LECTURE NOTES ON
GEOTECHINCAL ENGINEERING
COURSE CODE : TH2
DIPLOMA
3RD SEM(2023-24)

DEPARTMENT OF CIVIL ENGINEERING

GANESH INSTITUTE OF ENGINEERING AND TECHNOLOGY (POLYTECHNIC)
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Geotechnical Engineering:~

It is the branch of civil Engineering which deals with the Engineering properties behaviour of soil.

Types of soil:~

The soil is classified into following Categories:~

(1). Alluvial soil:– Transported soil by running water of river.

(2). Laccustrine soil:– Transported soil by water in lakes.

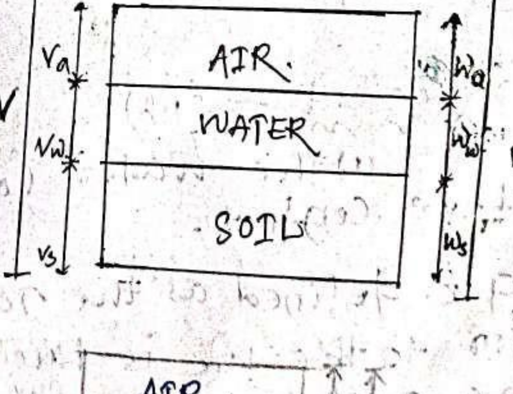
(3). Marine soil:– Transported soil by water in Marine or Ocean.

(4). Aeoline soil:– Transported soil by air or winds.

(5). Black cotton soil:– This soil formed due to Chemical action of rock.

(6). Loam soil:– It is the mixture of clay and sand.

(2). Phase System:–



Example:–

Total 100 g.m
Soil 65 g.m
water 20 gm
Air 5 g.m

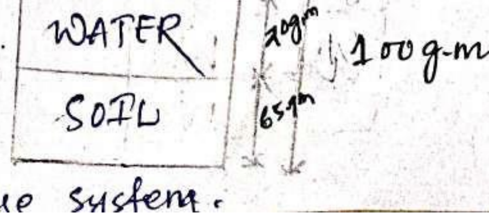


Fig. No. 01 — 3 phase system.

⇒ Structure Soil = Water + Soil

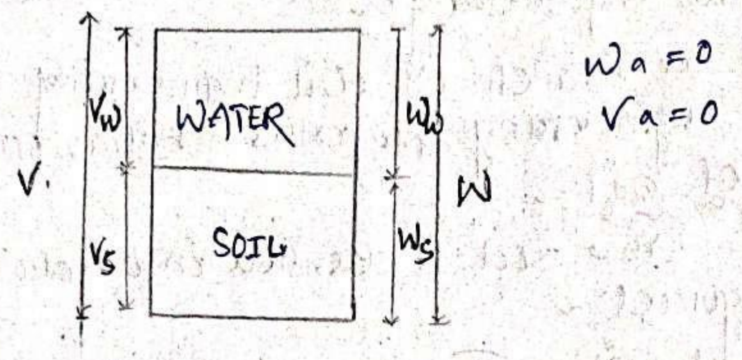


Fig No. 2 - 2-Phase System

⇒ Dry Soil :— Air + Soil

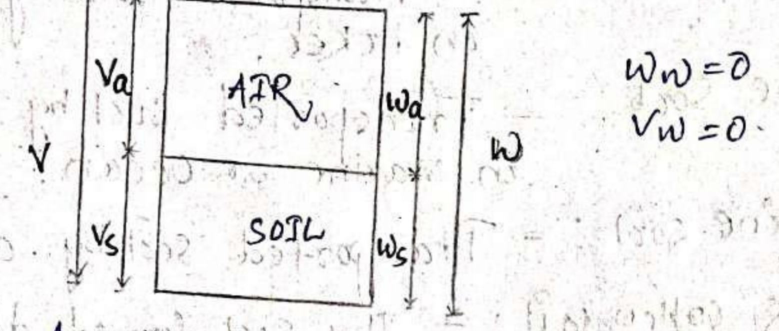


Fig No. 3 - 2Phase System.

#03:- Important xxx Terminology (D.T - 5/10/21)

There are 2Phase -

(a) Fully saturated (solid + water) } ∴ % air = 0

(b) Fully Dried Soil (solid + air) } ∴ % water = 0

(1) Water Content :— (w)

(i) The water Content (w) also called as Moisture Content.

(ii). It is defined as the ratio of weight (W_w) of water to the W_s is known as water content in a given soil Mass.

$$\therefore \boxed{w = \frac{W_w}{W_s}}$$

Example:- $W_w = 30$ gm
$W_s = 120$ gm

$$w = \frac{W_w}{W_s} = \frac{30\,gm}{120\,gm} = \frac{1}{4} = 0.25$$
$= 0.25 \times 100$
$= 25\%$

∴ w = Unitless

(02) Density :- (ρ) (Row)

→ The density of soil is defined as the ratio of Mass of soil to unit volume.

→ It is denoted by (ρ) - row

$$\rho = \frac{M}{V} = \frac{gm}{cm^3}$$ — cc

→ It is classified into 3 Types :-

(a). Bulk Density $(\rho) = \frac{M}{V}$

(b). Dry Density $(\rho_d) = \frac{M_d}{V}$

(c). saturated Density $(\rho_{sat}) = \frac{M_{sat}}{V}$

(03) Unit Weight :- (γ) gamma -

(1). Unit weight of soil is defined as the ratio of weight of soil Mass to volume of soil mass.

(2). It is denoted by (γ).

∴ $\gamma = \frac{W}{V}$

It is devided into 3 categories:—

(a). Bulk unit weight $(\gamma) = \frac{W}{V}$

(b). Dry unit weinght $(\gamma_d) = \frac{W_d}{V}$

(c). saturated unit weight $(\gamma_{sat}) = \frac{W_{sat}}{V}$

(04) Specific gravity :- (g) or (G)

> Specific gravity is denfined as the ratio of weight of a given volume of soil solid to the weight of an equal volume of distilled water.

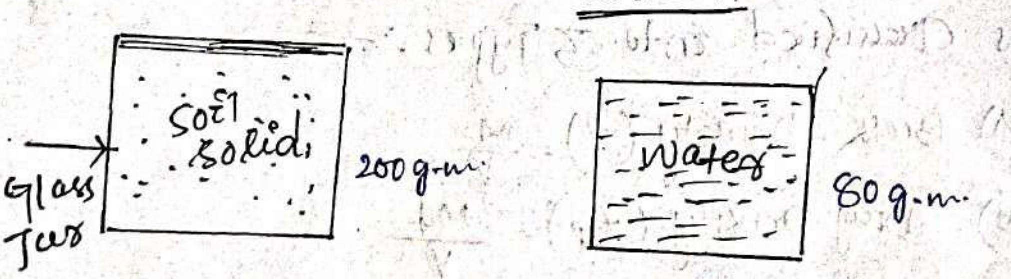
> It is denoted by (g).

Mathmatically,

$$g = \frac{\text{Wt of given volume of soil solid}}{\text{Wt of an equal volume of distilled water}}$$

case - I

case - II

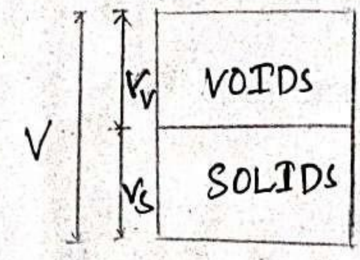


$$\therefore g = \frac{200 \text{ g.m}}{80 \text{ g/m.}} = 2.5$$

(05) Void Ratio (e) :—

→ Void Ratio of a given soil Sample is the ratio of volume of voids to the volume of soil solids.

→ it is denoted by (e).



Phase - Diagram

Mathmatically

$$\therefore \boxed{e = \frac{V_v}{V_s}} = \frac{m^3}{m^3} = \{\text{unit less})$$

Example :-

$e = 30\%$

$V_v = 60 m^3$

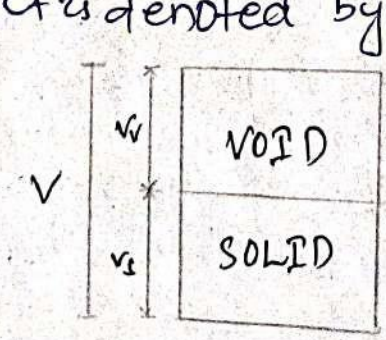
$V_s = \frac{30}{100} = 0.3$

$\Rightarrow 0.3 = \frac{60}{V_s} \Rightarrow V_s = \frac{60}{0.3} = 200\ m^3$

(06) Porosity :- (n)

→ porosity of a given Soil Mass is the ratio off Volume of voids to the total volume of soil Mass.

→ it is denoted by (n).



Phase - diagram

Mathmatically,

$$\boxed{n = \frac{V_v}{V}} \quad V \rightarrow V_v + V_s$$

$$= \frac{V_v}{V_v + V_s}$$

$$= \frac{V_v / V_s}{\frac{V_v}{V_s} + \frac{V_s}{V_s}}$$

$$\Rightarrow n = \frac{e}{e+1}$$

$$\Rightarrow n = \frac{e}{1+e}$$

Example - For a given soil mass $V_e = 0.3$ calculate the property for same soil.

Ans:- $n = \frac{e}{1+e}$

$$= \frac{0.3}{1+0.3}$$

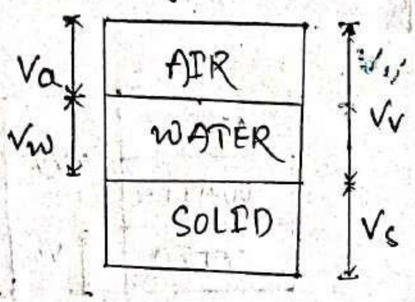
$$= \frac{0.3}{1.3} = 0.230 \text{ (Ans)}$$

(07) Degree of saturation (S) :-

(i) * In a given volume of voids of Sample, from space it occupied by water and the rest by air.

→ The degree of saturation is defined as the ratio of the volume of the water to the Total volume of voids.

→ it is denoted by (S)..



$V_a + V_w = V_v$

3Phase - diagram

Mathmaticall,

$$S = \frac{V_w}{V_v}$$

(08). Functional Relationship :-

(1) Relation Between e, G, w and s :-

$$S = \frac{V_w}{V_v} = \frac{e_w}{e}$$

$$\Rightarrow \boxed{e_w = e_s} \longrightarrow (a)$$

$$w = \frac{W_w}{W_s} = \frac{e_w \cdot \gamma_w}{\gamma_s \cdot 1} = \frac{e_w \cdot \gamma_w}{G\gamma_w \times 1} = \frac{e_w}{G}$$

$$G = \frac{W_s}{W_w} = \frac{\gamma_s}{\gamma_w} \Rightarrow \boxed{\gamma_s = G\gamma_w}$$

$$\boxed{e_w = wG} \longrightarrow (b)$$

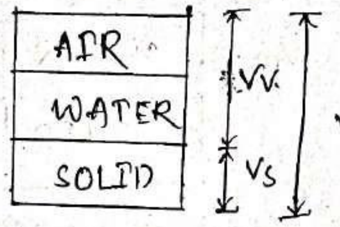
From the Equation ① and ② we get

$$\boxed{Se = wG} \quad — \text{(c)}$$

(ii) <u>Relation Between void ratio and porosity</u> :—

$$\boxed{n = \frac{e}{1+e}}$$

$$e = \frac{V_v}{V_s}$$



$$\Rightarrow \frac{V_v/V}{\frac{V}{V} - \frac{V_v}{V}}$$

$$\Rightarrow \boxed{e = \frac{n}{1-n}}$$

Q.1 A soil sample as a porosity of 40% the specific gravity of solid is 2.70 calculate the
(i) voids Ratio (w) if degree of Saturation is 50%
(ii) water content (iii) if the degree of substraction is 1 calculate voids ratio

Soln– given that
A soil sample as porosity is = 40% = $\frac{40}{100}$
Then, specific gravity are 2.70

We know that

① voids ratio (e) —

Voids Ratio (e) = $\frac{n}{1-n}$

$$\Rightarrow \frac{0.4}{1-0.4} = \boxed{0.66}$$

(ii) Water Content (w):

if $S = 50\% = 0.5$

$Se = wG$

$\Rightarrow 0.5 \times 0.66 = w \times 2.70$

$\Rightarrow w = \frac{0.5 \times 0.66}{2.70}$

$\Rightarrow w = 0.12$

(iii) Void Ratio (e)

if $S = 1$

now,

$Se = wG$

$\Rightarrow 1 \times e = 0.12 \times 2.7$

$\Rightarrow e = 0.12 \times 2.7$

$\Rightarrow e = 0.524$ (Ans)

Some Important Relationship :— (Dat - 08/10/2021)

(a) Relation between bulk unit weight (γ) and Dry unit weight (γ_d)

$$\boxed{\gamma_d = \frac{\gamma}{1+w}}$$

For $S=1$:- $Se = wG$

$e = wG$

$\Rightarrow w = \frac{e}{G}$

$$\therefore \boxed{\gamma_d = \frac{\gamma}{1+\frac{e}{G}}}$$

Example:-1

The Mass specific gravity of a given soil is 2.70, and void ratio is equal to 0.34 The bulk unit weight of the sample is 15.5 KN/m³ if the soil fully saturated. calculate the dry unit weight.

Soln:-

given that,

$$G = 2.70$$

$$e = 0.34$$

$$\gamma = 15.5 \text{ KN/m}^3$$

$$\gamma_d = \frac{\gamma}{1+\frac{e}{G}}$$

$$= \frac{15.5}{1+\frac{0.34}{2.70}}$$

$$= \frac{15.5}{1+0.125}$$

$$= 13.77 \text{ KN/m}^3 \quad \text{(Ans)}$$

Example:-02

For a given soil mass the bulk unit weight is 20 KN/m³. calculate dry unit weight. If water content is 0.3.

Soln:-

given that,

$$\gamma = 20 \text{ KN/m}^3$$

$$w = 0.3$$

$$\gamma_d = \frac{\gamma}{1+w}$$

$$= \frac{20}{1+0.3}$$

$$= \frac{20}{1.3}$$

$$= 15.38 \text{ KN/m}^3 \quad \text{(Ans)}$$

Ex-3 In a given Soil mass of 500 gm water content is 20 g.m. the sample occupied 300 cm³ space. calculate bulk density & water content.

soln:- given that,

soil of mass (M) = 500 g.m.

water amount (W_w) = 20 g.m

volume (V) = 300 cm³

(i) Bulk density (ρ) = $\frac{M}{V} = \frac{500\ gm}{300\ cm^3} = 1.66\ gm/cm^3$

(ii) water Content (w) = $\frac{W_w}{W_s}$

$= \frac{20}{500-20}$

$= \frac{20}{480}$

$= \frac{1}{24} = 0.041$ (Ans)

Ex-04 The dry unit weight of a given soil sample is 15 KN/m³ & water content content is 35%. calculate bulk ~~density~~ unit weight.

soln:-

$\gamma_d = 15\ KN/m^3$

$w = 35\% = 0.35$

$\gamma_d = \frac{\gamma}{1+w}$

$\Rightarrow 15\ KN/m^3 = \frac{\gamma}{1+0.35}$

$\Rightarrow \gamma = 15(1+0.35) = 15 \times 1.35 = 20.25\ KN/m^3$

(b) $$\gamma_d = \frac{G\gamma_w}{1+e}$$

where, γ_w = unit weight of water.

γ_d = dry unit weight

G = specific Gravity

e = void ratio.

Saturated value :— $\gamma_w = 9.81\ KN/m^3$

Ex-1 For a given soil mass the specific gravity is 2.68 and void ratio is 2.28 Calculate dry unit weight.

soln- given that,

$G = 2.68$

$e = 0.28$

$\gamma_w = 9.81\ KN/m^3$

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

$$= \frac{2.68 \times 9.81}{1+0.28}$$

$$= \frac{26.2908}{1.28}$$

$$= 20.53\ KN/m^3 \text{ (Ans)}$$

Date - 09/10/21

Some Important Relationship: -

(iii) $\rho_d = \frac{G \rho_w}{1+e}$

(iv) $V_s = \frac{M_s}{G \rho_w}$

The density of a water equal to 1:0

- saturation density $\gamma_w = 9.81 \frac{KN}{m^3}$.

Q.1 The Mass of a moist soil 20 kg and it volume is 0.011 m^3 after drying the mass Reduce to 16.5 kg determine -

(i) water Content.

(ii) density of moist soil

(iii) density of dry soil

(iv) void ratio.

(v) porosity

(vi) degree of saturation

Take this specific gravity (g) = 2.70. Then calculate the all required data.

Soln.

given data;

(i) $M_{moist\ soil} = 20 kg$

(ii) $M_{Dry\ soil} = 16.5 kg$

(iii) $V = 0.011 m^3$

(iv) $G = 2.70$

solid + water = 20 Kg
Solid = 16.5 Kg.

$\Rightarrow$ 16.5 + water = 20 Kg

$\Rightarrow$ water = 20 - 16.5
= 3.5 Kg.

(i) water content (w) :-

$$= \frac{water}{solid} = \frac{3.5\,Kg}{16.5\,Kg}$$

$$= 0.212$$
$$= 0.212 \times 100$$
$$= 21.2\%$$

(ii) Density of moist soil :-

$$\because \rho = \frac{M}{V} = \frac{20\,kg}{0.011\,m^3}$$

$$= 1818.18 \left(\frac{Kg}{m^3}\right)$$

(iii) Dry Density (ρ_d) :-

$$\because \rho_d = \frac{M_d}{V} = \frac{16.5\,Kg}{0.011\,m^3} = 1500 \left(\frac{Kg}{m^3}\right)$$

(iv) void Ratio (e) :-

$$\because \rho_d = \frac{G \cdot \rho_w}{1+e}$$

$$\Rightarrow \rho_d = \frac{2.70 \times 1000}{1+e}$$

$$\Rightarrow 1500 = \frac{2700.000}{1+e}$$

$\Rightarrow 1500 \times (1+e) = 2700$

$\Rightarrow 1500 + 1500e = 2700$

$\Rightarrow 1500e = 2700 - 1500$

$$\Rightarrow e = \frac{2700 - 1500}{1500}$$

$\Rightarrow e = 0.8 \quad \Rightarrow e = 0.8 \times 100 = 80\%$

(There is no negative point in void ratio)

(v) Porosity (n) :-

$$\therefore n = \frac{e}{1+e}$$

$$\Rightarrow \frac{0.8}{1+0.8}$$

$\Rightarrow 0.4444$

$\Rightarrow 0.4444 \times 100 \Rightarrow 44.44\%$

(vi) Degree of saturation (s) :-

$$\therefore S = \frac{V_w}{V_v}$$

$Se = wG$

$$\Rightarrow S = \frac{wG}{e}$$

$$\Rightarrow S = \frac{0.212 \times 2.7}{0.8}$$

$\Rightarrow S = 0.7155$

$\Rightarrow S = 0.7155 \times 100$

$= 71.55\%$

Date - 21/10/21

Density Index and Relative Compaction:-

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{V} \quad \text{AQI:-}$$

$$\rho = \frac{M}{V} = \frac{gm}{cm^3} \quad Kg/m^3$$

* Index - Number
* Density Index is unitless.

$$e = \frac{V_v}{e_s}$$

→ The term density Index is defined as the ratio of the difference between the void ratio of the soil looset state and it's natural conditions to the difference between the void ratio in looset state an denset state.

