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Section # A
Paper # Geotechnical foundation
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Ans (a) -

force acting on Dam :-

- (1) water pressure
- (2) uplift pressure
- (3) wave pressure
- (4) silt pressure
- (5) ice pressure
- (6) self weight of the dam
- (7) seismic force.

(1) self weight of dam

The weight of the dam and its foundation is a major resisting force. It can be computed using the following equation

$$W = \gamma \times \text{volume}$$

where γ_m = unit weight of material

(2) Silt pressure:

It is the pressure that is caused by the deposition of the silt in the bed of the dam causing at h/3 from the base and can be computed using equation

$$p_{\text{silt}} = 0.5 \gamma_s h^2 / k_a$$

where k_a = coefficient acting earth pressure of silt which is equal

$$to = \frac{1 - \sin \phi}{1 + \sin \phi}$$

(3) wave pressure:-

wave are generated on the surface of the reservoir by the blowing winds which exert the pressure on the upper part of the dam above the water level. This pressure is calculated by the following formula

waves pressure depends upon wave heights which is given by.

$$P_w = 2.4 v w h_w$$

for $f > 32 \text{ km}$

$$h_w = 0.32 \sqrt{P_w} + 0.763 - 0.27 u f^{1/4}$$

for $f > 32 \text{ km}$

$$h_w = 0.32 \sqrt{P_w}$$

where h_w = height of water from the top of crest to bottom of trough in meter

v = wind velocity in km/hours

f = fetch or straight length of water expanse in km.

(4) Ice pressure :-

The ice which may be formed on the water surface of the reservoir in cold countries may some-time melt and expand. The dam face is subjected on the thrust and exerted by the expanding ice. This force acts linearly along the length of the dam and at reservoir level

⑧ Seismic force

Dynamic load created due to earth quakes must be considered in the design of all major dam located in high risk seismic region. Earthquake pressure wave in every possible direction. However it has to be resolved into vertical and horizontal component for the design purposes.

Q. part b:

① liquefaction of soil:

Liquefaction is the process that leads to a soil losing strength most commonly as a result of ground shaking during a large earthquake.

② Batter dam:-

A batter dam is defined as a dam consisting of a relatively thin water supporting facing or deck supported by batters generally in the form of equally spaced tripular walls or counter forts that transmit the water load and deck weight to the foundations.

(3) Infinite slope -

Slope which have great extent with uniform soil condition at any given depth below the surface.

(*) The soil stratum is not necessary homogenous with depth but the strata of different soil are parallel to the slope surface.

(4) Pier foundation -

A pier foundation consists of a cylindrical column of large condition diameter to support and transfer large super imposed loads to the firm strata below through pile foundation transfer the load through friction and or bearing pier foundations transfer the load only through bearing.

(5) Dynamic loads -

The load which acts on ground by the movement of subjects and sometimes the load due to earthquake can be classified as dynamic load.

Q2 Part A

Shallow foundation :-

The foundation in which depth of the foundation is less or equal to width of the foundation is called Shallow foundation

$$D_f \leq B$$

Types of Foundation.

- (1) wall footing
- (2) combined footing
- (3) Raft / Mat footing
- (4) Strapped footing
- (5) column / isolated footing
- (6) stepped footing.

(1) wall footing

The footing which runs across the length of the wall and transfer the load of the wall to the soil safely it is called wall or strip footing

(2) combined footing :-

The footing which is constructed for two or more column transfer the load of the two or more column to the soil safely then it is called combined footing

(3) Raft/mat footing.

The footing which covers the whole area of the structure is called Raft footing. This type of footing is proposed in area which have soil weak in bearing capacity. This is also provided when the load of super structure is heavy.

(4) Strapped footings.

The footing in which the outer column is connected with the inner column by means of the beam or strap is called Strapped footing.

(5) Column/isolated footing :-

The footing which is constructed for a single column and transmit the load to the soil safely. It may be circular, square or rectangular.

(6) Stopped footing :-

The footing which have slope in all direction as in all sides is called as Stopped.

Q2 part b:-

Ground Improvement Techniques:-

Ground improvement techniques are the techniques which are used to enhance the engineering property of soil in order to bear heavy structure load. The main properties are steel strength permeability bearing capacity and stiffness etc.

Need of Ground Improvement Techniques:-

The soil in which volumetric changes takes place due to shrinkage and swelling such soil needs ground improvement techniques.

- The soil which is organic in nature
 - ⑥ The soft soil also required ground improvement techniques.
 - ⑦ The soil which is sandy and gravelly
- The foundation in sanatory dump places also required ground improvement techniques.

Method of ground improvement techniques

① Removal and replacement of soils:-

This is an oldest and simple method. This method is performed on loose soil. In this method the unsuitable soil is replaced with compacted fill. In this method the same soil is used to refill. The higher compaction and better engineering properties.

