SOLUTION -IMPROVEMENT TEST

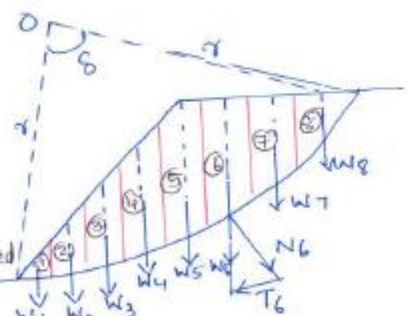
GEOTECHNICAL ENGINEERING-II (10CV64)

1(a). Explain swedish circle method of stability analysis of slopes for C-Φ soils.

Ans:-

② $c-\phi$ analysis

→ Trial circle 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 circle.

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

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

1(b). Distinguish between finite and infinite slopes.

Ans:- Infinite slopes: They have dimensions that extend over great distances and the soil mass is inclined to the horizontal. Eg: Natural hills, mountains etc. If different strata are present strata boundaries are assumed to be parallel to the surface. Failure is assumed to occur along a plane parallel to the surface.

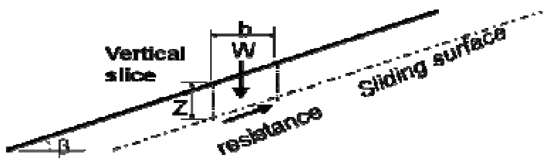


Fig 1: Infinite Slope

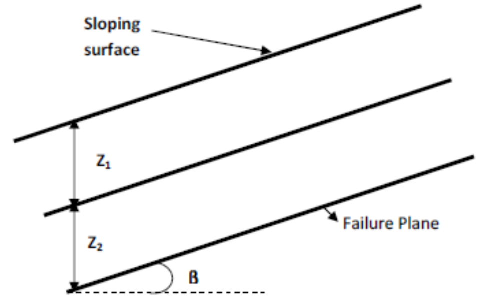


Fig 2: Infinite Slope in layered soils

Finite slopes: A finite slope is one with a base and top surface, the height being limited. The inclined faces of earth dams, embankments and excavation and the like are all finite slopes.

Investigation of the stability of finite slopes involves the following steps a) assuming a possible slip surface, b) studying the equilibrium of the forces acting on this surface, and c) Repeating the process until the worst slip surface, that is, the one with minimum margin of safety is found.

The different methods of analysis are Swedish method of slices or Method of slices, Friction circle method, Taylor's method etc.

2(a). Explain any five limitations of plate load test.

Ans:- The plate load test has the following limitations:

1) Size effect:- The test does not truly represent the actual conditions if the soil is not homogeneous and isotropic to a large depth.

2) Scale effect:- The ultimate bearing capacity of saturated clays is independent of the size of the plate but for cohesionless soils, it increases with the size of the plate.

3) Time effect:- For clayey soils the test does not give the ultimate settlement since it is of short duration.

4) Reaction load:- It is not practical to provide a load more than 250 kN. Hence test on a plate of size larger than 0.6 m width is difficult.

5) Water table:- If the water table is above the level of the footing, it has to be lowered by pumping before placing the plate.

2(b). The soft normally consolidated clay layer is 18 m thick with following properties: LL= 63 %, γ_{sat} = 18 kN/m^3, w= 28 % and G = 2.70. The vertical stress increment at the center of the layer is 9 kN/m^2 . The ground water level is at surface of clay layer. Determine consolidation settlement.

Ans:-

Given :- H = 18 m, LL = 63%, γ_{sat} = 18 KN/m^3, w = 28%, G = 2.70.

$\Delta\sigma$ = 9 KN/m^2

$$S_c = \frac{C_c}{1+e_0} \times H \times \log_{10}\left(\frac{\sigma_0 + \Delta\sigma}{\sigma_0}\right)$$

$$\sigma_0 = \gamma_{sub} \times \frac{H}{2} = (18-10) \times \frac{18}{2} = 72 \text{ KN/m}^2$$

$$C_c = 0.009(63-10) = 0.477$$

$$e_0 = w \times G = 0.28 \times 2.70 = 0.756$$

$$\therefore S_c = \frac{0.477}{1+0.756} \times 18 \times \log_{10}\left(\frac{72+9}{72}\right)$$

$$= 0.250 \text{ m} = \underline{\underline{250.111 \text{ mm}}}$$

3(a).List the assumptions of Terzaghi's bearing capacity equation.