→ Density Index is denoted by I_D.

where, I = Index

D = Density

Mathmatically

$$I_D = \frac{e_{max} - e}{e_{max} - e_{min}}$$

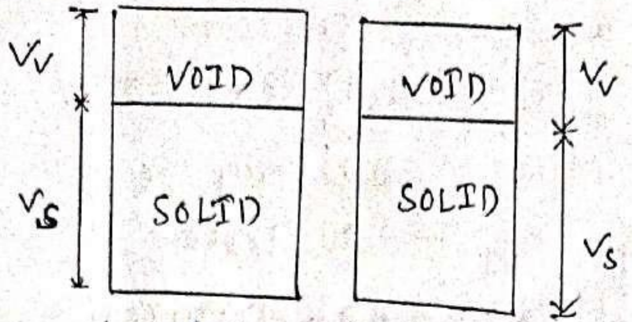
Here,

e_{max} = Maximum void ratio

e_{min} = Minimum void Ratio

e = Natural void Ratio

Case - 1   case-2



loose set   dense set

$$V_{v_1} > V_{v_2}$$

$$e_1 = \frac{V_v}{V_s} = \frac{30}{50} = 0.6 \qquad e_2 = \frac{V_v}{V_s} = \frac{20}{50} = 0.4$$

Case-1

when $e = e_{max}$

$I_D = 0 \longrightarrow \begin{cases} e_{max} - e \\ \Rightarrow e_{max} - e_{max} \\ \Rightarrow 0 \end{cases}$

Case-2

when $e = e_{min}$

$$I_d = \frac{e_{max} - e_{min}}{e_{max} - e_{min}} = 1$$

Relative density:—

e_{max} = loosest State

e_{min} = Densest State.

Relative Density :-

Index Value	Description
0 - 15 →	Very loose
15 - 35 →	loose
35 - 65 →	Medium
65 - 85 →	Dense
85 - 100 →	Very Dense

Relative Compaction :-

(i) → Relative Compaction is defined as the ratio of natural dry unit weight to maximum dry unit weight.

→ It is denoted by Symbol (R_c) { R = Relative, C = Compaction }

$$\boxed{R_c = \frac{\gamma_d}{\gamma_{d\,max}}}$$

⇒ It is unit less (Relative Compaction)

∴ $\gamma_d = 15 \frac{KN}{m^3}$

$\gamma_{d\,max} = 18 \frac{KN}{m^3}$

∴ $R_c = \frac{15}{18} = 0.83 \times 100$

$= 83\%$

Problem 1 Calculate the relative density and classified the Condition as per the following data ?

(i) The natural void ratio = 0.62

(ii) The Maximum void ratio and the minimum void 1 and 0.45 respectively.

Soln

given Data

$e = 0.62$

$e_{max} = 1$

$e_{min} = 0.45$

$$I_D = \frac{e_{max} - e}{e_{max} - e_{min}}$$

$$= \frac{1 - 062}{1 - 0.45}$$

$$= \frac{0.38}{0.55}$$

$= 0.69$

$= 69\%$

∴ The respectively density = 69%

The Soil is classification is Dense.

{Date- 22/10/21.

Particle Size Distribution:-

- Size - diameter.
  - → soil size.

Defn.:- (i) The percentage of various sizes of particles in a given dry soil sample each found by a particle size anality.

(ii) The Analysis is performed in Two stages:- are

① . Sieve Analysis

② . Wet Mechanical Analysis.

(iii). The first stage is for Coarse-Grained soil only.

(iv). When The 2nd Stape in performed the fine-grained soil.

Coarse - Grained:-

The Sieve Analysis canbe devided in to Two part are:-

(1). Coarse - grained Analysis (4.75mm)

(2). Fine- grained Analysis.

The soil sample is separated by the set of sieves.

(1) Coarse-grained Soil :-

(i) In the Course-grained soil Analysis you are using 4.75 mm IS sieve.

(ii) When the Amount of passing is not more than 50% through the IS sieve.

(2). Fine-grained Soil :-

(i) For the grain Analysis where using 4.75 mm.

(ii) When the Amount of passing is more than 50% then that is fine grained.

Imp { ≥ 50% — Fine-grained soil
< 50% — Coarse-grained soil.

Particle Size distribution Curve :-

A particle size distribution curve gives of an Idea About the Type and gradation of soil.

(1). (Fine-grained Analysis)

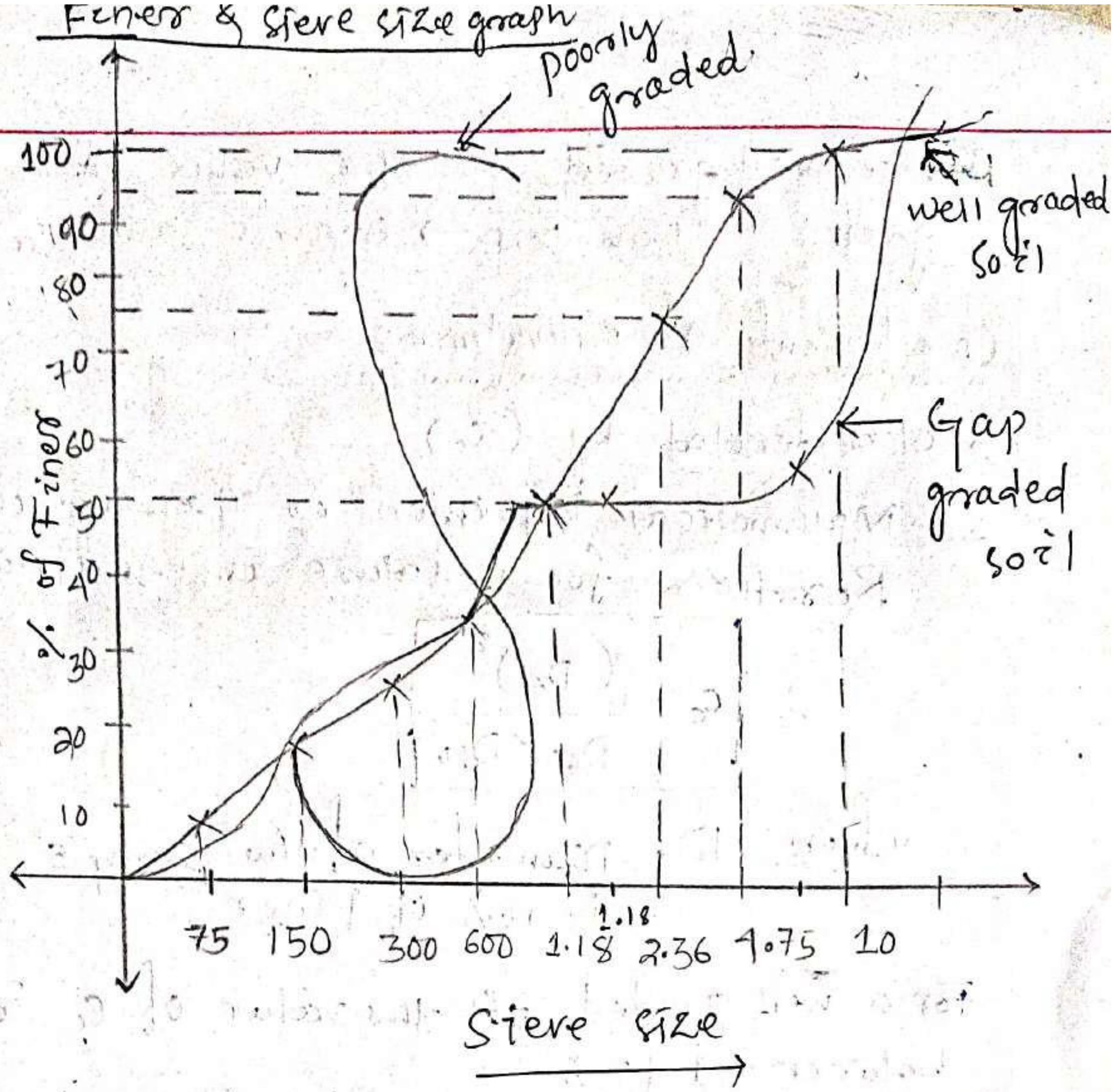
S.L No	I.S Sieve size	Mass of soil Retained	% of soil Retained	commulative Retained	% of Finer.
01					
02					
03					
04					
05					
06					

2. Coarse - grained Analysis :—

S.L No.	IS Sieve Size	Mass of Soil Retained	% of Soil Retained	Commulative % of soil Retained	% of Finer
01.					
02.					
03.					
04.					
05.					
06.					

Coarse-Grained	Fine Grained
80 mm	10 m
40 mm	4.7m
20 mm	2.36 mm
12.5m	1.18 mm
10 m	600 u
4.75 mm	300 u
	150 u
	75 u

Finer & Sieve size graph



Date - 23/10/2021.

Co-efficient of uniformity :-

Co-efficient of uniformity is defined as as the ratio of diameter of particle 60% finer to diameter of sample 10% of finer.

It is denoted by the symbol (Cu).

∴ Cu { C = co-efficient, u = uniformity.

Mathmatically,

$$\therefore C_u = \frac{D_{60}}{D_{10}}$$

→ it has no unit or unit less.

for a well graded soil the value Cu is greter than >4 → Gravels and Cu > 6 → Sa[nds]

Co-efficient of Curvature :-

→ It is denoted by (C_c).

→ Mathmatical Expression or Mathmatical Relation for Curvature is equal to .

$$\therefore \boxed{C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}}$$

where, D_{10} = Diameter of the sample is 10% of Finer.

For a well graded soil the value of C_c is between 1 to 3

C_c (1-3) .

{ less than 3 It is wellgraded and more than 3 It is poorly graded }

Example :-

If $C_u = 7$

$C_c = 2$

∴ It is well graded sands .

Example :-

$C_u = 7$

$C_c = 4$

∴ It is poorly graded sands .

Q.1 Calculate co-efficient of curvature and co-efficient of uniformity of data.

① D_{10} = 0.32 mm

② D_{30} = 1.23 mm.

③ D_{60} = 1.979 mm then calculate co-efficient?

Ans. Classified the soil.

$$\therefore C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

$$= \frac{(1.23)^2}{1.979 \times 0.321}$$

$$= \frac{1.5129}{0.63328}$$

$$= 2.388$$

$$C_u = \frac{1.979}{0.32} \quad \left[\therefore C_u = \frac{D_{60}}{D_{10}} \right]$$

$$= 6.184$$

∴ It is well gradded sand soil.

<u>Consistency of soil</u>: — (water level)

(1). water is used to determine the consistency of soil.

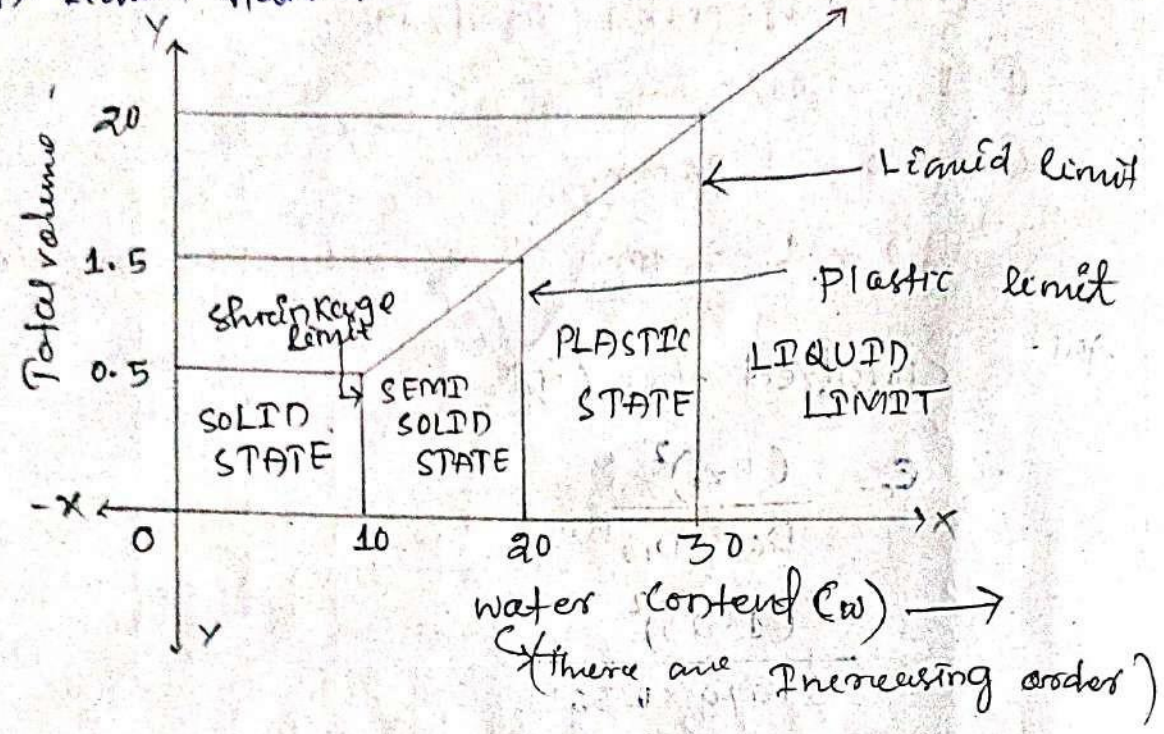
(ii). Swedish Agriculturist is name After beog divided the entire soil in a range form.

(iii). The soil is divided into four stage.

① solid state

② semisolid state

(3). Plastic state
(4). Liquid state.



Date - 01/11/21

There are 3 limits
(1) Liquid limit (L.L) / w_L
(2) Plastic Limit (P.L) / w_p
(3). Shrinkage (S.L) w_s

① Liquid limit :—

(i)- liquid limit is the water Content corresponding to the limit between liquid state & plastic state of consistency of soil.

(ii) It is denoted by the symbol (w_L) or (LL)

(2) Plastic Limit : —

(i) Plastic limit is the water content corresponding to the limit between plastic state and semisolid state of consistency of soil.

(ii). It is denoted by the symbol w_p or P.L.

(3) Shrinkage Limit : —

→ Shrinkage limit is the water content corresponding to the limit between semisolid and solid state of consistency of soil.

→ It is denoted by the symbol w_s or S.L.

→ Shrinkage limit is the corresponding water content at which if we decrease the water content their is no effect on change in volume.

Important Terminology in consistency of soil :-

(1) Plasticity Index (PI) : —

(i). The range of consistency within which a soil behaves as plastic and is indicated by plastic index.

(ii) It is denoted by the symbol PI.

(iii) Range between plastic limits & liquid limit.

(iv) Mathematical formula : —

$$\therefore \boxed{PI = LL - PL}$$

(2) Consistency Index (CI) : —

① The consistency index as the ratio of liquid limit − natural water content to

Plastic index of soil.

(ii). It is denoted by (CI) or Ic

$$CI = \frac{\text{Liquid limit} - \text{Natural water content}}{\text{Plasticity index of soil}}$$

$$\Rightarrow \boxed{CI = \frac{LL - w}{PI}}$$

Q-1 For a given soil liquid limit is 32% & plastic limit is 24%. calculate consistency Index if water content is 9%.

Ans:- Given

L.L = 32%

P.L = 24%

w = 9%

$$CI = \frac{LL - w}{PI}$$

$$= \frac{LL - w}{LL - PL}$$

$$= \frac{32 - 9}{32 - 24} = \frac{23}{8} = 2.875\%$$

Q-2 calculate the PI for a given soil whose L.L is 30% and PL 12%.

Ans:- L.L = 30%

PL = 12%

Now, PI = LL - PL

= 30 - 12

= 18%

Activity of Clay :-

→ The properties of clay and it behaviour influenced by the presence of clay particle. Thus Activity of clay plays an Important role in geotechnical engineerings.

→ Activity of clay is defined as the ratio of plasticity index to the percentage of clay particles.

→ It is denoted by the symbol "Ac".

$$A_c = \frac{P.I}{C_w}$$

∵ PI = Plasticity index
C_w = % of clay particles

→ size of clay is 2μ.

Activity	Classification of soil
< 0.75	Inactive
0.75 – 1.40	Normal
> 1.40	Active .

Q. A clay sample as liquid limit and plastic limit of 96% and 24% respectively. The clay percent as 50% of the particles smaller than 2μ - Indicate the Activity of clay.

Ans:- Given,

L.L = 96%

PL = 24%

C_w = 50%

$$A_c = \frac{96-24}{50} = \frac{74}{50} = 1.44.$$

Since the Activity number is 1.44 which is greater than 1.40, so the soil is maybe classified as active soil.

problem :- A clay sample has liquid limit 93% and plastic limit 32%. classify the soil based upon the following data.

Size	passing in gm
2.36 mm	100
1.18 mm	100
600 μ	80
150 μ	75
75 μ	72
2μ	54

Soln:-

Given data

L.L = 93%

P.L = 32%

$$\% \text{ of } c\omega = \frac{54}{100} \times 100 = 54\%$$

$$A_c = \frac{93-32}{54} = \frac{61}{54} = 1.12.$$

Since the activity number is 1.12 which is in between 0.75 – 140

So the soil may be classified as normal soil.

C.P-09 **Classification of soil** DT = 8/11/21

- The purpose of classification of soil is to arrange various types of soil into different groups according to their properties and characteristic.

→ For general Engineering purpose soil may be classified as particle size classification.

Particles size of classification: —

(i) In this system soil arranged according to the grain size.

(ii) There are various grain size classification in use, but the more commonly used system are as follows.

