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Section A

Subject Geotechnical Engineering.

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Q#1 (a)

→ Following are the forces acting on dams

1) Water pressure (2) Uplift pressure
3) Wave pressure (4) Silt pressure
5) Ice pressure (6) Self weight of Dam
7) Seismic forces.

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.

$$W = \gamma_m \text{ Volume}$$

where γ_m = unit weight of dam material.

2) Silt pressure :- Pressure 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 equations:

$$P_{silt} = 0.5 \gamma_s h^2 k_a$$

where k_a = Co-efficient of active earth pressure of silt $= \frac{1 - \sin\theta}{1 + \sin\theta}$

ϕ = Angle of internal friction of soil
cohession neglected.

γ = submerged unit weight of silt material.
h = height of silt deposited.

3) Wave Pressure :-

Waves are generated on the surface of reservoir by blowing winds which exert the pressure on the upper part of the dam above the water level. Computed by the formula:

$$P_w = 2.5\ \gamma_w h_w$$

Wave pressure depends upon wave height Given by:

For F < 32 km:

$$h_w = 0.32\sqrt{FV} + 0.763 - 0.27 \times F^{1/4}$$

For F > 32 km:

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

Where:

h_w = Height of water from top of the crest to bottom of trough in meters.

V = Wind velocity in km/hrs
F = Fetch of water expance in km

The max pressure intensity due to wave action occurs when it acts at 0.5.

Total force due to wave action is given by :-

$$P_w = (0.5)(2.4\, r_w h_w)\, 3/8\, h_w.$$

4) Ice Pressure :-

The ice which maybe formed on the water surface of the reservoir in cold countries may sometime melt and expand. The dam face is subjected on the thrust and exerted by the expanding ice. Acts along nearly the length of the dam and at a reservoir level. The magnitude of these forces varies from 250 to 1500 kN/sq depending upon the temprature.

5) Seismic Forces :-

Dynamic load created due to earthquakes must be considered in the design of all major dam located in high risk seismic region.

Earthquake pressure waves in every possible ~~region~~ direction. However it has to be resolved in vertical and horizontal components for the design purposes. Seismic vibrations influence both dam body and water in the reservoir of the dam. Generated dynamic load is due to inertia of the dam and hydro dynamic forces by the water in reservoir.

part (b)

→ 1) liquification of soil :

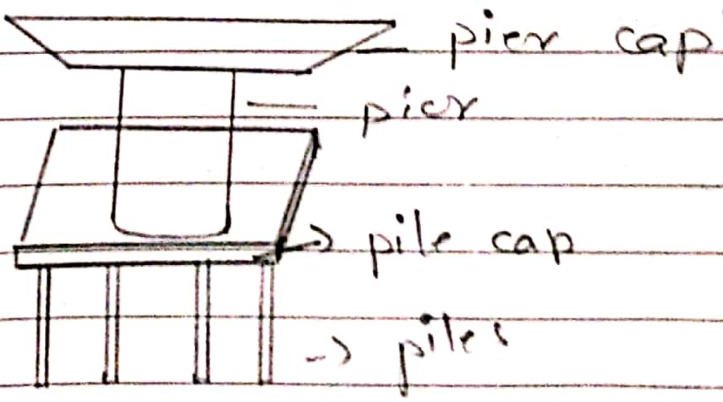
occurs when a saturated or partially saturated soil substantially loses strength and stiffness in reponse to an applied stress such as shaking during an earthquake or other sudden changes in stress condition.

2) Buttress dam :-

A buttress or hollow dam is a dam with solid, water tight upstream side that is supported at intervals on the down stream side by a series of buttress or supports. The dam may be straight or curved. Most buttress dam's are made of reinforced concrete and are heavy pushing the dam into the ground.

3) Infinite slope :
Slope extending infinitely or up to an extent whose boundaries are not well designed. For this type of slope the soil properties for all identical depths below the surface are same in the making of natural slopes there is no contribution from our side.

4) Pier foundation :-
A pier foundation is a collection of large diameter cylindrical columns to support the super structure and transfer large super-imposed loads the firm strata below. It stood several feet above the ground. Also known as "post foundation".



5) Dynamic load :-
Soil dynamic deals with the engineering behaviour of soils subjected to time varying loads and loads applied very rapidly. In soil dynamics applied loads vary with time. This implies that the stress and strain induced in the soil are also function of time.

