – homogeneous soils
non circular – non-homogeneous soils.

Again divided into 3 types.

(1) Toe failure:-



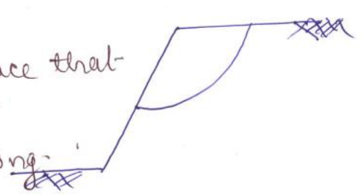
→ Failure occurs along the surface that passes through the toe.

→ occurs in steep & homogeneous slopes.

② Slope failure :-

→ Failure occurs along a surface that intersects the slope above toe.

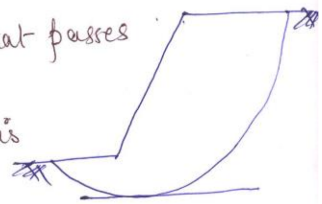
→ Occurs when soil at toe is strong.



③ Base failure :-

→ Failure occurs along a surface that passes below the toe

→ Occurs when soil below the toe is weak & soft.

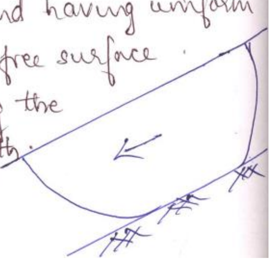


② Translational failure – occurs only on infinite slopes along a long failure surface parallel to the slope.

→ Infinite slope – slope of unlimited extend having uniform soil properties at same depth below the free surface.

→ Shape of failure surface is influenced by the presence of hard stratum at shallow depth.

→ occurs in layered materials also.

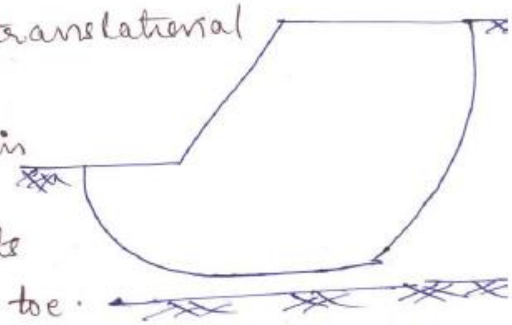


③ Compound failure.

→ Combination of rotational & translational failure.

→ curved at 2 ends and plane in the middle portion.

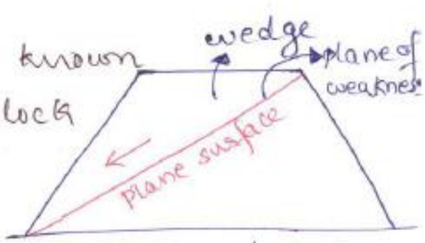
→ occurs when hard stratum exists at considerable depth below the toe.



④ Wedge Failure

→ Failure is along an inclined plane known as plane failure / wedge failure / block failure.

→ occurs in a finite slope consisting of 2 different materials or in a homogeneous slope section having cracks, fissures, joints etc.



⑤ Miscellaneous failures – in the form of spreads & flows may also occur.

3.(c) A homogeneous slope 15 m high is made of c — ϕ soil with unit weight of l8kN/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:-

$F_c = C/ S_n*\gamma*H = 50/ 0.05*18*15 = 3.704$ – ***1.5 mark***

$H_c = F_c * H = 3.704*15 = 55.55$ m – ***1.5 mark***