	0.002mm	0.075mm	0.425mm	2mm	4.75mm	20mm	80mm	300mm
CLAY	SILT	FINE	MED	COARSE	FINE	COARSE	COBBLE	BOULDER
		SAND			GRAVEL			

Fine grain | (I.S classification) Coarse.

Problem:-1 For a given soil of 500 gm, if 312 gm is size of 2.6 mm calculate percentage of sample and classified it.

Soln

Type of soil is COARSE sand 2.6 mm.

$\% \text{ of sample} = \frac{312}{500} \times 100 = 62.4\%$ (Ans)

Devision : — ① · Coarse grained soil

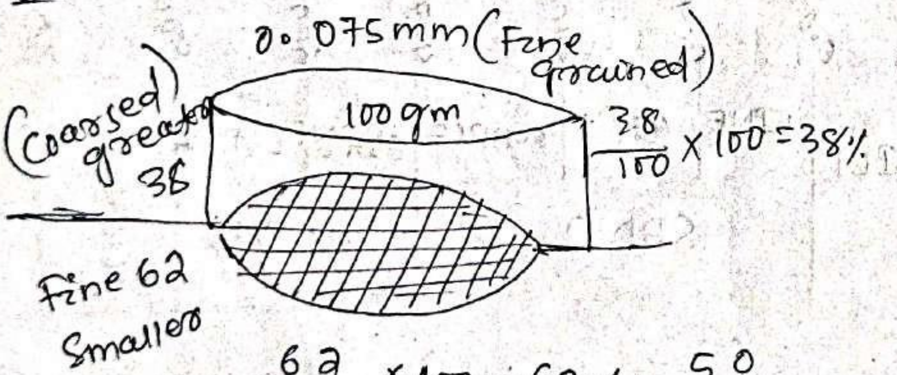
① It is the soil system more than 50% by mass is Larger than or greater than 0·075 mm Is sieve .

(II) Fine grained soil : —

In the soil system more than 50% by mass is Smaller than 0 075 mm of IS sieve.

problem-02 For a 100 gm soil sample 38 gm retained on 0·075 mm IS sieve classified the soil.

Soln



$\frac{62}{100} \times 100 = 62\%$ 50 62%

$100 - 38 = 62\%$

$\frac{62}{100} \times 100 = 62\%.$

$\frac{38}{100} \times 100 = 38\%.$

The soil is fine grained soil because the passing is 62% which is greter than 50%.

The coarse grained soil is again divided into two categories.

(a) Gravel (G)

(b) Sand (S)

(a) Gravel (G) –

In the soil system, more than 50% is larger than 4.75 mm IS sieve.

⇒ It is denoted by the symbol (G).

(b) Sand (S) –

→ In the soil system, more than 50% is larger than 4.75 mm I.S sieve.

⇒ It is denoted by the symbol (S)

W: Well graded

C: clay

P: poorly-graded

M: silt

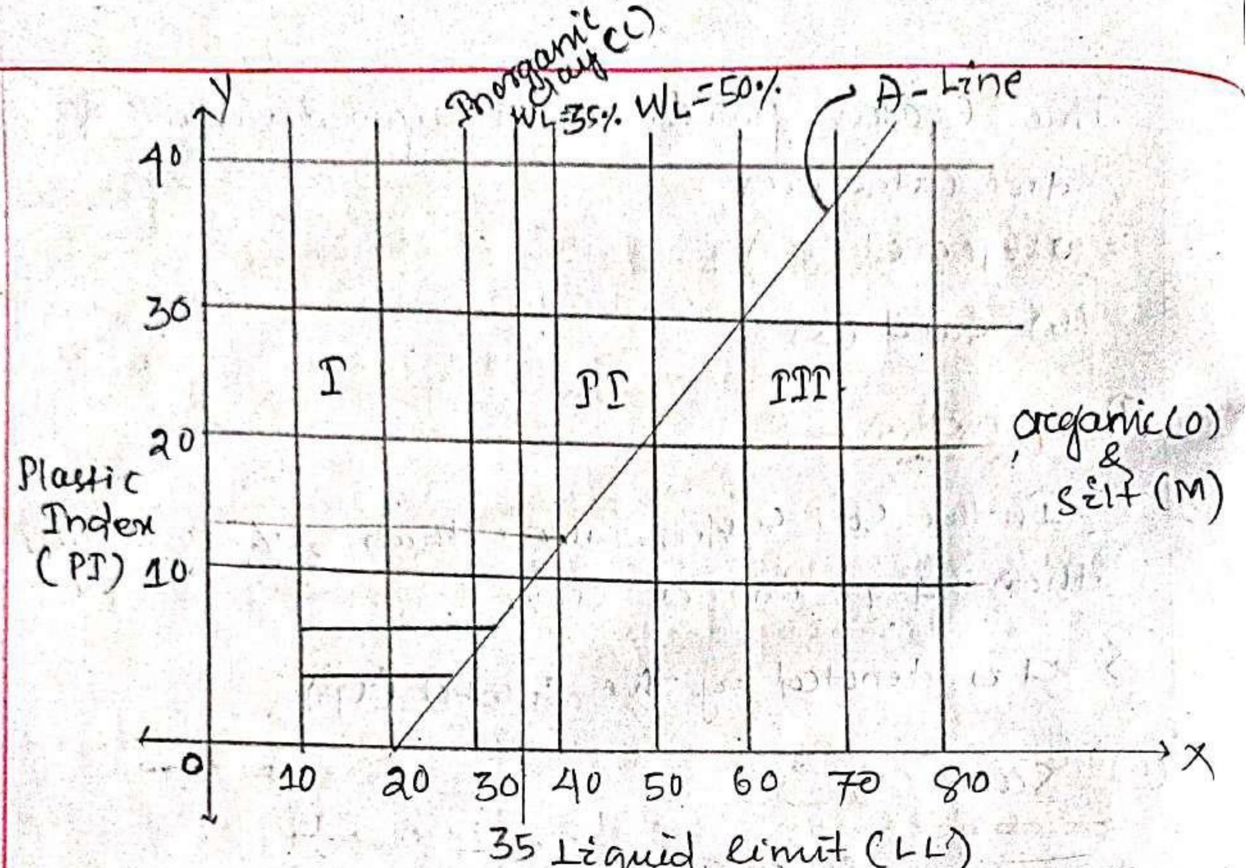
O: organic matter.

PLASTICITY CHART

Date - 10/11/21

(i) Laboratory classification of grained soil is done with the help of plasticity chart as shown in figure.

(ii) The A - line, dividing inorganic clay from silt and organic soil.



$$PI = LL - PL$$

(iii) For the 1st boundary line liquid limit is 35% & the 2nd boundary line liquid limit is 50%.

Compressibility

I → Low Compressibility (L)

II → Intermediate compressibility (I)

(III) → High Compressibility (H)

OL or ML

$$PI = 0.73(W_L - 20)$$ (equation of A-Line)

W_L = liquid limit
PI = plasticity Index

eq – 0.73 (15 – 20)
= –3.65

Problem:-1 For a given soil w_L is 40% plastic limit (w_p) 18%. classified the soil by using plasticity chart.

Ans:-

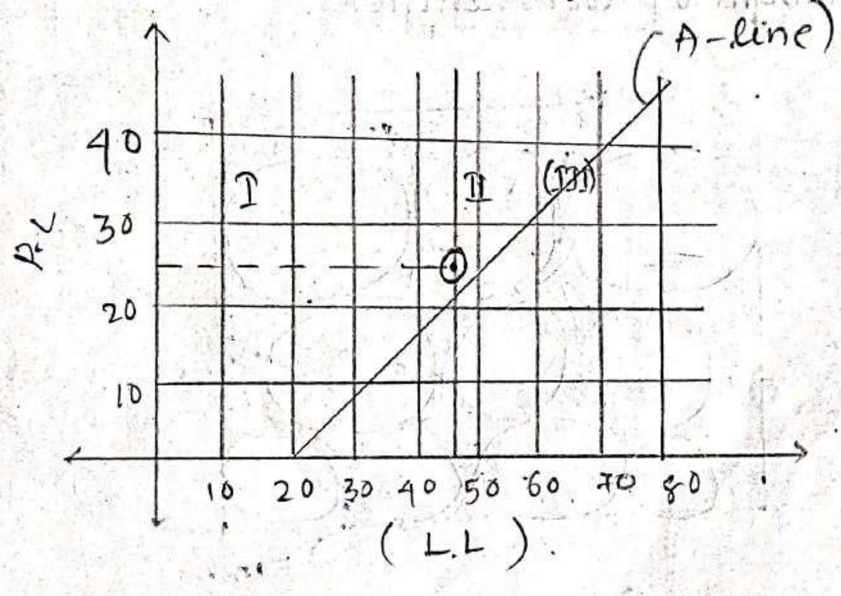
Given data

Here;

LL = 40%

PL = 18% ∴ PI = 40 − 18%

= 22%



Ans − CI ⇒ Intermediate Compressibility clay.

chapter:-05 (Permeability and seepage)

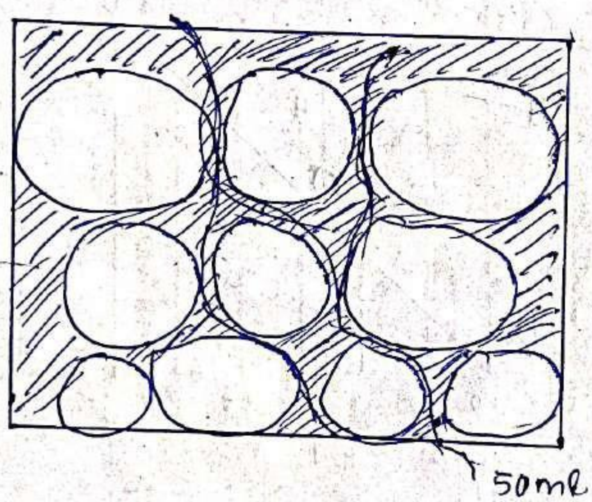
Introduction:-

→ It is defined as the property of a porous materials which permit the passage of water through it's connecting voids.

→ It is a properties of soil.

→ when the water is pass through one place to another place is called permiability.

100gm of soil sample:-



→ It is a 3 phase diagram.

$$\text{Soil} = \text{Solid} + \text{water} + \text{Air}.$$

Solid ↓ Soil grained. water + Air → Void

→ A material having Continuous voids or interconnected voids is called permeable.

→ A material having no-Interconnected voids is called Impermeable.

Seepage: -

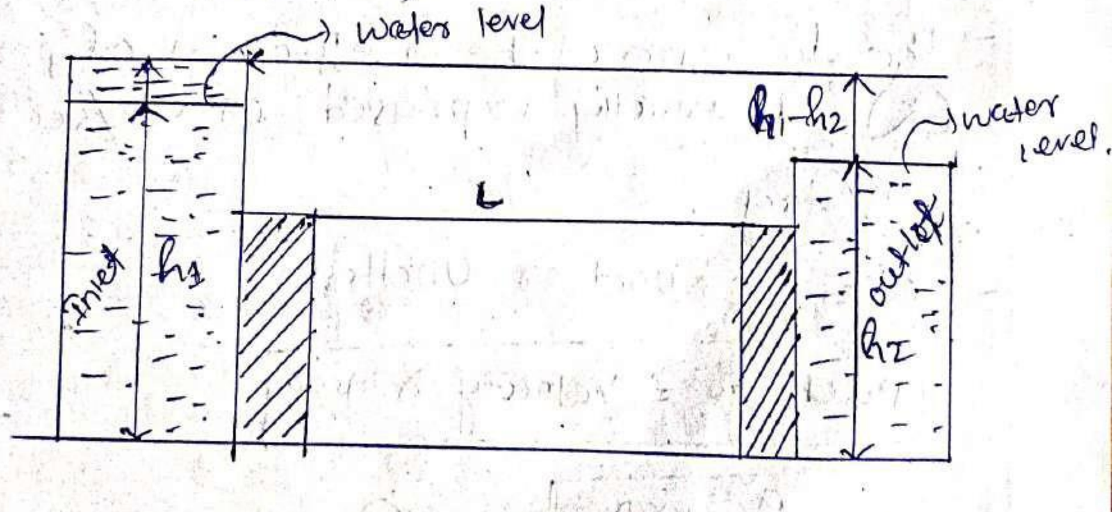
The process of flow of water through the soil voids is called as seepage.

Darcy's Law: -

The law of flow of water through soil was first studied by Darcy in the year of (1856). who demonstrated that for flow condition in a saturated soil the rate of flow or the discharge per unit time is proportional to hydraulic gradient.

Rate of flow ∝ Hydraulic gradient

(water flow)



h_1 = level of water on left side tank

h_2 = Level of water on right side tank

$h_1 > h_2$

L = length of soil sample.

A = Cross-sectional area of soil sample.

Formula

$$q = KIA \quad \text{--- (I)}$$

$$A = B \times W$$

where, q = Discharge per unit Time

K = Darcy's co-efficient of permiability

Hydraulic gradient (i) :-

→ It is defined as the ratio of head difference or level difference to length of soil sample.

$$i = \frac{h_1 - h_2}{L}$$

→ The dimension of the co-efficient of permeability (K) is usually expressed as cm/sec or m/day.

→ It is no unit or unitless.

Discharge = Velocity × Area

$$q = V \times A \quad \text{--- (II)}$$

$$V = \frac{q}{A}$$

$\Rightarrow VA = q$

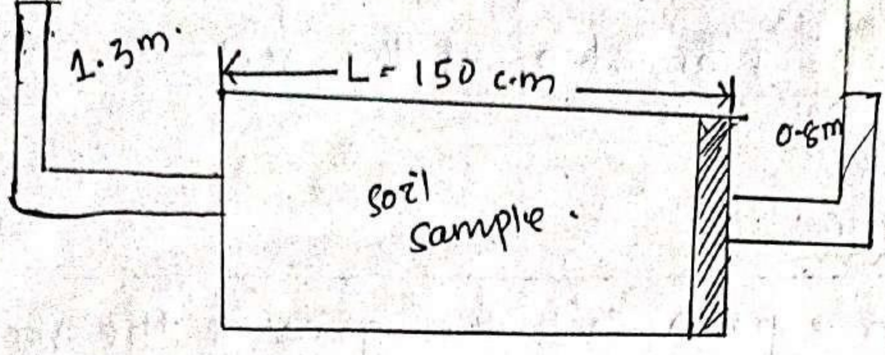
$\Rightarrow \cancel{V}\cancel{A} = KI\cancel{A}$

$\Rightarrow$ $V = KI$

where,

V = Velocity of flow of water.

Q.1 Calculate = ?



Sol^n

$$i = \frac{h_1 - h_2}{l}$$

$$= \frac{1.3 - 0.8}{150} = \frac{0.5}{1.5} = 0.33$$

Dt:- 15/11/21

Factor Affecting permeability :-

→ The Factors affecting permeability as follows :

1. Grain size
2. void Ratio
3. properties of fluid.
4. Structural Arrangement of the soil
5. Adsorbed water.

(1) Grain size :-

- permeability varies approximately as the Square of the grain size → (diameter of the soil)

$$\therefore \boxed{K \propto D^2}$$

where, K = co-efficient of the permeability
D = Diameter of the soil.

(ii) Void ratio :—

→ For a given soil, the greater the void ratio the higher is the value of co-efficient of permeability.

e↑↓ K↑↓

$$e \propto K$$

(iii) properties of fluid :—

→ The co-efficient of permeability is directly proportional to unit weight of water and inversely proportional to it's viscosity.

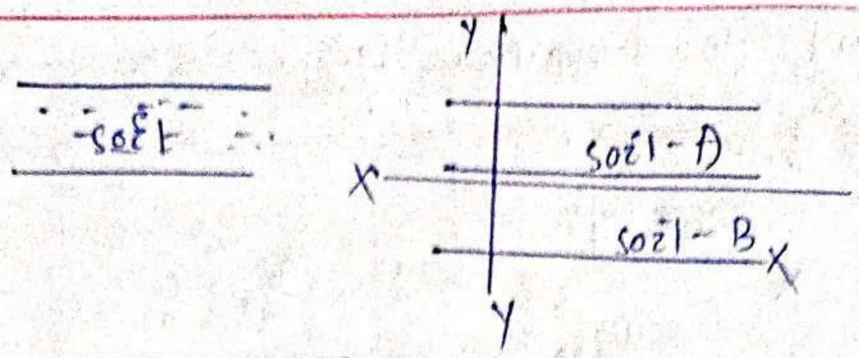
$$K \propto \gamma_w \quad \& \propto \frac{1}{\mu}$$

Inversly
K↑↓ U↓↑

directly
K↑↓ γ_w↑↓

(iv) Structural Arrangement of the soil :—

→ Stratified (one layer) soil deposites have greater permeability parallel to the plane of stratification then that perpendicular to this plane (No of layer)



∴ $K_{xx} > K_{yy}$

(v) Adsorbed water :—

→ Flow of water is not free to move under gravity due to obstruction in flow path which causes reduces in the permeability. (It is a oppose the flow of water)

(Some initial water present in a soil)

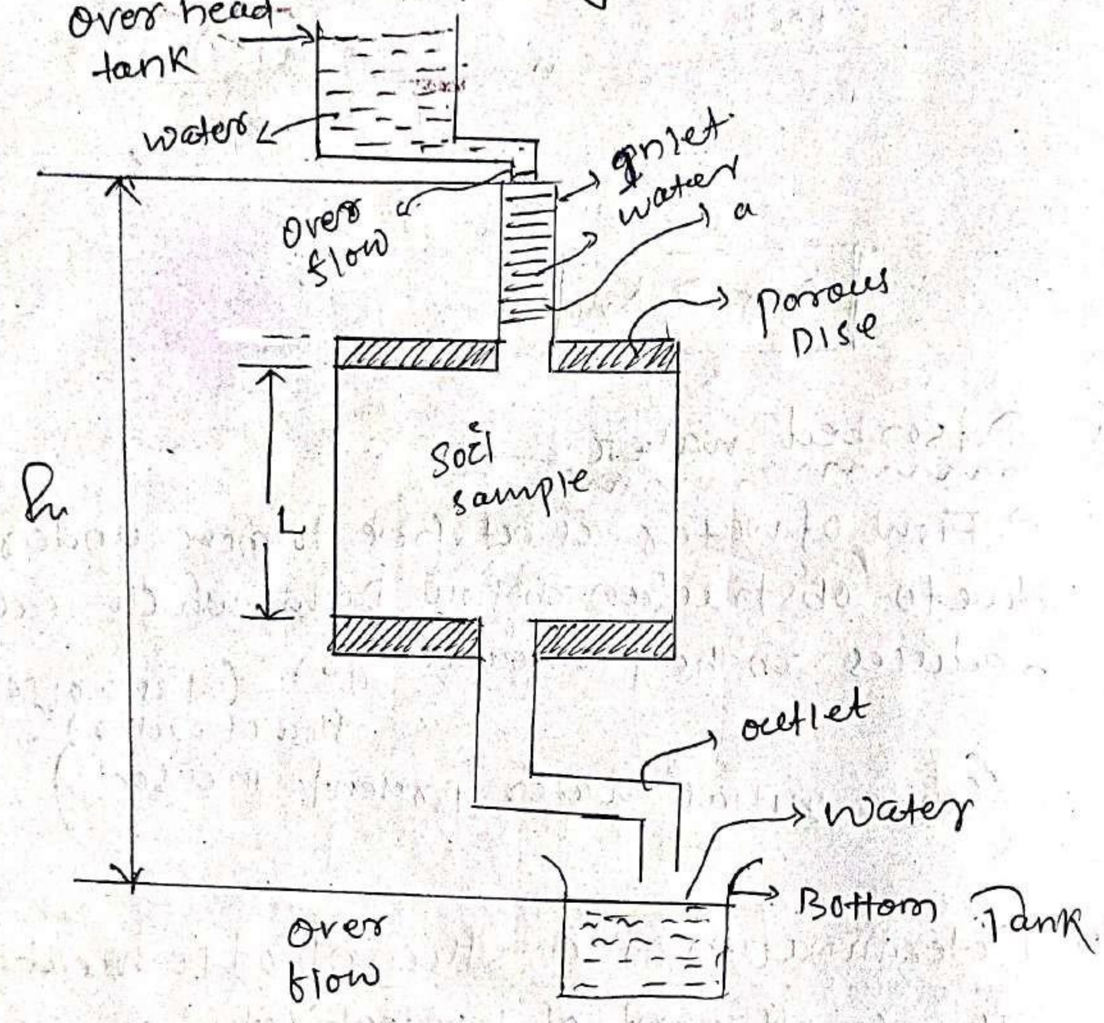
Imp Determination of co-efficient of permeability :—

→ The co-efficient of permeability can be determine by the following methods :—

1. Constant Head permeability Test
2. Falling Head Permeability Test.

(1)

① Constant Head permeability Test :-



O2 Nos

① over Head tank

② Bottom tank

L = length of sample

$A_{c/s}$ = Area of sample

h - Head of water

If 'h' value is verying through out the experiment, then it is called Falling.

a = Area of inlet pipe.

$$a = \pi/4 + D^2$$
$$= \pi/4 + (3)^2$$
$$= \pi/4 + 9 m^2$$

Theory:-

(i) Water flows from over head tank consisting inlet tube (pipe) and collected in out let tank.