Q#2 (a)

→ FOUNDATION:

The lowest part of the structure which transmit the load of super structure safely to the soil surface.

→ TYPES OF FOUNDATION:

There are two types of foundations,

(1) Shallow Foundation.
(2) Deep foundation.

1→ SHALLOW FOUNDATION:

→ According to TERZAGHI :-

The foundation in which the depth of the foundation is less as equal to width of the foundation is called shallow foundation.

$$D_f \leq B$$

→ According to SKEMPTON :-

The foundation in which Df/B ratio is less than as equal to 2.5, then the foundation is called shallow foundation.

→ TYPES OF SHALLOW FOUNDATION:-

(1) Wall footing.
(2) Combined footing.
(3) Raft / Mat facing.
(4) Strapped footing.
(5) Column / Isolated footing.
(6) Slapped footing.

1. WALL/ STRIPPED FOOTING:-

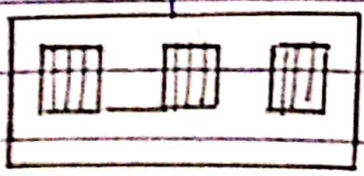
The footing which runs across the length of the wall and transfers the load of the wall to the soil safely. It is called wall or strip footing.

2. COMBINED FOOTING:-

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

If the load column is uniform, then the combined footing will be rectangular in shape, and if it is not uniform the shape will be Trapezoidal.

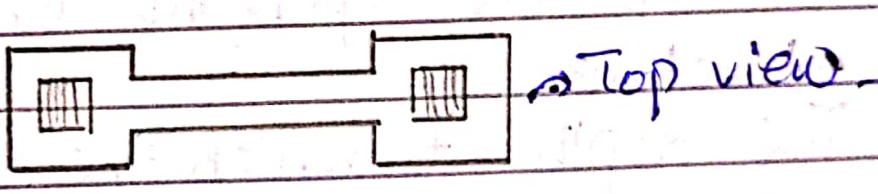
Rectangular



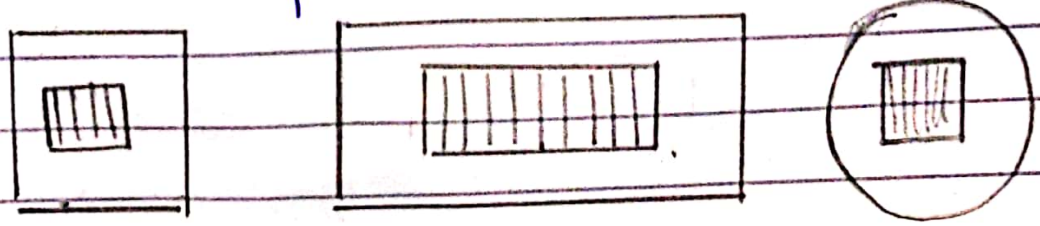
Trapezoidal

3→ RAFT/MATT 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 FOOTING:-
The footing in which the outer column is connected with the inner column by the means of the beam as strap is called strapped footing.

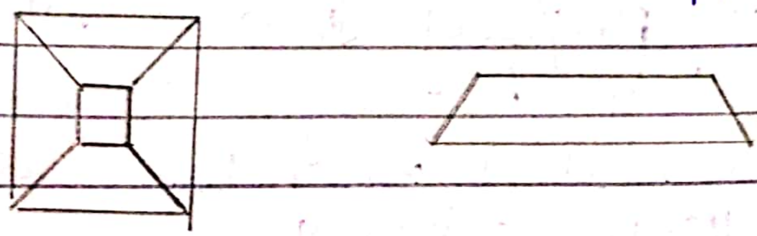


5 COLUMN/ ISOLATED FOOTING:-
The footing which is constructed for a single column and transmits its load to the soil safely. It may be circular, square or rectangular in shape.



6 → SLOPPED FOOTING:-

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



→ SELECTION OF FOUNDATION:

Selection of foundation depend upon the following;

(1) The type of soil and condition of soil.

(2) It depends upon the load of super structure.

(3) The depth at which the safe sealing capacity exists.

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 structural load.

The main properties are shear strength, permeability, bearing capacity, and stiffness etc.