(2) Dynamic compaction.

This method is used to increase the bearing capacity of soil. This also increases the consolidation rate. This method actually increases the density of soil. In this method, actually densification of soil takes place.

(3) Vibro compaction.

It is also called vibro densification. In this method, the compaction takes place at a certain depth in granular soil through a vibratory probe. This motor's penetration is enhanced by ejecting water at the tip of the probe.

(4) Rapid impact compaction:-

Applied to the surface of ground as a result of which densification of soil takes place up to a depth of 15 feet. This impact energy is actually applied through a hydraulic rammer. The hydraulic rammer weight values range from 4-8 tons.

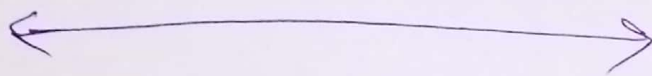
(5) Vibro concrete column:

Vibro concrete columns is a ground improvement technique which transfers the load from weak strata to hard strata by using strength concrete.

⑥ wet Soil Mixing:- In this method of ground improvement technique a paste of cement is prepared and inserted in the soil. This method is used to improve the characteristics of weak soil by using cementitious binders slurry.

⑦ Dry Mixing of Soil:-

Dry soil mixing is ground improvement techniques by which the characteristics of weak soil are improved by using dry cementitious binder.



Q₃
Ans

Given data:

$$c = 25 \text{ kN/m}^2$$

$$\phi = 26^\circ$$

$$G_s = 2.72$$

$$e = 0.50$$

Required:-

f_c (F.O.S) when soil is dry

f_c (F.O.S) when there is seepage in soil

Solution:-

$$f_c = \frac{c}{\gamma_d \times H \times \sin i \times \cos i} + \frac{\tan \alpha}{\tan i}$$

$$\gamma_d = \frac{G_s \times \gamma_w}{1 + e} = \frac{2.72 \times 9.8}{1 + 0.5}$$

$$\gamma_d = 17.8 \text{ kN/m}^3$$

$$F_c = \frac{25}{17.8 \times 6 \times \sin(26^\circ) \times \cos(26^\circ)} + \frac{\tan(16^\circ)}{\tan(26^\circ)}$$

$$F_c = 1.18$$

When there is seepage of water

$$F_c = \frac{c}{\gamma \times H \times \sin i \times \cos i} + \frac{\gamma'}{\gamma} \times \frac{\tan \phi}{\tan i}$$

$$\gamma' = \gamma - \gamma_w$$

$$\gamma = \frac{G + e}{1 + e} \times \gamma_w$$

$$= \frac{2.72 + 0.5}{1 + 0.5} \times 9.8$$

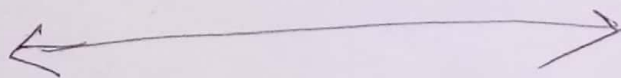
$$\gamma = 21.04 \text{ kN/m}^3$$

$$\gamma' = 21.04 - 9.8$$

$$\gamma' = 11.24 \text{ kN/m}^3$$

$$F_c = \frac{25}{21.04 \times 6 \times \sin(26^\circ) \times \cos(26^\circ)} + \frac{11.24}{21.04} \times \frac{\tan(16^\circ)}{\tan(26^\circ)}$$

$$F_c = 0.816$$



Q = 4 part a.

Given data

$$\text{Height} = H = 10 \text{ m}$$

$$c = 18.8 \text{ kN/m}^2$$

$$\gamma = 17 \text{ kN/m}^3$$

$$\alpha = 20^\circ$$

$$\text{FOS} = 1.5$$

$$F\alpha = 1.0$$

Required -

inclination.

Solution:-

As we know that

$$\ln = \frac{c}{\text{FOS} \times \gamma \times H}$$

$$S_n = \frac{18.8}{1.5 \times 17 \times 10}$$

$$S_n = 0.073$$

Using Taylor chart for

$$\alpha = 20^\circ$$

$$S_n = 0.073$$

then

$$j = 44 \text{ from Taylor chart.}$$

Q4 part b

Given data -

Height of water on upstream side = 75m
 Bottom width of the dam = 12m
 Top width = 6m
 unit weight of water = 1000 kg/m³
 unit weight of concrete = 1450 kg/m³
 unit weight of silt = 1350 kg/m³
 Angle of friction for silt = $\phi_s = 35^\circ$
 Free Board = 3.5m
 silt deposit height = 2.5m

Required

silt pressure = ?

Solution.

As we know that

$$P_s = \frac{\gamma_s \times H_s^2}{2} \times \frac{1 - \sin \phi}{1 + \sin \phi}$$

$$P_s = \frac{1330 \times (2.5)^2}{2} \times \left(\frac{1 - \sin 35^\circ}{1 + \sin 35^\circ} \right)$$

$$P_s = 1126.30 \text{ kg/m}$$