(ii) The head of the water is same through out the Experiment.

(iii) By using Darcy's law.

$$q = \frac{Q}{t}$$

Q → Discharge; t → Time; q → Rate of discharge.

$$K = \frac{QL}{thA}$$

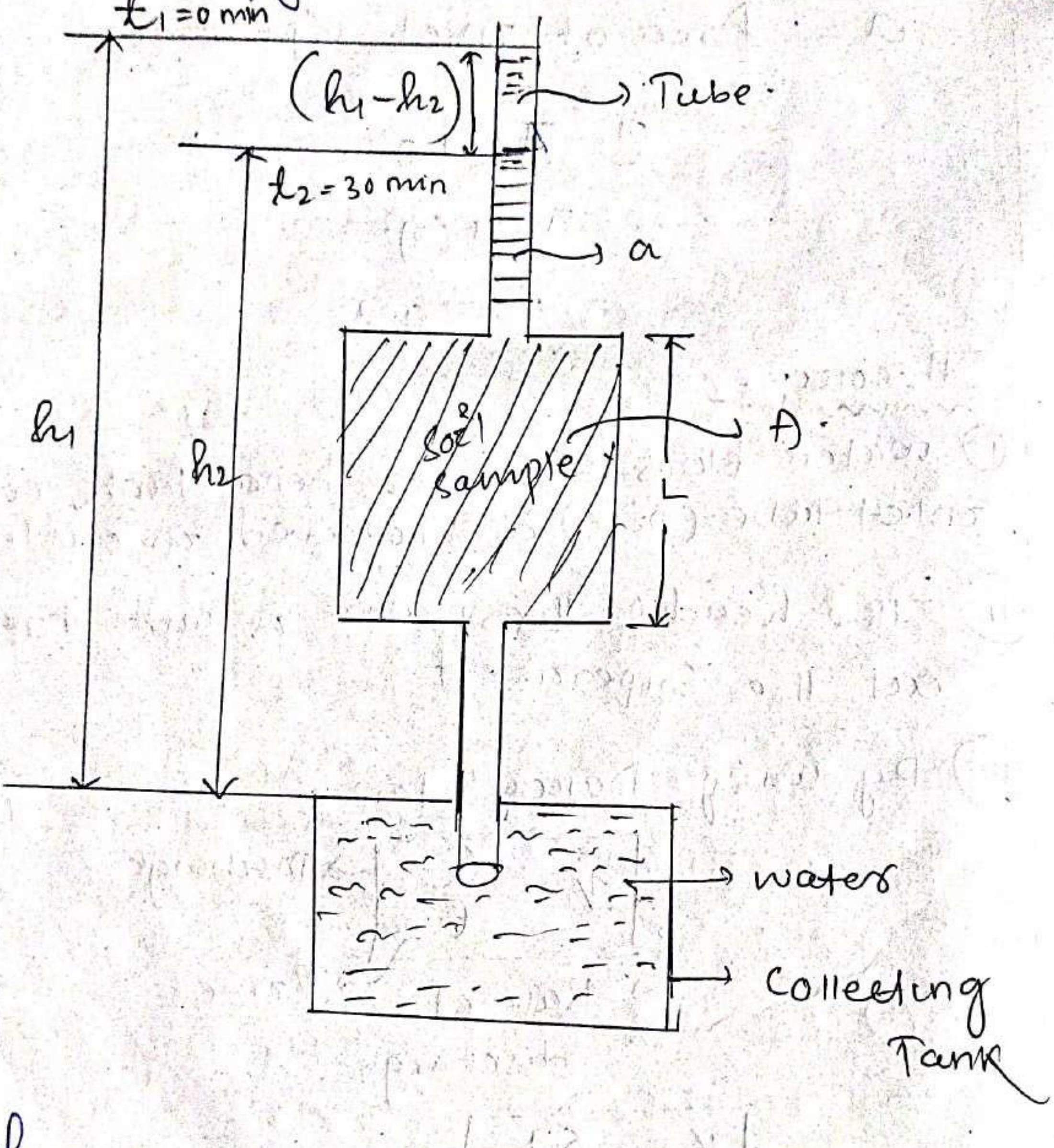
(ii) Falling Head Permeability Test:-

(i) Falling head permeability test is also called as variable head permeability test.

S.S.C.T.T

(ii) This test is used for Fine grained soil.

(iii) Figure show's the falling head permeability test Arrangement.



where, L = length of soil sample.

a = (C/S) Crossectional of Tube.

A = C/S of soil sample.

$h_1 > h_2$

(iv) The water level in pipe constantly falls (decreasing) as waters flows

(v) According to darcy's law

$$\therefore \quad K = 2.303 \frac{aL}{AT} \log_{10}\left(\frac{h_1}{h_2}\right)$$

where,

K = Co-efficient of permeability (cm/s)

T = Time period $(t_2 - t_1)$ (sec)

h_1 = level of water w.r.t $t_1 = 0$

h_2 = level of water w.r.t $t_2 = 30$

K = cm/s   T = sec

a = cm^2 h_1 = cm

A = cm^2 h_2 = cm

L = cm

D.P:- 20/11/21

constant Head permeability	Falling Head permeability
$K = \frac{QL}{ThA}$	$K = 2.303 \frac{aL}{AT} \log_{10}\left(\frac{h_1}{h_2}\right)$.

Q:- calculate the co-efficient of permeability for a given soil sample. 6 c.m in length & 50 cm^2 in crossectional Area if a quantity of water equal to 430ml following in 10 min under and effective constant head of 0.4m.

Soln given that

$Q = 430 ml$

$L = 6$ c.m

$T = 10$ min $= 600$ sec

$h = 0.40 = 40$ c.m

$A = 50\ cm^2$

According to the darcy's law:-

$$K = \frac{QL}{ThA}$$

$$= \frac{430 \times 6}{600 \times 40 \times 50}$$

$$= \frac{2580}{1200000}$$

$$= 2.15 \times 10^3 \ cm/sec.$$

Q.? In a falling head permeability test the followings results were obtained Sample length is 12c.m sample diameter 80mm initial head 1200mm final head 400 mm, time for fail is 6min diameter of tube 4mm. Find the co-efficient of permeability of the soil in mm/sec.

Soln

given data,

$L = 12\,c.m = 120\,mm$

$h_1 = 1200\,mm$

$h_2 = 400\,mm$

$T = 6\,min = 360\,sec$

$a = 4\,mm = 12.56\,mm/sec$

$A = 80\,mm = 5026.54$

$\left\{ a = \frac{\pi}{4} + (4)^2 = 12.56\,mm^2 \right.$

$\left\{ A = \frac{\pi}{4} + (80)^2 = 5026.54\,m^2 \right.$

Now,

$$K = 2.303 \frac{aL}{AT} \log_{10}\left(\frac{h_1}{h_2}\right)$$

$$= 2.303 \times \frac{12.56 \times 120}{5026.54 \times 360} \times \log_{10}\left(\frac{1200}{400}\right)$$

[illegible]

$$= 2.303 \times 108 \times \log\left(\frac{1200}{400}\right)$$

$$= 248.60 \times \log_{10} \times 3$$

$$= 248.60 \times 0.477$$

$$= 118.5822\,mm/sec \text{ (Ans)}$$

DT. = 22/11/2

Permeability of stratified soil Deposits:-

(i) In nature. soil mass may consist of several layers deposited one above the other.

(ii) Each layer has it's own value of co-efficient of permeability.

(iii) The average permeability depends upon the direction of flow to the soil deposits.

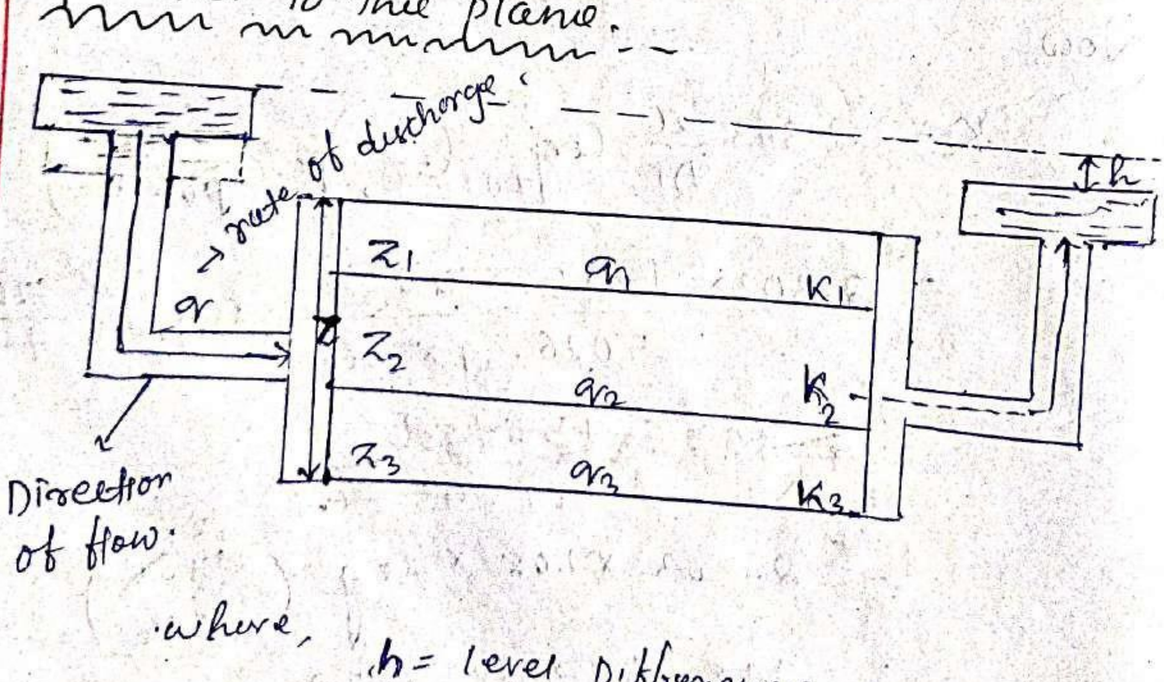
(iv) xx – axis is parallel to soil layer deposition & yy - axis is perpendicular to soil layer deposition.

Case of flow:-

(i) parallel to the plane

(ii) perpendicular to the plane.

(1) Parallel to the plane.



where,
h = level Difference.
Z_1, Z_2 & Z_3 is the Thickness of each layer.

K_1, K_2 & K_3 = co-efficient of permeability of each layer.

K_x = Avarage permeability of soil deposition

$q_i = q_1 + q_2 + q_3$

$q = KIA$

where, K = co-efficient of permeability

I = Hydrolic gradient

A = Corossectional Area of soil Sample

Z = Total Thickness of each layer.

$$\boxed{Z = z_1 + z_2 + z_3}$$

Let, Assume width of soil deposition = 1 unit

$A = Z \times 1 = Z$

$q = KIA$

$= \boxed{K_x i Z}$

Cross-sectional area of layer $= Z_1 * 1 = Z_1$

c/s are of layer (2) $= Z_2 \times 1 = Z_2$

c/s are of layer (3) $= Z_3 \times 1 = Z_3$

$q_1 = K_1 i Z_1$

$q_2 = K_2 i Z_2$

$q_3 = K_3 i Z_3$.

Now put the value in 1st equation.

$$q = q_1 + q_2 + q_3$$

$$\Rightarrow K_x i z = K_1 i z_1 + K_2 i z_2 + K_3 i z_3$$

$$\Rightarrow K_x z = K_1 z_1 + K_2 z_2 + K_3 z_3$$

$$\Rightarrow \boxed{K_x = \frac{K_1 z_1 + K_2 z_2 + K_3 z_3}{z}}$$

Q: For Example.

$K_1 = 2 \quad z_1 = 4$

$K_2 = 1 \quad z_2 = 1$

$K_3 = 4 \quad z_3 = 2$

$K_x = ?$

Solⁿ:-

$$K_x = \frac{K_1 z_1 + K_2 z_2 + K_3 z_3}{z}$$

$$\Rightarrow = \frac{(2\times4) + (1\times1) \times (4\times2)}{7}$$

$$= \frac{8+1+8}{7}$$

$$= \frac{17}{7}$$

$$= 2.42 \text{ (Ans)}$$

D4:- 24/11/21

Effective stress:- (σ')

(i) The sheppage pressure always acts in the direction of flow.

(ii) The vertical effective pressure may be decreased or Increas due to sheepaige pressure depending upon the direction of flow.

(iii) The effective pressure in a soil mass Subjected to sheepage pressure as given by :-

$$\sigma' = z\gamma_{sub} \pm P_s$$

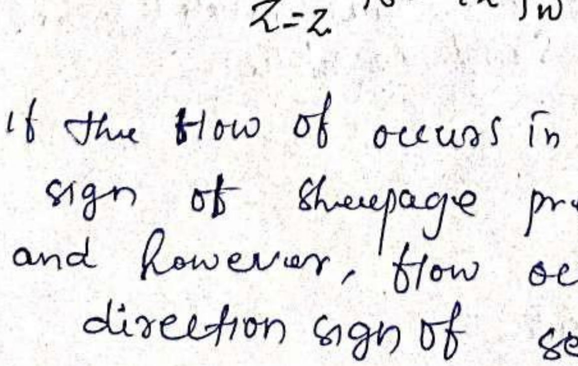
{xx & 11 = z = 0
xx & 22 = z = z}

σ' = Effective stress

γ_{sub} = submerged unit weight

z = Thickness of soil layer.

P_s = seepage pressure.



$$P_s = i z \gamma_w \qquad i \times 0 \times \gamma_w$$
$$= i \times z \times \gamma_w \qquad = 0$$

(iv) If the flow of occurs in downward direction sign of sheepage pressure is positive (+ve) and however, flow occours in upward direction sign of seepage pressure is negative (−ve).

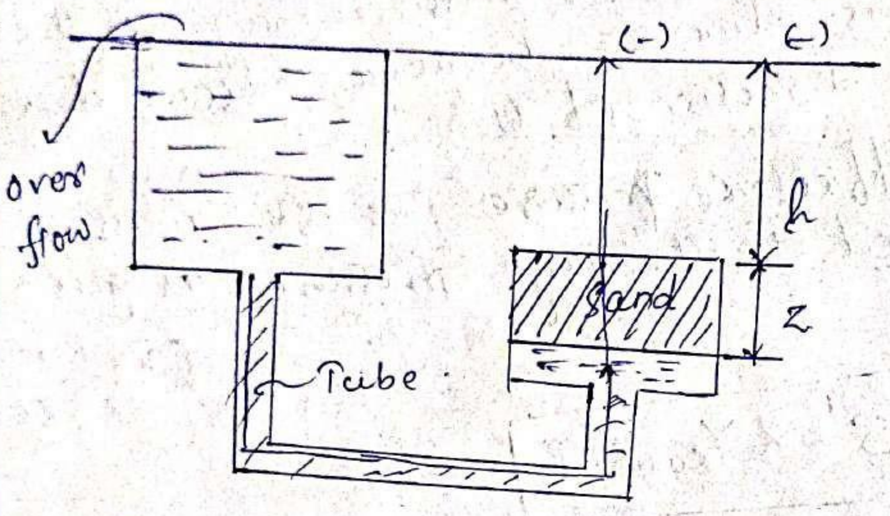
Case-I

$$\boxed{\sigma' = Z\gamma_{sub} + P_s}$$

Case-II

$$\boxed{\sigma' = Z\gamma_{sub} - P_s}$$

Phenomenon of quick sand condition:—



where, h = level Difference.
Z = Thickness of sand layer.

$$\boxed{\sigma' = Z\gamma_{sub} - P_s}$$

(i) Quick sand Condition is also called as upward direction of flow.

(ii) when seepage pressure equal to submerged weight pressure of soil, that condition is known as quick sand condition.