→ Methods of ground improvement techniques

1→ Removal and replacement of soil :-

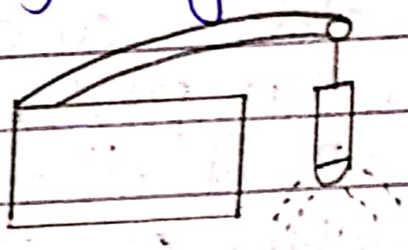
This is an oldest and simplest method. This method is performed on loose soil. In this method the unsuitable soil is replaced with compacted fill. In this method the same soil is used to refill the higher compaction and better engineering properties.

This method is applicable above the ground water table.

2- Dynamic Compaction:-

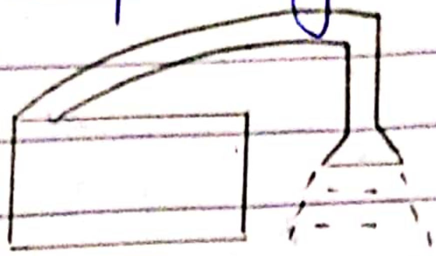
This method is used to increase the bearing capacity of soil. This also increase the consolidation rate. This method also increase the density of soil. In this method actually densification of soil take place.

3. Vibro compaction:
It is also called vibro densification. In this method the compaction takes place at a certain depth in granulal soil through vibratory probe. This vibratory probe is run by an electric motor. The penetration of probe is enhanced by ejecting water at the tip of probe.

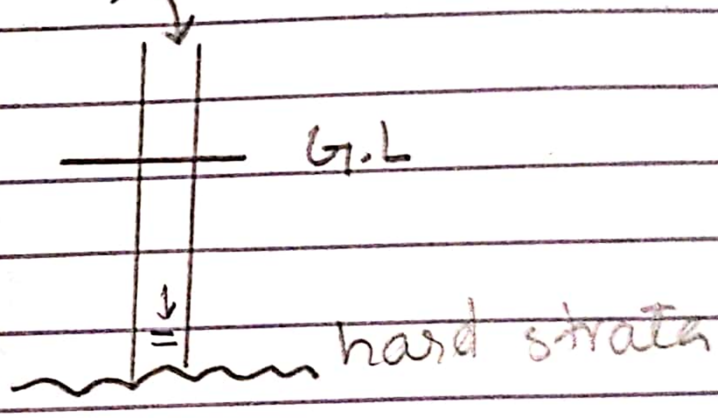


4. Rapid Impact compaction:
Impact energy is applied to surface of ground as a result of which densification of soil take place upto a depth of 15 feet.
This impact energy is actually applied through hydraulic ~~[illegible]~~ ramp. The

hydraullic ramp weight varies from 4-8 tons. (12)



5. Vibro concrete column;
Vibro concrete column is a ground improvement technique which transfer the load from weak strata to hard strata by using strength concrete.



6 Wet soil mixing:-
In this method 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.

Q# 3

→ Given data :-

$C = 25\ kN/m^2$

$\phi = 16°$

$G = 2.72$

$e = 0.50$

→ Required :-

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

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

→ Solution :-

$$F_c = \frac{c}{\gamma_d \cdot H \cdot \sin i \cdot \cos i} + \frac{\tan \phi}{\tan i}$$

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

$$= 17.8\ kN/m^3$$

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

$$= 1.18$$

→ When there is seepage of soil

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

$\gamma' = \gamma - \gamma_w$

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

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

$\gamma = 21.04 \ kN/m^3$

$\gamma' = \gamma - \gamma_w$

$= 21.04 - 9.8$

$\gamma' = 11.24 \ kN/m^3$

$Fc = \frac{25}{21.04 \cdot 6 \cdot \sin(26) \cdot \cos(26)} + \frac{11.24}{21.04} \times \frac{\tan(16)}{\tan(26)}$

$Fc = 0.836$ — Ans.

Q# 4 (a)

Given data :

Height = 10 m
c = 18.8 kN/m²
γ = 17 kN/m²
θ = 20°
F.O.S = 1.5
Fϕ = 1.0

Required inclination i = ?