Ans:-

① The base of the footing is rough.

② The footing is laid at a shallow depth i.e $D_f \le B$.

③ The shear strength of the soil above the base of the footing is neglected. The soil above the base is replaced by a uniform surcharge γD_f.

④ The load on the footing is vertical & is uniformly distributed.

⑤ The footing is long i.e L/B ratio is infinite where B is the width and L is the length of the footing.

(6) The shear strength of the soil is governed by the Mohr-Coulomb eqn.

(7) Soil is homogeneous & isotropic.

(8) Elastic zone has straight boundaries inclined at an angle equal to Φ to the horizontal.

3(b). A flow net drawn for seepage flow below a dam has 4 channels and 9 equi-potential lines. There is 8 m of water on upstream side and no water on downstream. If the soil below the dam has Kx = 4 × 10^{-4} cm/s and Ky = 2 × 10^{-4} cm/s, calculate the seepage loss per day for every 100 m length of the dam.

Ans:- *Data given :*

$H = 8\ m$, $N_d = 8$, $N_f = 4$, $k = sqrt(k_x\ X\ k_y) = 2.83\times10^{-4}\times 10^{-2}\ m / sec$

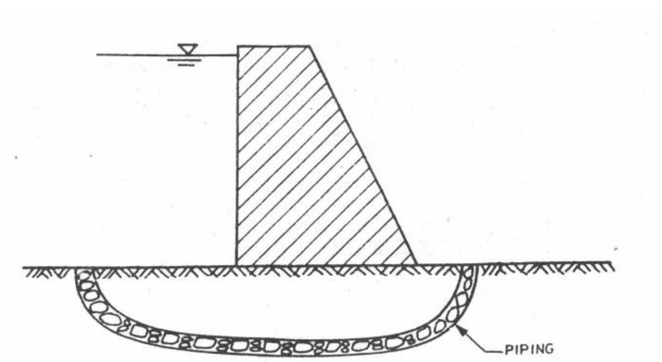
$$Q = k \times H \times \left(\frac{N_f}{N_d}\right)$$

$= 2.83\times10^{-2} \text{ x } 60 \text{ x } 60 \text{ x } 24 \text{ x } 4 \text{ x } 100 \text{ x } 8 \text{ x } 10^{-4} \text{ x } 10^{-1}$

= 78.2 m^3/day.

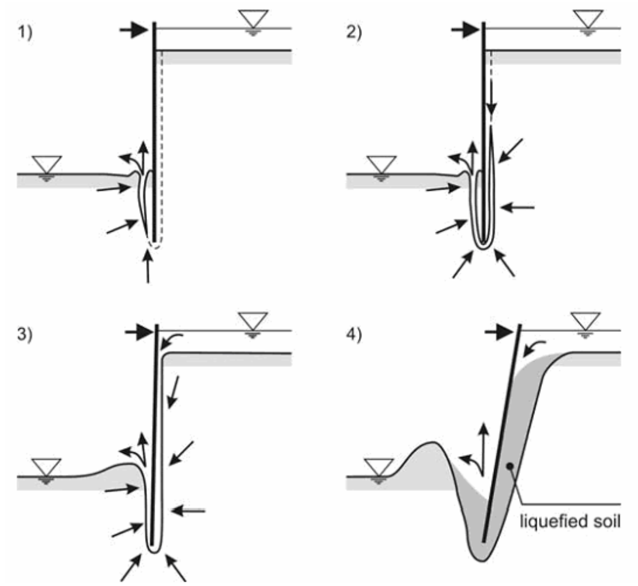
4(a). Explain briefly piping failures.

Ans:- *Backward erosion Piping:-*It is caused by the percolating water and the piping begins when the exit gradient exceeds the critical gradient. The soil at the exit is removed by the percolating water. When the soil gets removed the flow gets modified. As there is more concentration in the remaining soil mass, there is an increase in exit gradient.



*Hydraulic Heave or Piping:-*Many dams on soil foundations have failed because of the sudden formation of a piped shaped discharge channel. As the store water rushes out, the channel widens and catastrophic failure results. This results from erosion of fine particles due to water flow.