(iii) $\boxed{P_s = Z\gamma_{sub}}$

$\sigma' = Z\gamma_{sub} - Z\gamma_{sub}$

$= 0$

(iv) : Effective pressure is zero in the case of quick sand condition.

$$i z \gamma_w = z \gamma_{sub}$$

$$\Rightarrow \boxed{i = \frac{\gamma_{sub}}{\gamma_w}}$$

$$P_s = \boxed{i z \gamma_w = z \gamma_{sub}}$$

$$\boxed{P_s = z \gamma_{sub}}$$

Chapter - 06 Compaction and Consolidation

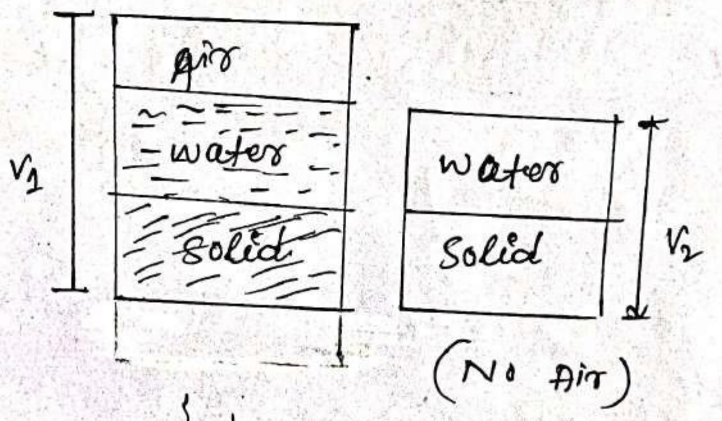
D.T. - 25/11

Compaction :-

(i) Compaction Means pressing the soil particles by a Mechanical method.

(ii) During compaction air voids are expelled (removed) from the soil mass.

(iii) Compaction of soil mass is done to Improve engineering properties of soil.



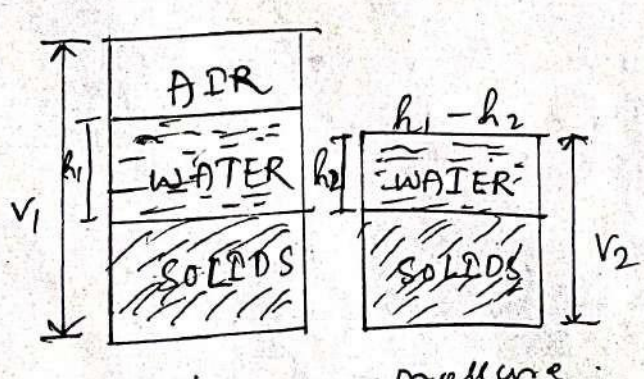
$V_1 > V_2$

→ (Artificial process or Mechanical process)

Consolidation. -

(i) It is the gradual reduction in the volume of soil Under natural Conditions.

(ii) water voids are Expelled from the soil mass during the process of consolidation.



$V_1 > V_2$

$h_1 > h_2$

→ Natural pressure

Comparison between Compaction and Consolidation.

COMPACTION	CONSOLIDATION
(i) Compaction is a Mechanical process.	(i) Consolidation is a natural process.
(ii) Expelled of air void from soil mass.	(ii) Expelled of water on consolidation.
(iii) Compaction is rapid process or quick process.	(iii) Consolidation is a gradual process.

Date - 26/11/21

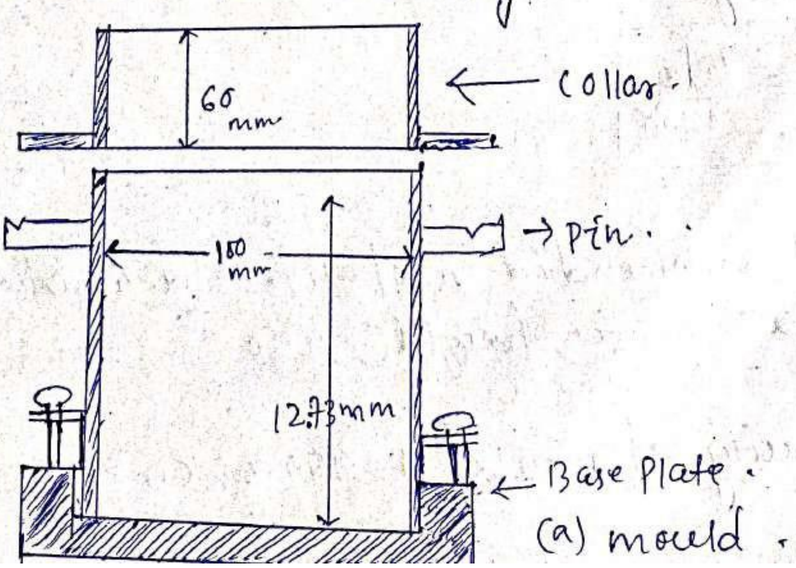
Compaction is a Two Type are: —

① Light Compaction

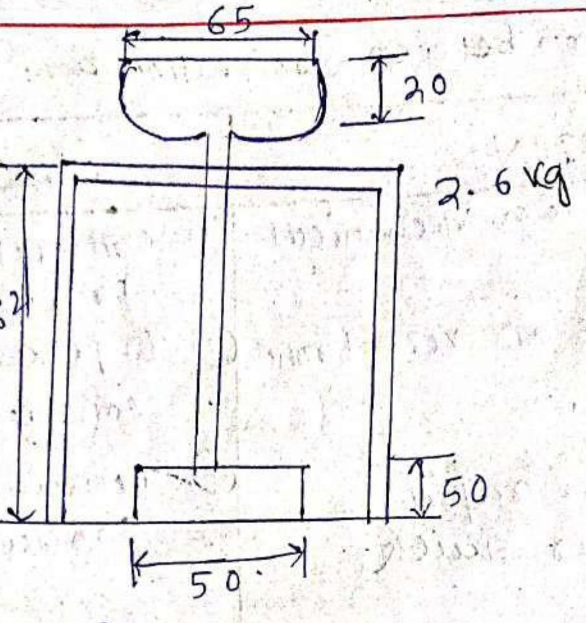
② Heavy Compaction.

① Light Compaction - (Standard proctor Test): —

To assess the amount of compaction and water content required in the field, Compaction Test are done on the laboratory.



(a) mould



(b) Rammer.

$M = 4528$ gm

$V = A \times H$

$= \pi/4 \times D^2 \times 12.73$

$= \pi/4 \times 10^2 \times 12.73$

$= 78.53 \times 12.73$

$= 999.68 \ cm^3$ (Ans).

$\rho = \frac{M}{V} = \frac{45280}{999.68} = 4.529$

dry density :-

$$\rho_d = \frac{\rho}{1+w}$$

(i) The mould recomended is of 100 mm diameter and 1.273 mm in height.

(ii) The capacity of mould is 999.68 cm3.

(iii) The rammer Recomended is of 2.6 kg mass.
(The moving of updwon is called Blows)

(iv) The collar is 60mm height.

(v) 3kg of oven dry soil sample passing in 4.75mm IS: sieve is Taken for this Experiment.

(vi) The soil is compacted In 3 layer.

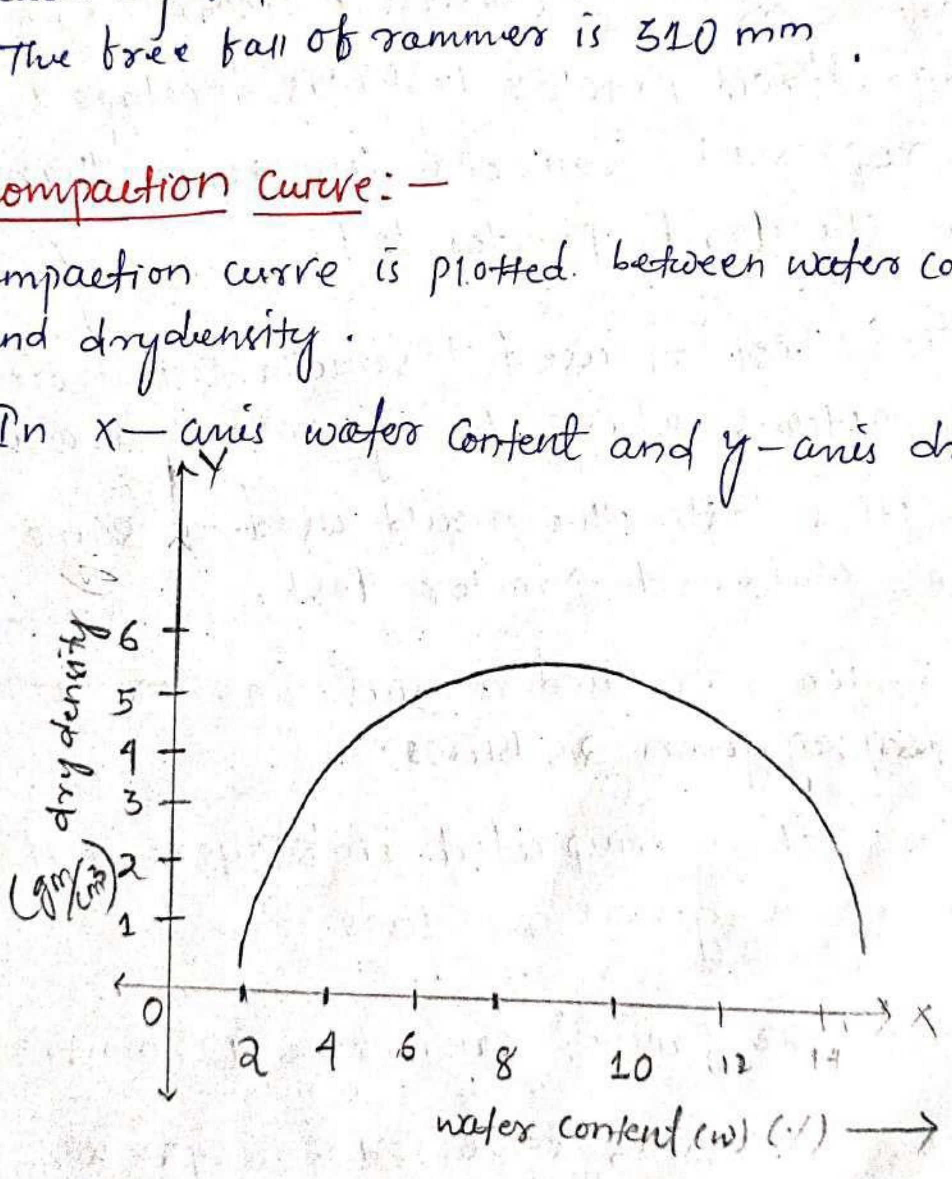
(vii) The soil is compacted 25 blows of the Rammer in each layer.

(viii) The free fall of rammer is 310 mm.

2) Compaction curve:—

(i) compaction curve is plotted between water content and drydensity.

(ii) In x— axis water content and y-axis dry density.



(iii) up to certain percentage of water dry density is Increasing but after that when i add extra water, dry density is known as decreasin

(iv) When slope of the curve is zero at a point of curve the density is known as maximum dry density (MDD).

(v) The water content corresponding to the maximum dry density is known as optimum moisture contents. (OMC).

D.T:— 29/11/21.

Heavy Compaction:- (Modified proctor Test).

→ Modified proctor test was developed to represent heavier compaction than the standard proctor test.

→ The Test is used to simulate the field compactions where heavy rollers are used.

→ in this test, the mould used is same as the standard proctor test.

→ The rammer used is much heavier is that 4.89 kg.

→ The soil is compacted in 5 Layers, each layer is given 25 blows.

→ The free fall of rammer is 450 mm.

$3 \times 25 \times 2.6 \times 310 = 60450 \text{ KJ/m}^3$

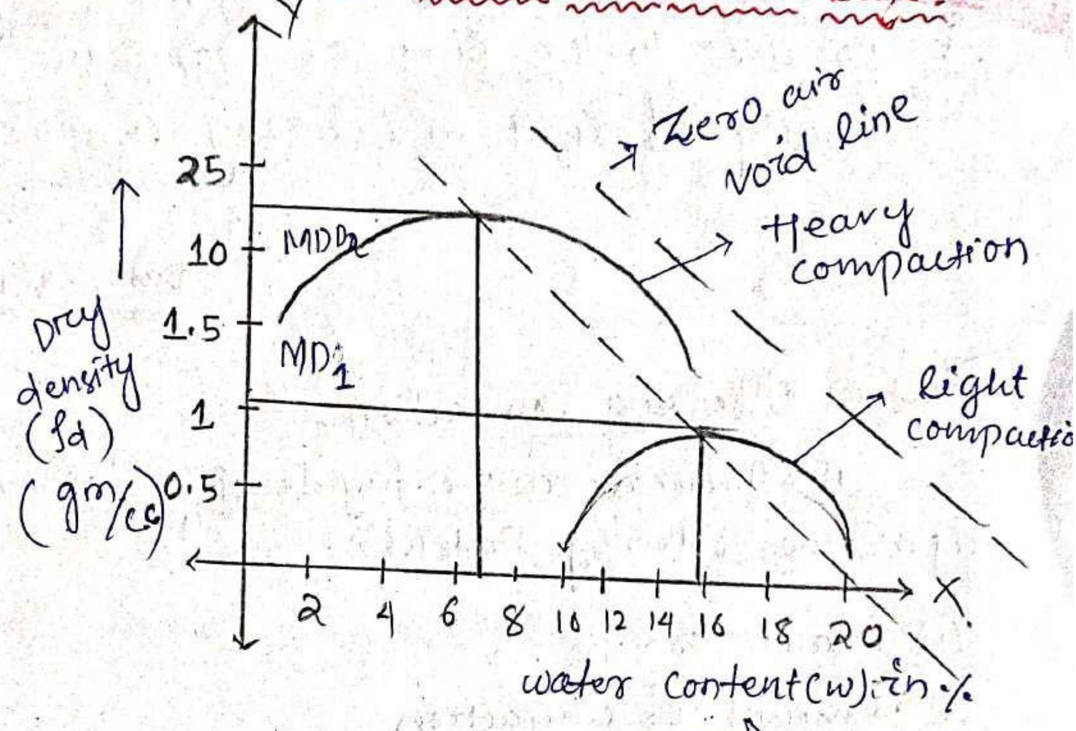
$5 \times 25 \times 4.89 \times 450 = 275062.5 \text{ KJ/m}^3$

$\Rightarrow \frac{275062.5}{60450} = 4.55$

It is 4.55 times heavier than Standard proctor Test.

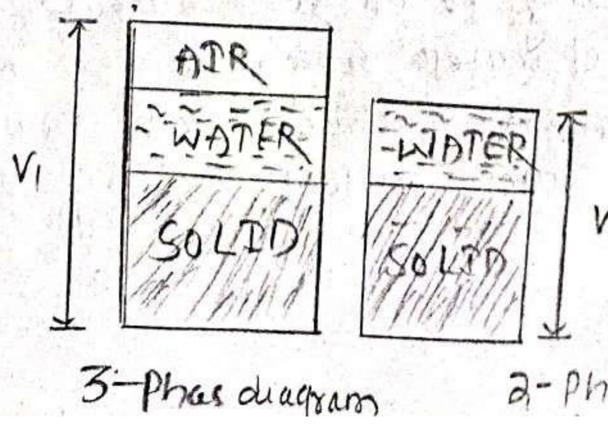
→ The compactive effort in modified proctor Test is about 4.55 times than the standard proctor test.

Compaction curve and zero air void line :-



$$\left\{ \begin{array}{l} w_1 > w_2 \\ MDD_2 > MDD_1 \end{array} \right\}$$

(i) The modified proctor test increase the dry density but decrease the water content.



3-Phas diagram 2-Phage diagram.

where,

$S = 1$ $Se = wG$

$\Rightarrow 1 \times e = wG$

$\Rightarrow \boxed{e = wG}$

$$\boxed{\rho_d = \frac{G \rho_w}{1 + wG}}$$

→ consolidation

$S = 100\%$

$\Rightarrow \frac{100}{100} = 1$

→ Zero air void line of Approximately parallel to the line of Maximum dry density of light and heavy compaction.

Date - 30/11/21

Factors Affecting Compaction :-

The Increase in the dry density depends upon the following Factors :-

(1) Water content.
(2) Amount of compaction.
(3) Type of soil
(4) Methods of compaction.
(5) Admixture.

(1) Water Content :-

The dry density of the soil increased with the Increase of water content till the optimum Moisture content is reached. with Further Increase in water content, the dry density decreases.

(2) Amount of compaction: —

The effect of Increase the amount of compactive effort is to increase the Maximum dry density and decrease the optimum moisture content.

(3) Type of soil: —

Dry density achieved depends upon the type of soil. In general, coarse - grained soils can be compacted to higher dry density the fine grained soils.

(4) Method of compaction: —

The dry density achived also depends upon the Method of compaction.

i.e = Kneading action (By Hand), Static (Rollere)

OR = draynamic action (Heavy Compaction)

(5) Adminuture -

The compaction characteristics of the soils are Improved by adding other Materials, Known as adminture. The most comming used adminturas are lime, cement.

D.T - 01/12/2021.

Method of compaction used in field:-

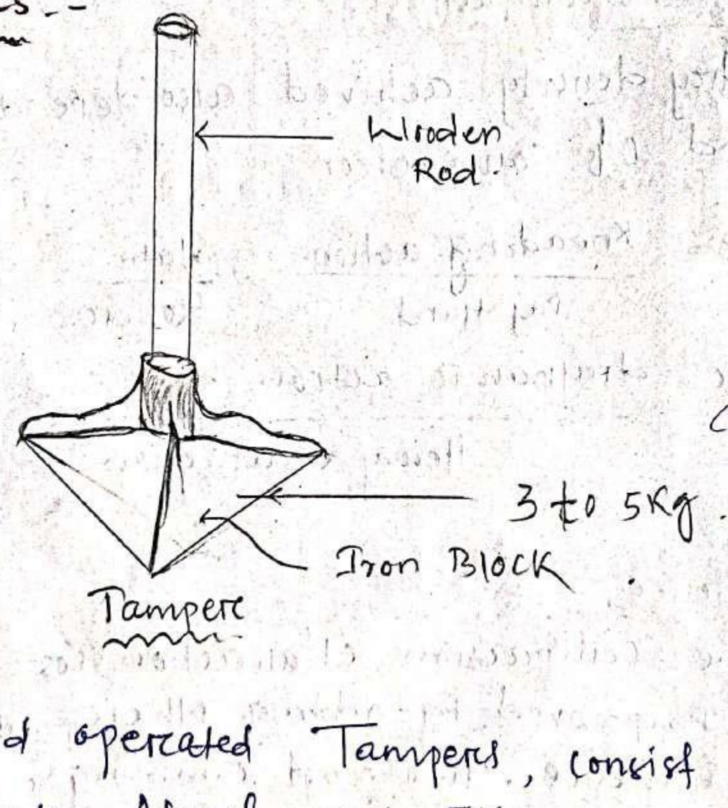
→ Several Method of are used for compaction of soil in the field.