Solution :-

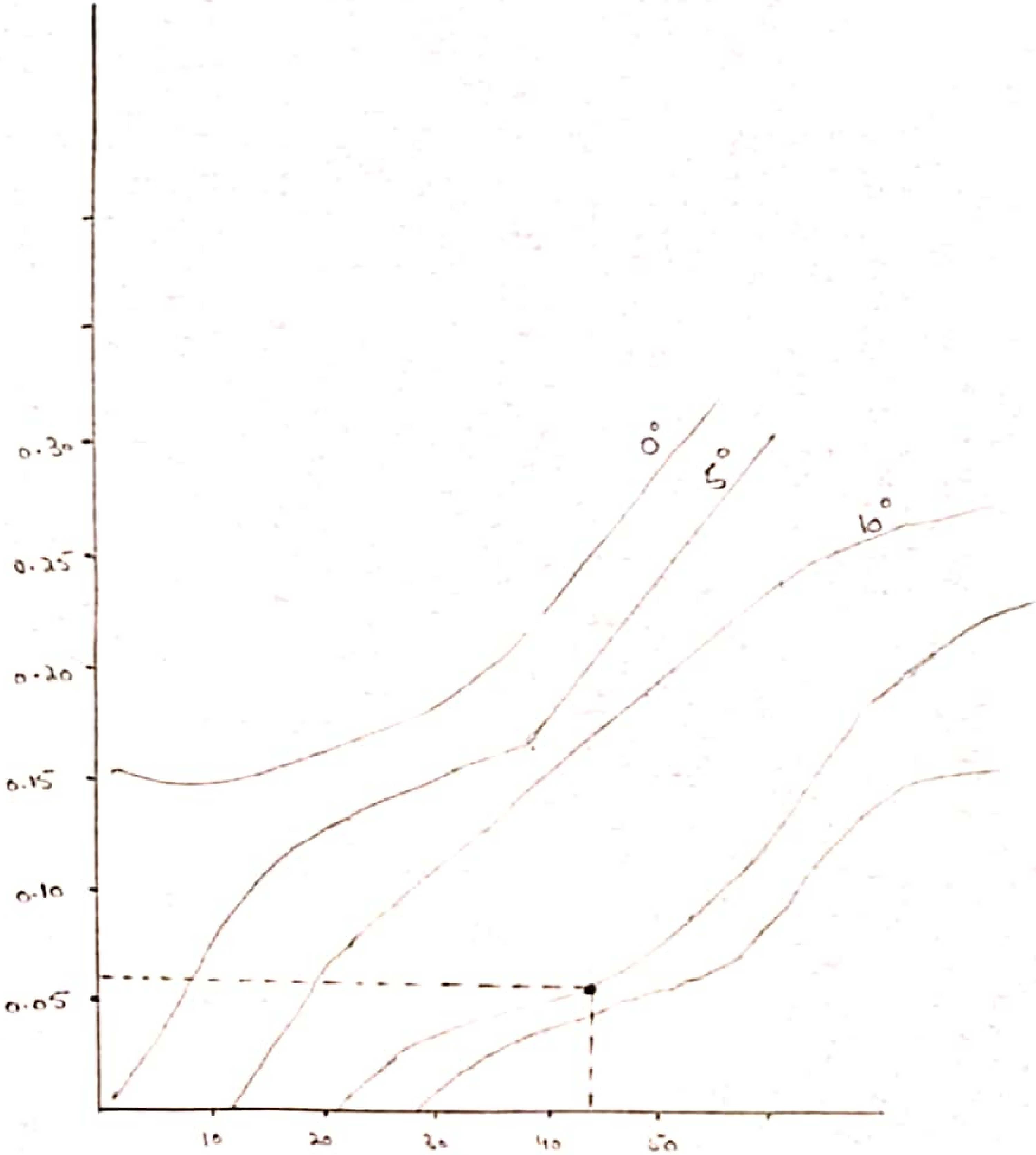
$$S_N = \frac{c}{F.O.S \times \gamma \times h}$$

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

$$S_N = 0.73$$

Using taylor chart for

$\theta = 20°$
$S_N = 0.073$
$i = 44°$


0.30
0.25
0.20
0.15
0.10
0.05
10
20
30
40
50
0°
5°
10°

Part (b)

Given data :-

Height of water on upstream side
= 15 m

Bottom width = 12 m

top width = 6 m

γ water = 1000 kg/m^3

γ concrete = 1450

γ silt = 1330 kg/m^2

θ = 35°

Free board = 3.5 m

H = 2.5 m

Required silt pressure P_s = ?

Solution :-

As we know

$$P_s = \frac{\gamma_w \times H^2}{2} \times \frac{1 - \sin\theta}{1 + \sin\theta}$$

$$= \frac{1330 \times 2.5^2}{2} \times \frac{1 - \sin 35}{1 + \sin 35}$$

$$= 4156.25 \times 0.27$$

P_s = 1122.18 kg/m.