Another situation where flow can cause failure is in producing 'quicksand' conditions. This is also often referred to as piping failure.



Piping Failure : 1) initiation and first deterioration, 2) regressive erosion, 3)formation of flow channel, 4) liquefaction and collapse

4(b).) Explain the types of slope failure.

Ans:- Broadly slope failures are classified as:

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

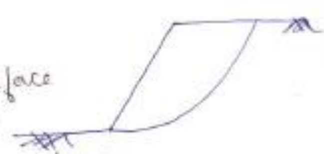
→ slip surface — circular — homogeneous soils
non circular — non-homogeneous soils.

Again divided into 3 types.

① Toe failure:-

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

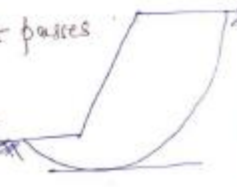
→ occurs in steep & homogeneous slopes.



② Slope failure:-

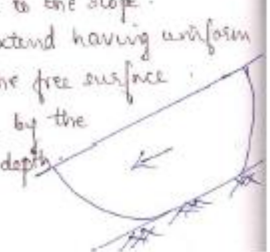

→ Failure occurs along a surface that intersects the slope above toe.

→ Occurs when soil at toe is strong.

③ Base failure:-


→ Failure occurs along a surface that passes below the toe

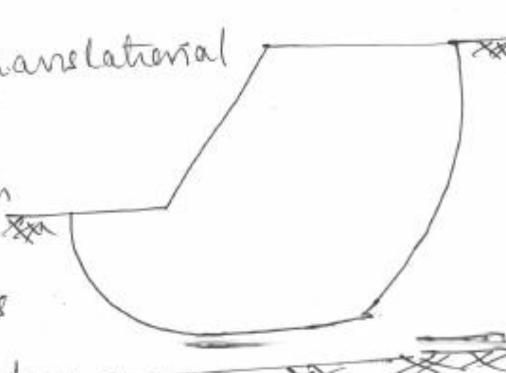
→ Occurs when soil below the toe is weak & soft.

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.

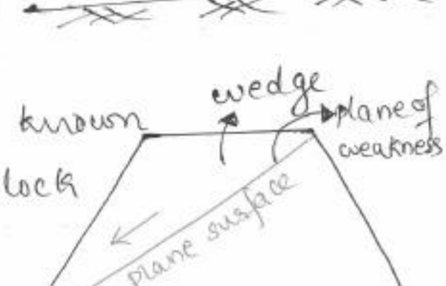
→ occurs in layered materials also.

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 a different materials or in a homogeneous slope having cracks, fissures, joints etc.

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

5(a). Explain the causes of slope failure with neat sketch.

Ans:- The causes of slope failure are:

1.Erosion: The wind and flowing water causes erosion of top surface of slope and makes the slope steep and thereby increase the tangential component of driving force.

2. Steady Seepage: Seepage forces in the sloping direction add to gravity forces and make the slope susceptible to instability. The pore water pressure decreases the shear strength. This condition is critical for the downstream slope.

3. Sudden Drawdown: in this case there is reversal in the direction flow and results in instability of side slope. Due to sudden drawdown the shear stresses are more due to saturated unit weight while the shearing resistance decreases due to pore water pressure that does not dissipate quickly.

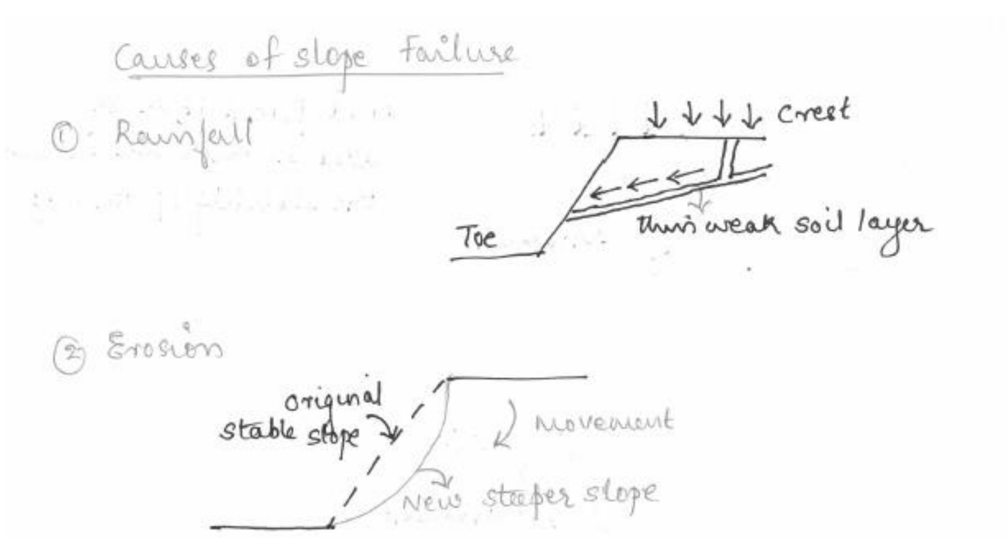
4. Rainfall: Long periods of rainfall saturate, soften, and erode soils. Water enters into existing cracks and may weaken underlying soil layers, leading to failure, for example, mud slides.