→ The choice of the Method will depends upon the soil Type.

→ Some of the Method commonly used are:-

(1) Tampers.
(2) Rollers
(3) Vibrating compactors:-

(1) Tampers:-



Tamper

(i) A hand operated Tampers, consist of a Iron Block About 3 to 5Kg In Mark and connected wooden Rod.

(ii) It is hand operated. (Manually)

(iii) Tamperes are used To compacts Confinede Area such as Tranches where other methods of compaction are not switeable.

{ ① confindie = small Area / Fined Area.
{ ② Tranches :- Total height of Excavation Tranches

(iv) Tamperes can be use for all Types of soil.

(ii) Rollers:—

(1) Rollers of Different Type are used for compaction.

Rollers are 3 Type :—

(a) Smoth wheels Rollers.
(b) Pneumatic Rollers
(c) Sheep Foot Rollers

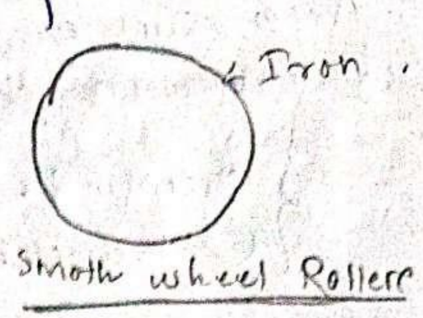
(a) **Smoth wheels Rolleres:**— (Finishing operator)

(i) Smoth wheel Rollere generally consist of 3 wheel.

(ii) Two large wheel In the back side and one small wheel in front side.

(iii) This Rollere are use-full for finishing operation.

(iv) This Roller is used for Granullar base Course.

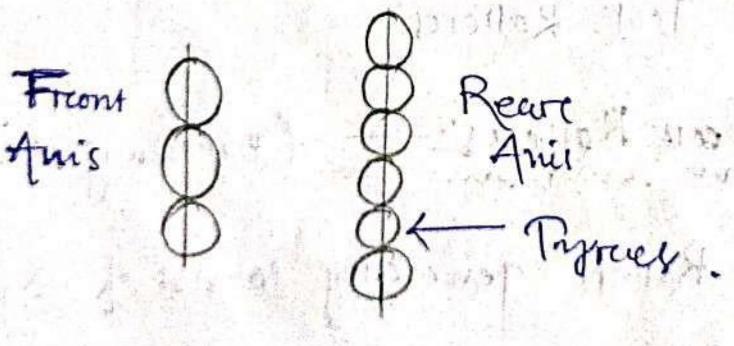


(b) Pneumatic Tyred Roller:—

(i) The Rollers generally consist of 9 wheel on Two axis.

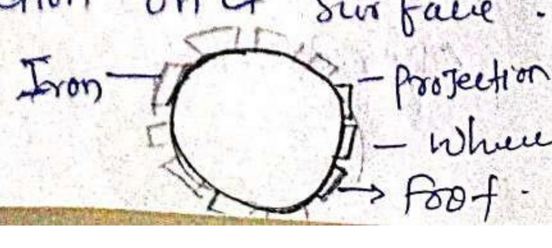
(ii) The Rollers are Effective for Booth Side Type soil.

Clay → cohesive soil (Binding properties)
Sand → cohessionless.



(c) Sheep Foot Roller:—

(i) The Sheep Foot Roller consist of a hollow drum with Small projection on it Surface.



(ii) The drum can be field with water To Increase the Mass.

(iii) This Roller is used for cohesive Soil.

(iv) cohessive Soil are used in clay.

③ Vibrating Compaction: —

(i) vibrating Compaction are the Modification of smooth wheel rollere.

(ii) When a vibrator is connected on the drum. It is called as vibrating Compaction.

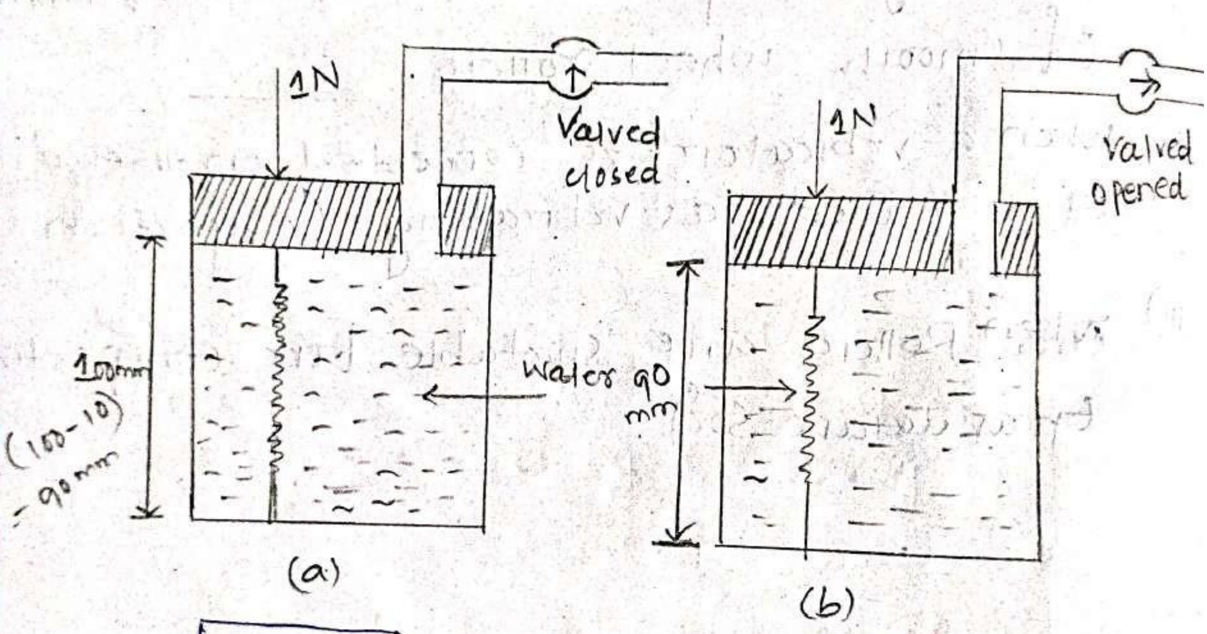
(iii) This Rollers are suitable for compacting Granualar Soil.

D.T:- 9/12/21

Spring Analogy For Consolidation: —

→ The process of consolidation can be with the help of spring analogy Method given by Terzaghi also Known as Father of Soil Mechanics.

consolidation:— { Decreasing of volume due to remove of water voids }.



$P_w = 1N$

$P_s = 1N$

→ Figure :— Shows cylindrical arrangments of spring, water and connected with a outlet value.

→ Let the initial length of spring is 100 mm and the stiffness of spring is 10mm per 1N.

→ when a load 1N is applied with is valued closed, the entire load is take by water.

Date :- 11/12/21

@=

t = 0 sec

1N

P_w = 1N

P_s = 0N

(b)

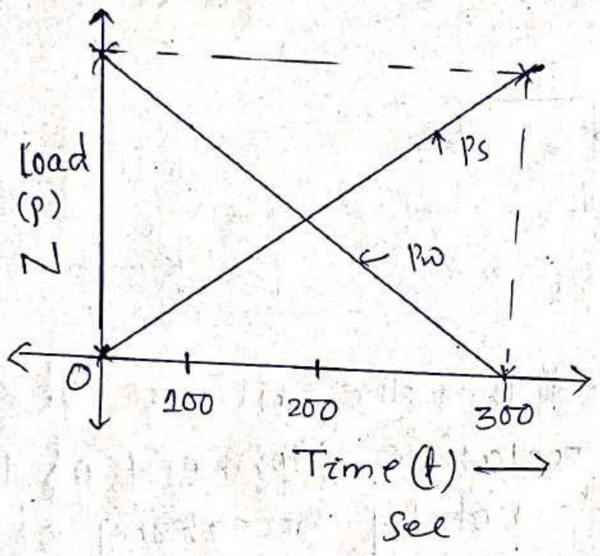
t = 1 sec

1N

P_s = 1N

P_w = 0N

draw a graph xx - yy axis.



Where,

P_s = load taken by the spring.

P_w = load taken by the water.

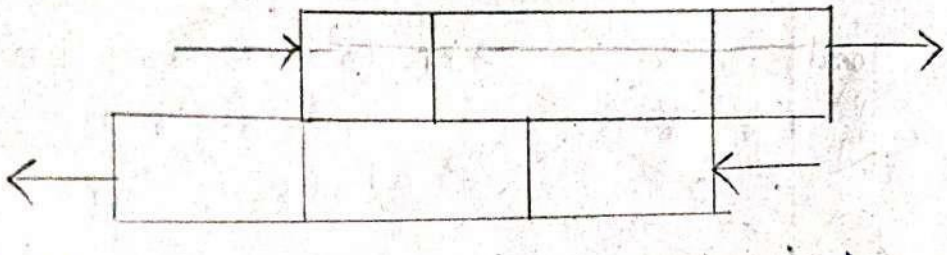
Imp/- { Different between compaction and Consolidation. }

SHEAR STRENGTH

Strength:-

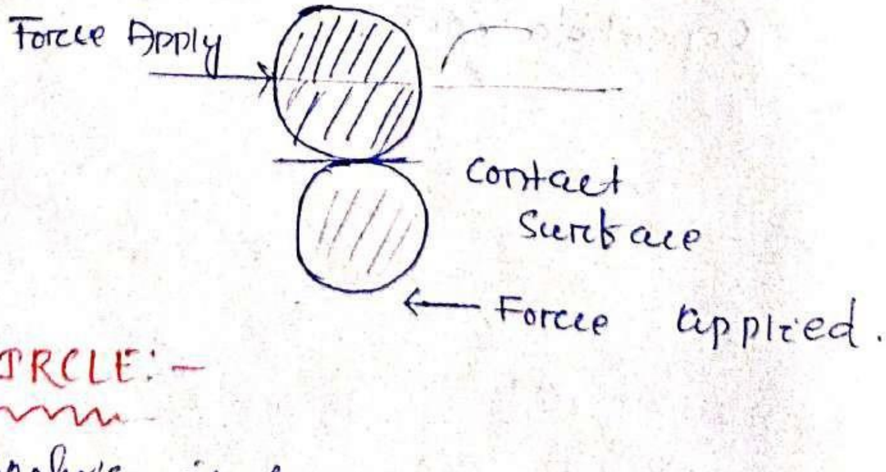
→ The sheare strength of a Soil is it's Maximum Resistance Two sheare Just before the Failure.

→ Sheare Stress developed when the Soil is Subjected to direct compression.



→ It May be noted That the failure of soil occours by relative Morment of the particles and not by breaking of the soil particles.

→ Sheare Strength is the principal Engineering Properties which controls the stability of a soil Mass under the load.



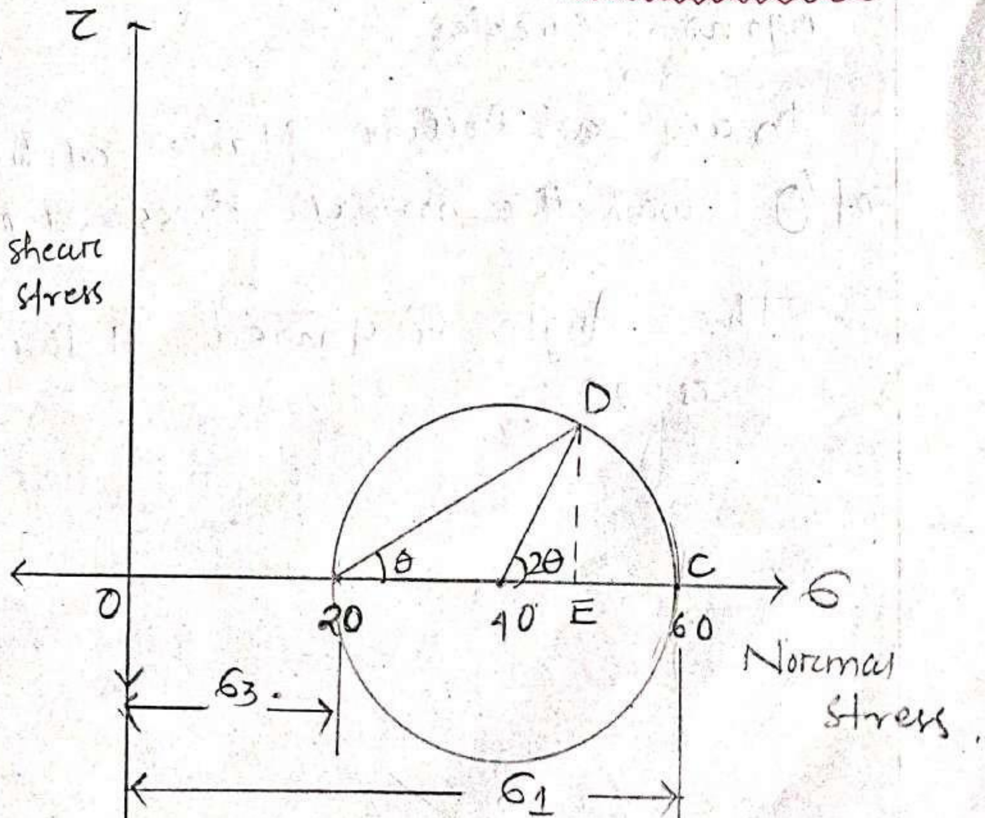
MOHR'S CIRCLE:-

Otto Mohr's is German scienstist dericed A graphical Method for the determination of Stress on a plane Inclined to the principal Plane.

1. Principal plane.
2. Inclined plane.

→ It is the graphical representation of Inclined Plane.
→ The graphical construction is known as Mohr's circle and instrumely use full for the determination of stress In the failure plane.

Date:- 13/12/21



→ This Method, Are origine 'O' is selected and the normal of the stress are ploted alone Horizontal Axis and shear stress are ploted on vertical Axis.

→ In the figure, The point 'A' represent the minor principal stress (σ_3) and the point 'B' represent the major principal stress (σ_1).

→ The point 'c' is the middle point with the normal stress co-ordinate

→ 'c' represent $c = \frac{\sigma_1 + \sigma_3}{2}$

→ Draw a circle with 'c' as center and 'AB' as diameter, The circle is known as Mohr's circles.

→ Draw a Incline plane at the angle of 'θ' with the normal stress at point 'A'.

→ The Angle substained At the center is 2θ.

$$\therefore \tau = \frac{\sigma_1 - \sigma_3}{2} \sin 2\theta$$

$$(\sigma)_{OE} = OC + CE$$

$$= \frac{\sigma_1 + \sigma_3}{2} + \frac{\sigma_1 - \sigma_3}{2} \cos 2\theta$$

Date:- 15/12/21

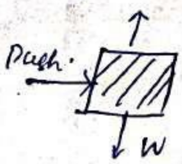
Imp

Mohr – Coulomb Theory: –

→ According to mohr, the failure is caused by critical combination of the normal stress and shear stress.

→ The soil Fails when the shear stress on the failure plane is a function of normal stress.

$\therefore \boxed{\tau = f(\sigma)}$



Cohesion (C): –

→ Cohesion is defined as the force of attraction between the molecules in the mass.

→ It is denoted by the symbol (C).

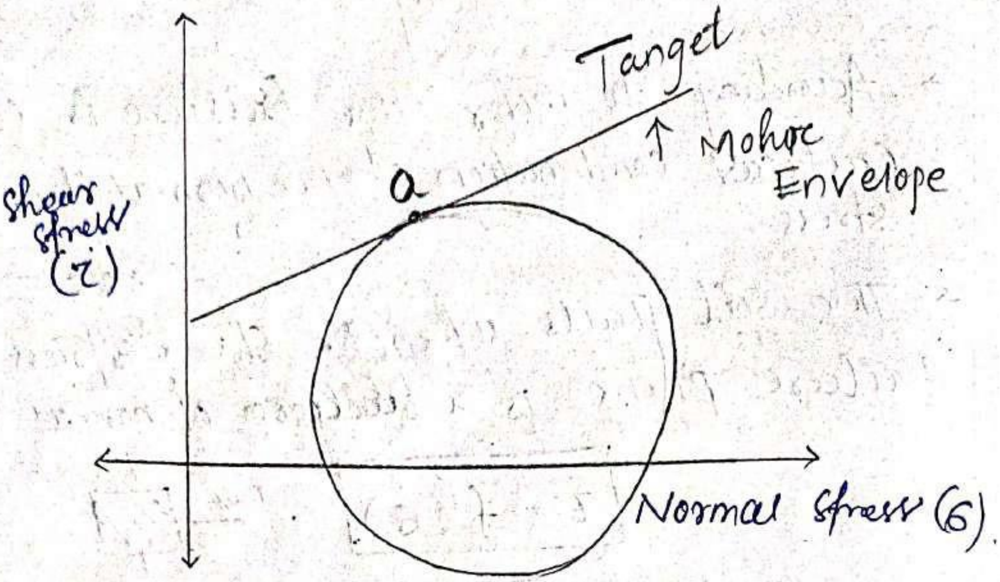
Angle of friction (ϕ): –

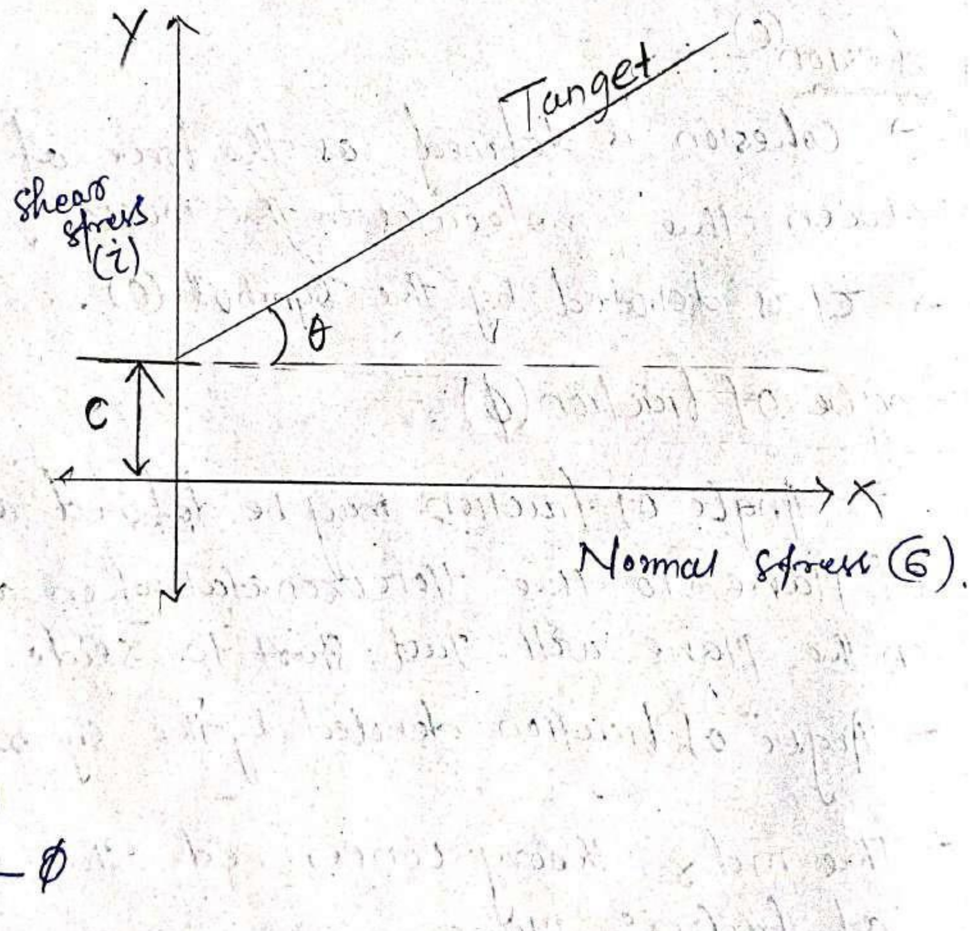
→ Angle of friction may be defined as the angle of plane to the Horizonatal when a body placed on the plane will Just start to slide.

→ Angle of friction denoted by the symbol ϕ.

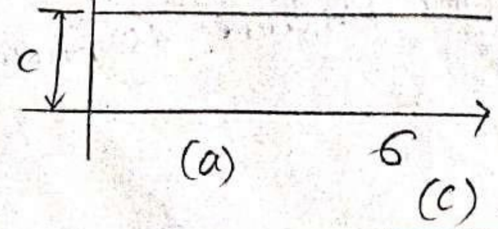
→ The mohr Theory concernced the shear stress at failure plane.

→ A plot can be made between the shear stress and the normal stress at the failure is known as mohr's Envelope.

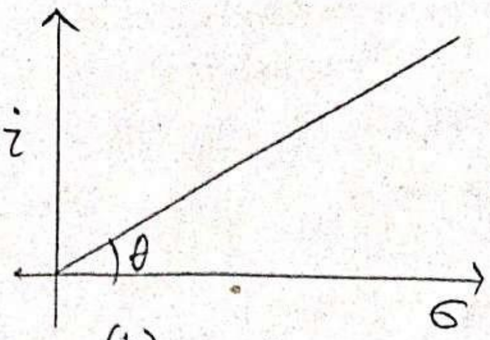




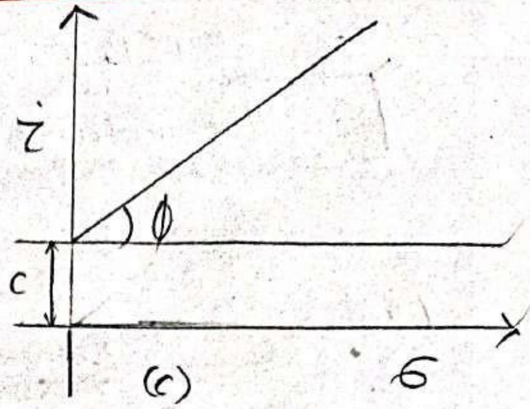
(i) c
(ii) ϕ
(iii) $c-\phi$



(C) soil.



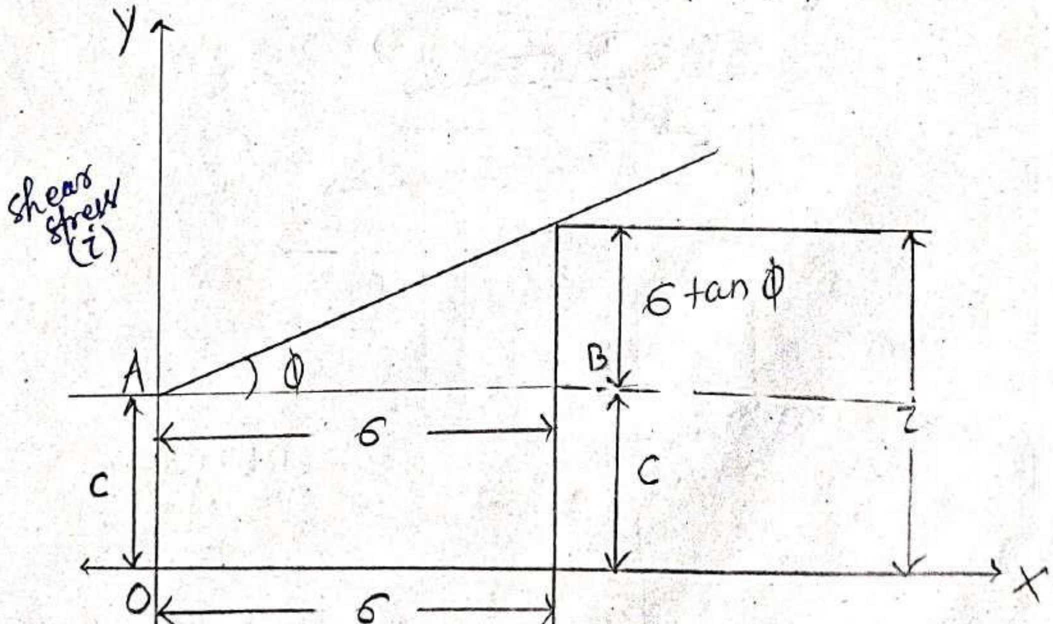
(b) (φ) - soil



(c) (c - φ soil)

→ The shear strength of soil a denoted by Symbol (s).

→ The shear strength of a soil at a point on a particular plane was expressed by coulumb as a linear function of the stress.



$OD = AB$

$\boxed{\sigma = AB}$

$AO = BD$

$\Rightarrow \boxed{c = BD}$

$\tan(\phi) = \dfrac{CB}{AB}$

$\Rightarrow \tan(\phi) = \dfrac{CB}{\sigma}$

$\Rightarrow CB = \sigma \tan\phi$

$\tau = DB + CB$

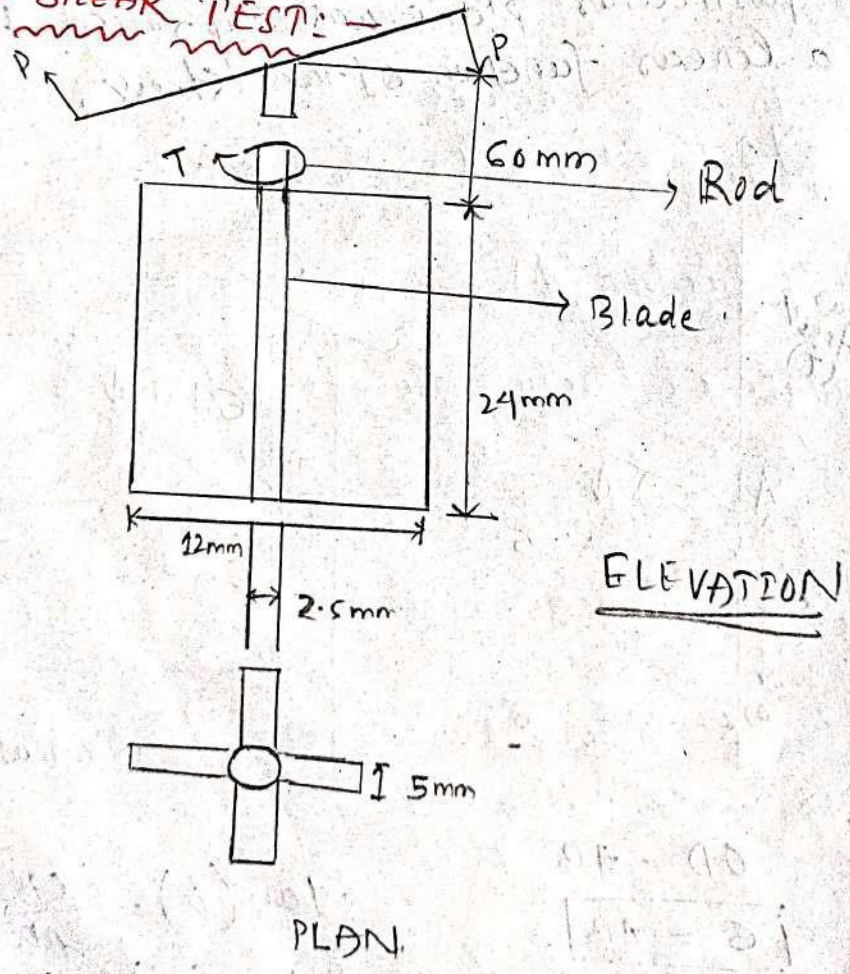
$$\boxed{\tau = C + \sigma \tan\phi}$$

Measurement of Shear Strength: -

There are 3 type method.

1. Direct Shear
2. Trianical Shear
3. Vane Shear.

① VANE SHEAR TEST: -



→ It can be conducted in both laboratary and field.

→ The apparatus consist of vertical steel rod having. Steel blades fixed at it's botton end.

→ The diameter and the length of rod are 2.5 mm and 60 mm respectively.

→ The width and depth of blade are 12 mm and 24 mm respectively.

→ Torque is applied to the upper end of the rod at the rate of 6° per minute or 0.1° /sec.

→ The shear strength of soil can be calculated by using mathmiatical formula.

$$\therefore S = \frac{T}{\pi\left(\frac{D^2H}{2} + \frac{D^3}{6}\right)}$$

where,

S = shear strength (N/m^2).

T = Torque

D = Diameter (m) of vane shear

H = Height (m) of vane shear

Unit:-

N/m

Q.1 A vane shear of 7.5 c.m diameter and 11 c.m length was used to measure shear strength of clay if a torque of 600 N/m was required to shear the soil, calculate the shear strength of soil :-

Sol^n Given that :-

$D = 7.5cm = 0.075m$

$H = 11 cm = 0.11 m.$

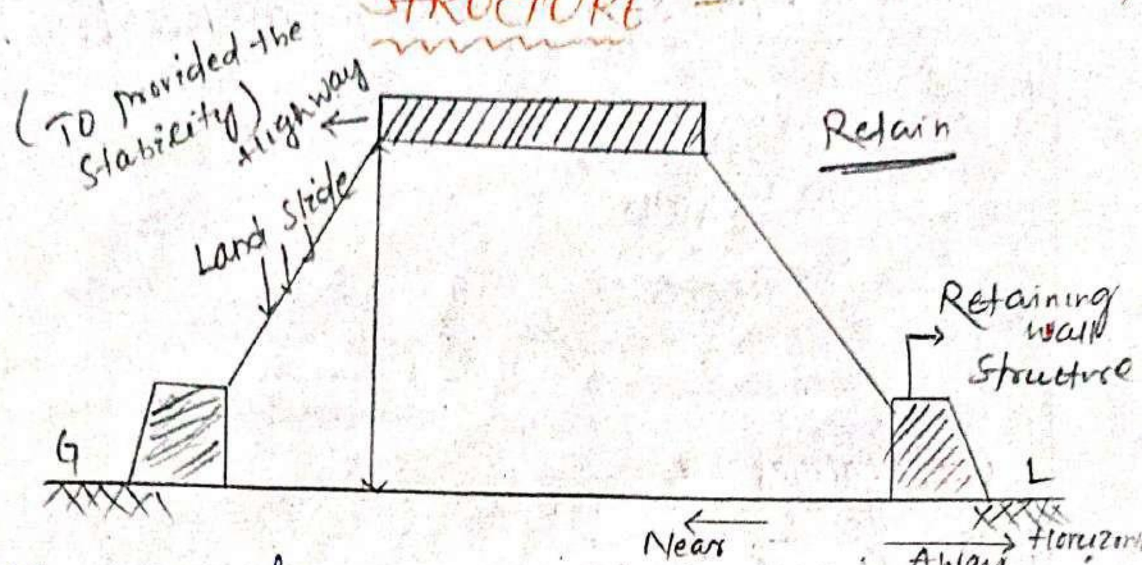
$T = 600 Nm$

$$S = \frac{T}{\pi\left(\frac{D^2H}{2} + \frac{D^2}{6}\right)}$$

$$= \frac{600}{\pi\left(\frac{(0.075)^2 \times 0.11}{2}\right) + \frac{(0.075)^2}{6}}$$

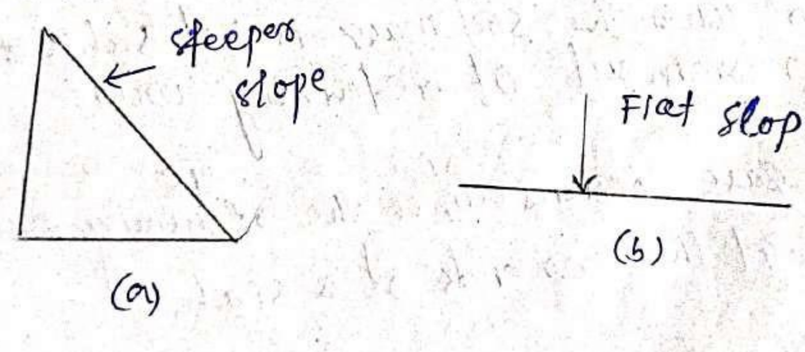
Date. 17/12/21

(Chap-08) (EARTH PRESSURE ON RETAINING STRUCTURE) –



A soil mass is stable when the slope of surface of the soil mass is flatter then the safe slope.

→ At some locations where the space is limited, it is not possible to provide flate slope and the soil is to be retained at a slope steeper then the safe one.

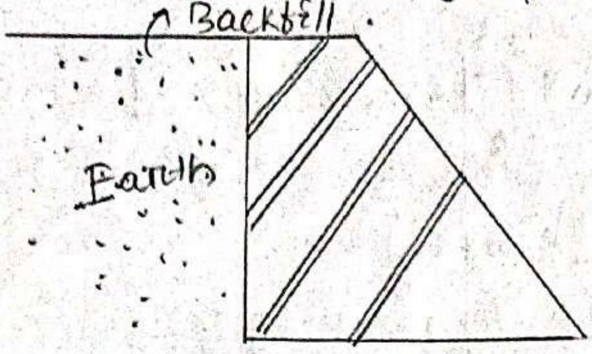


→ The pressure which Exists between the Earth Material and a structure is known as earth pressure on retaining walls.

Different types of earth pressure: –

Earth pressures can be devided into 3 categories- depending upon the movement of the retaining wall with respect to the soil retaining wall with respect to the soil retained.

→ The soil retained is also Known as backfill.



Categories :-

1. At rest pressure.
2. Active pressure.
3. passive pressure.

① At rest pressure :-

→ The earth pressure is Called at rest pressure when the soil mass is not subjected to any movement of retaining wall.

→ This case occurs when the retaining wall is fixed at the two ends of a slab.

② Active pressure :-

→ The Active pressure occurs when the soil mass is subjected to a horizontal movement.

→ A retaining wall when moves away from the backfill active earth pressure will be developed.

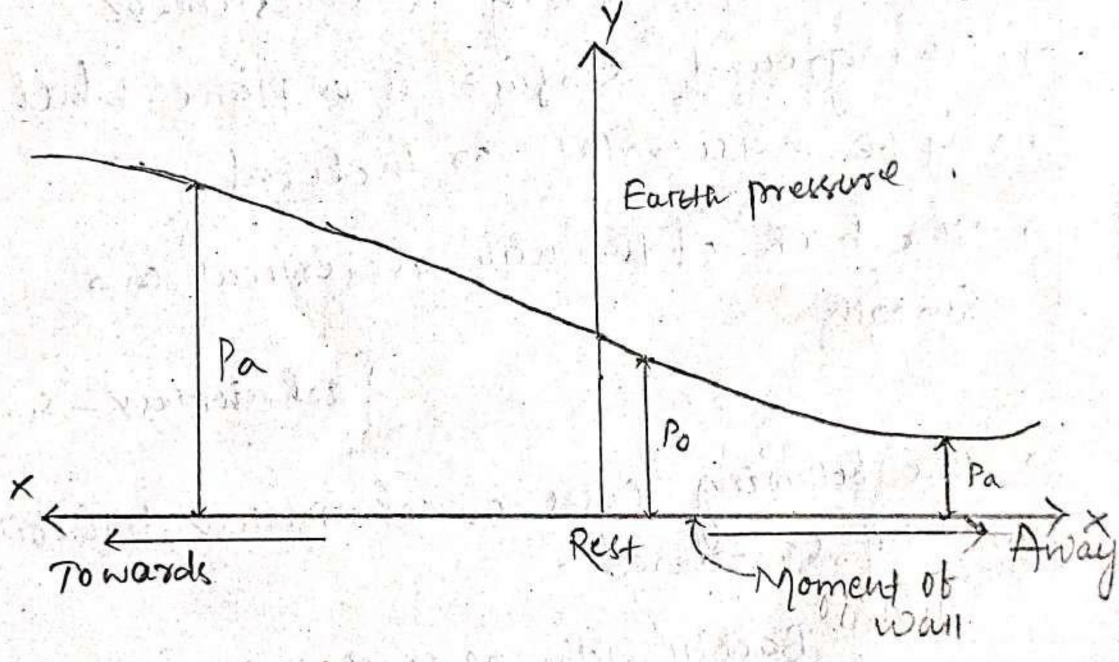
③ passive pressure :-

→ The passive pressure occurs when the soil mass is subjected to horizontal movement.

→ the passive pressure developed on the soil due to movement of wall towards the soil.

Variation of pressure:-

→ The variation of the earth pressure with the wall movment is known on the figure.



Mathmatical Relation:-

$$P_p > P_o > P_a$$

P_p - is the highest earth pressure

P_a - is the lowest earth pressure.

Date - 18/12/21

Active Earth Pressure :- (Rankine's Theory).