5. Earthquakes: They induce dynamic shear forces. In addition there is sudden buildup of pore water pressure that reduces available shear strength.

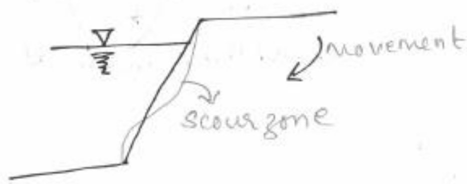
6. External Loading: Additional loads placed on top of the slope increases the gravitational forces that may cause the slope to fail.

7. Construction activities at the toe of the slope: Excavation at the bottom of the sloping surface

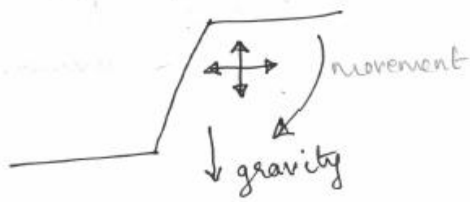
will make the slopes steep and thereby increase the gravitational forces which may result in slope failure.



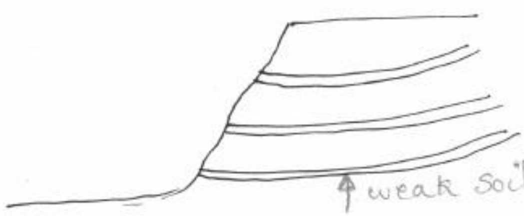
(3) Scour by rivers & streams



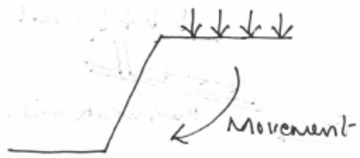
(4) Gravity & earthquake forces :



(5) Geological features – soil stratification

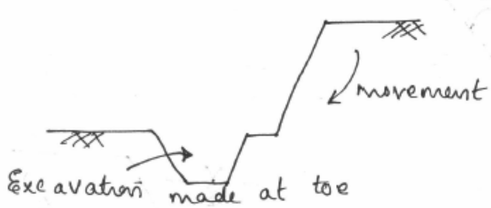


(6) overloading at the crest of the slope

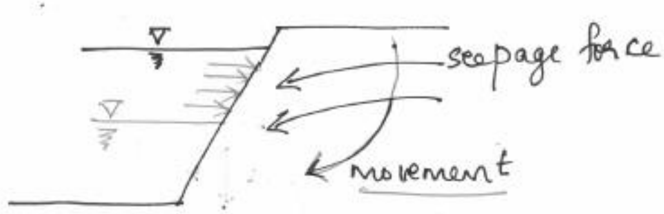


Load placed at the toe called as *berm* will increase the stability of the slope

(7) Excavation at the toe of the slope



(7) Drawdown



5(C). **A clay layer 3.5m thick is sand-wiched between layers of sand. Calculate the time required by the clay layer to reach 50% consolidation, the co-efficient of consolidation, is 4 x 10-4cm^2/sec.**

Ans:- *Given* d= 3.5 m X 100 /2 = 175 cm, $C_v = 4x10^{-4}$ cm^2/s, $(T_v)_{50} = 0.196$.

$Cv = (T_v)_{50}$ x d^2 / t_{50}

$t_{50} =$ 0.4758 yrs.