→ Rankine's theory of earth pressure is applied to uniform cohesionless soil only.
→ The Theory has also been extended to Stratified partially Imerged and submerged soil.

Assumption of Rankine's Theory :-

→ The soil mass is dry & choesionless.
→ The ground surface is a plane which may be horizontal or Inclined.
→ The back of the wall is vertical and smooth.

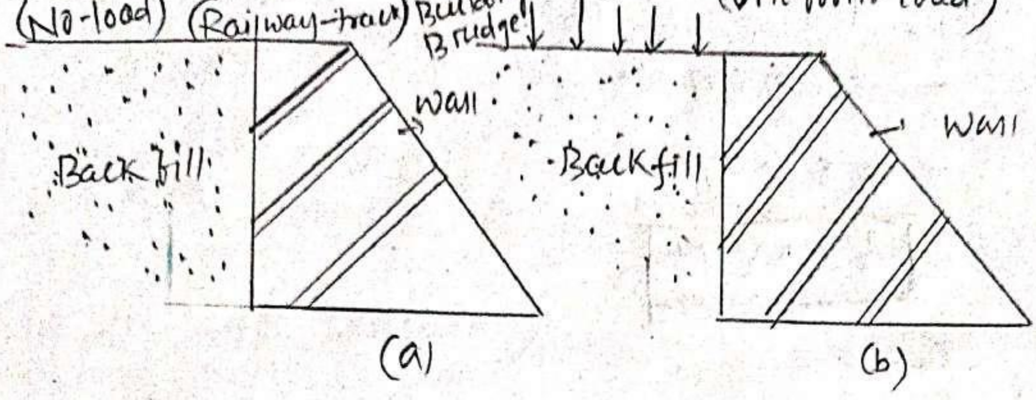
{cohesionless – sand}

→ The following cases of cohesionless backfill will be considered.

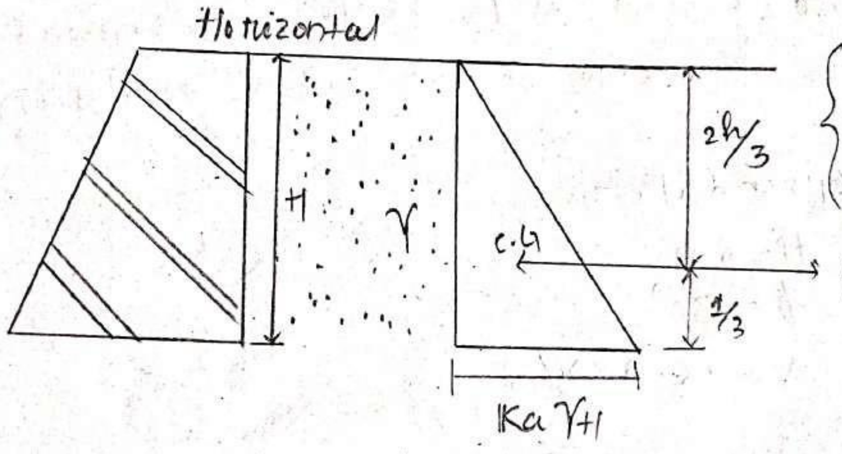
(a) Backfill with no surcharge.
(b) Backfill with uniform surcharge.

NOTE: [Surcharge :- Extra load which is applied on the backfill]

(a) Backfill with no surcharge:-



(a) Backfill with no-surcharge:-



$\frac{1}{3}h + \frac{2}{3}h$
$= \frac{1h + 2h}{3}$
$= \frac{3h}{3} = h$

where,

Ka = co-efficient of active earth pressure.

γ = unit weight of soil

H = Height of retaining wall.

$\therefore \boxed{K_a = \frac{1 - \sin\phi}{1 + \sin\phi}}$ $\therefore \boxed{B = K_a \gamma H}$

$\therefore \boxed{K_P = \frac{1 + \sin\phi}{1 - \sin\phi}}$

Total pressure (P) :-

$P =$ Area of Tringle.

$= \frac{1}{2} \times B \times H$

$= \frac{1}{2} \times K_a \gamma H \times H$

$= \boxed{\frac{1}{2} K_a \gamma H^2}$

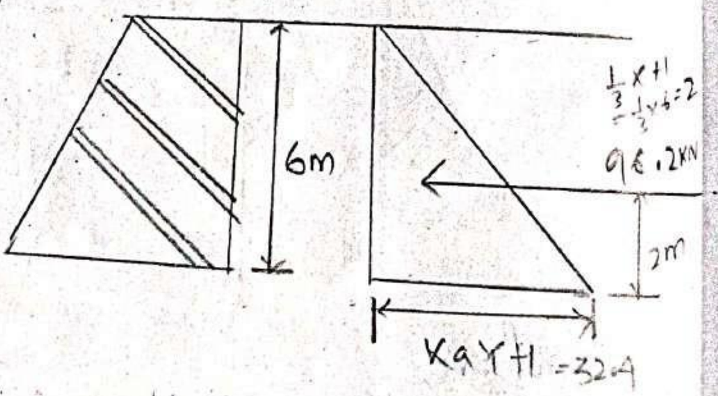
Q:1 A retaining wall, 6 m height retains dry soil with an angle of friction of 30° and unit-weight of soil is 16.2 kN/m3. Determine the earth pressure at the active condition.

Solⁿ Given data;-

$H = 6 m$

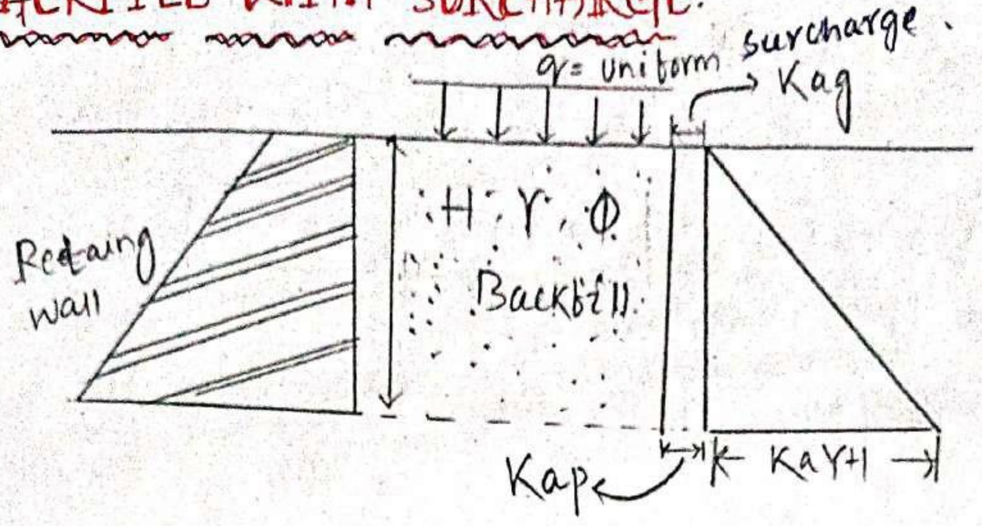
$\phi = 30°$

$\gamma = 16.2 kN/m^3$



Date- 21/12/21

② BACKFILL WITH SURCHARGE:



$K_0 = 1 - \sin\phi$

$K_a = \dfrac{1 - \sin\phi}{1 + \sin\phi}$

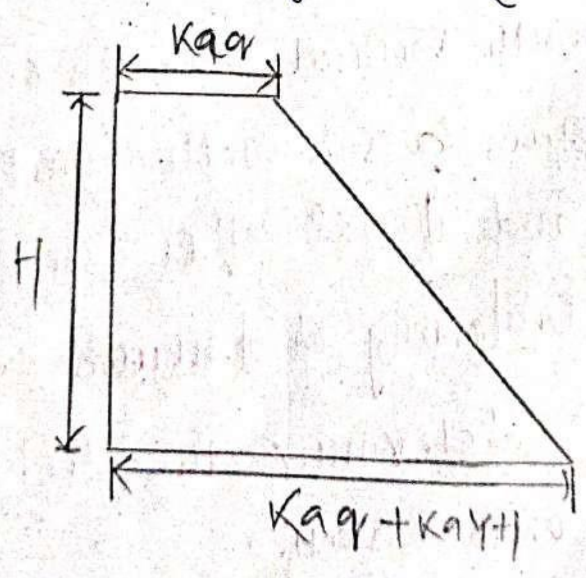
$K_p = \dfrac{1 + \sin\phi}{1 - \sin\phi}$

Where,

ϕ = Angle of friction.

γ = Unit weight of soil.

H = Height of Reatraining wall.

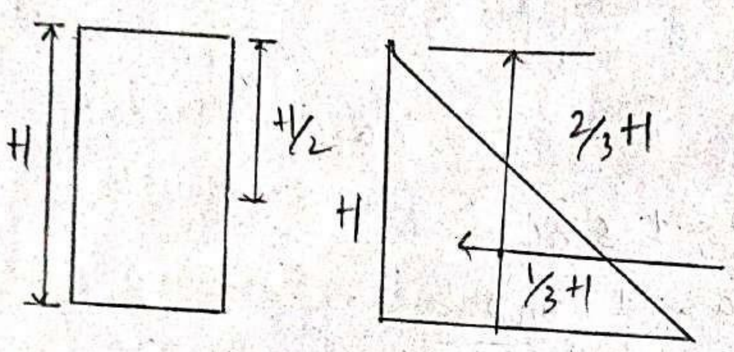


We Know,

P_a = Area of pressure.

$= K_a q \times H + \frac{1}{2} K_a \gamma H \times H$

$= \boxed{K_a q H + \frac{1}{2} K_a \gamma H^2}$



$$C.G = \frac{\text{Area} \times \text{height}}{\text{Total Area}}.$$

$$\vec{X} = \frac{A_1 x_1 + A_2 x_2 + \cdots + A_n \times x_n}{A_1 + A_2 + \cdots + A_n}.$$

Problem-1

A smooth vertical wall in 6.3m high and retain ~~sa~~ soil with a unit weight of 80KN/m³ and $\phi = 18^0$. If the soil surface carries a uniformly distributed load of 4.5 KN/m³ determine the Active Earth Pressure on the wall.

DT-22/12/21 C-P-08

FOUNDATION ENGINEERING

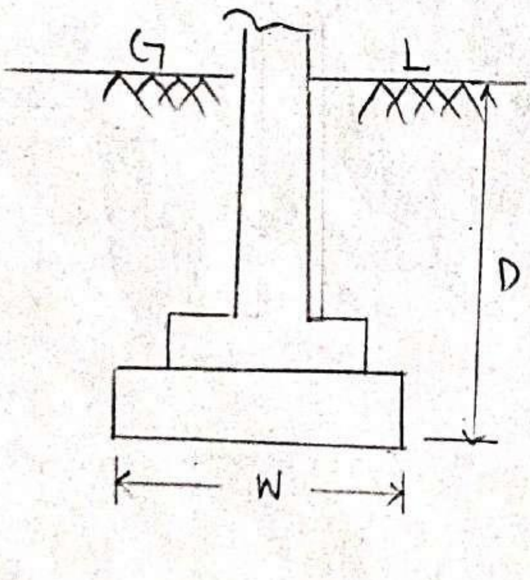
Foundation is that part of a structure which Transmits to the gravity the weight of the structure.

→ A foundation is a connecting link between the structure and soil.

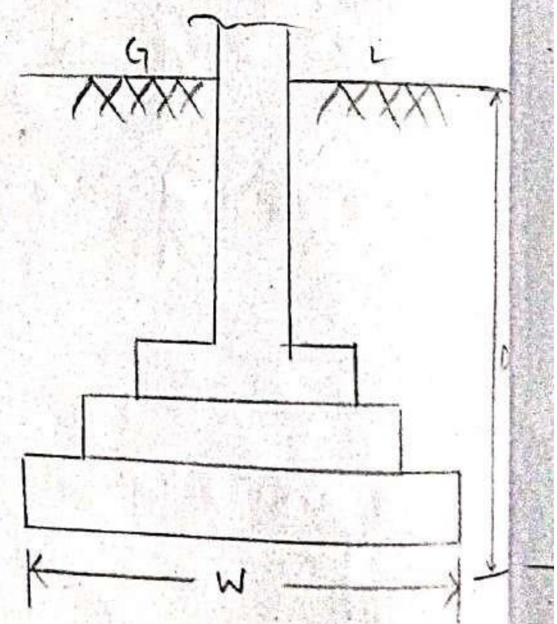
→ Foundation may be classified into Two categories.

1. Shallow Foundation
2. Deep Foundation.

① Shallow Foundation:-



∴ D ≤ W



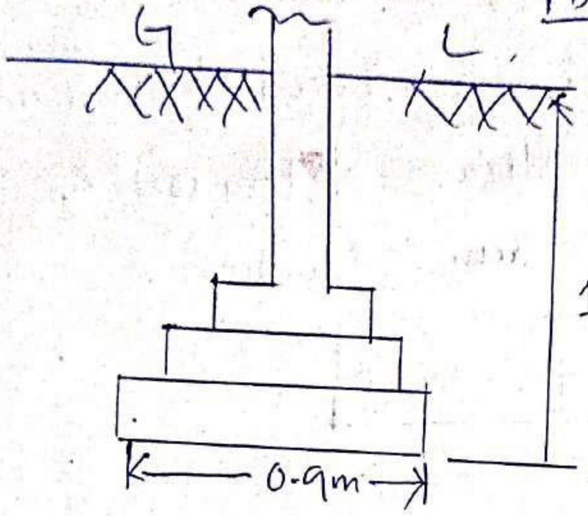
D > W
(Depth of foundation is more)

Where, W = Width of foundation

D - Depth of foundation

Q.1 If width of foundation if 0.9m and depth of foundation of foundation 1.3m which Type foundation.

Ans- Depth foundation | W>D / D>W |



Bearing Capacity:-

→ The supporting power of a soil is known as bearing capacity.

→ Bearing Capacity $= \frac{P}{A}$ { where P = load, A = Foundation of Area.

$= KN/m^3$

or N/m^2

Imp Tearzaghi's Bearing Capacity Theory:-

→ Tearzaghi's gave a general Theory for bearing capacity of a soil in the year of 9043.

Assumttion's :-

(i). The base of the pooting is rough.

(ii). Foundation should be shallow.

(iii). The load on the Foundation is vertical.

(iv). The shear strain of the soil is calculate by mohr's coulomb Equation.

$$\therefore \boxed{\tau = C + \sigma \tan\phi}$$

Equation of Tearzaghi's For calculation of Bearing capacity :-

$$\boxed{q_u = CN_c + \gamma D_f N_q + 0.5 B\gamma N_\gamma}$$

Where,

q_u = ultimate Bearing Capacity

C = Cohession

γ = Unit weight of soil.

D_f - Depth of foundation

B = Width of foundation.

→ N_c, N_q & N_γ are the co-efficient.

Problem-1

Determine the Ultimate Bearing Capacity of strip footing 1.2 width and having 1m depth of foundation use Terzaghi's Theory $C = 15\ KN/m^2$, $\gamma = 18\ KN/m^3$, $N_c = 57.8$ $N_q = 41.4$, $N_\gamma = 42.4$.

Ans:-

Given Data:-

$B = 1.2$

$D = 1\ m$

$C = 15\ KN/m^2$

$\gamma = 18\ KN/m^3$

$N_c = 57.8$

$N_q = 41.4$

$N_\gamma = 42.4$

According to this Equation:-

$$q_u = CN_c + \gamma D_f N_q + 0.5 B\gamma N_\gamma$$

$$= 15 \times 57.8 + 18.1 \times 1 \times 41.4 + 0.5 \times 1.2 \times 18 \times 42.5$$

$$= 2070.12\ KN/m^2\ (Ans).$$

(Date-23/04/21)

Type of shear Failure:-

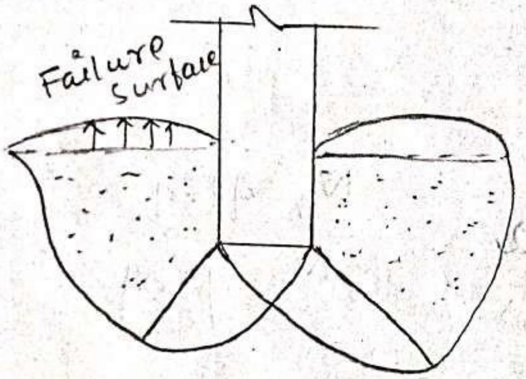
Shear failure of soil devided into three categories.,

(1) General Shear failure

(2) Local Shear failure.

(3) Punching Shear failure.

① General Shear failure:-

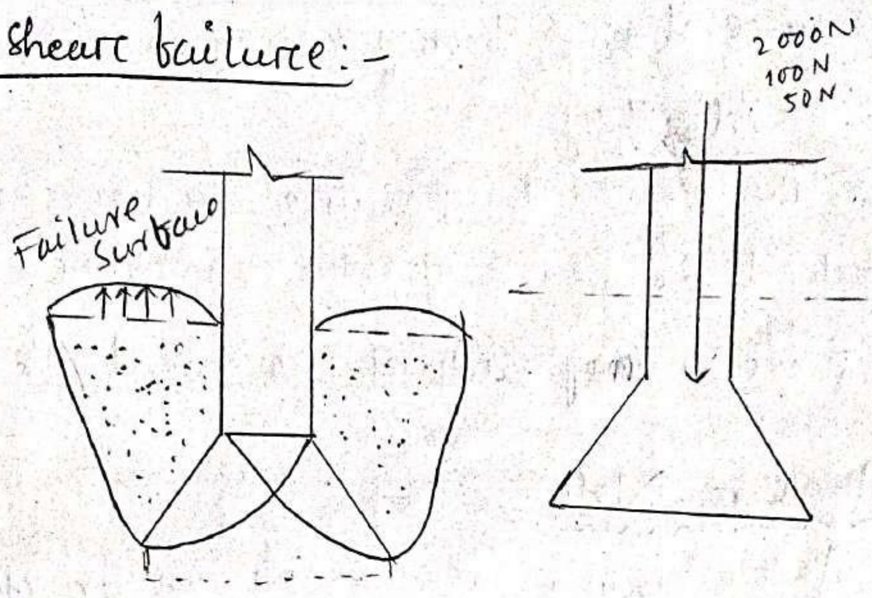


(i) Figures shows a footing resisting on the surface of a dense sand or clay.

(ii) A shear force occurs in the soil at that load and the failure surfaces extend to the ground surface.

(iii) this type of failure is known as general shear failure.

② Local shear failure:-



(i) Figure shows a footing resting on a medium dense sand or on a medium consistency clay.

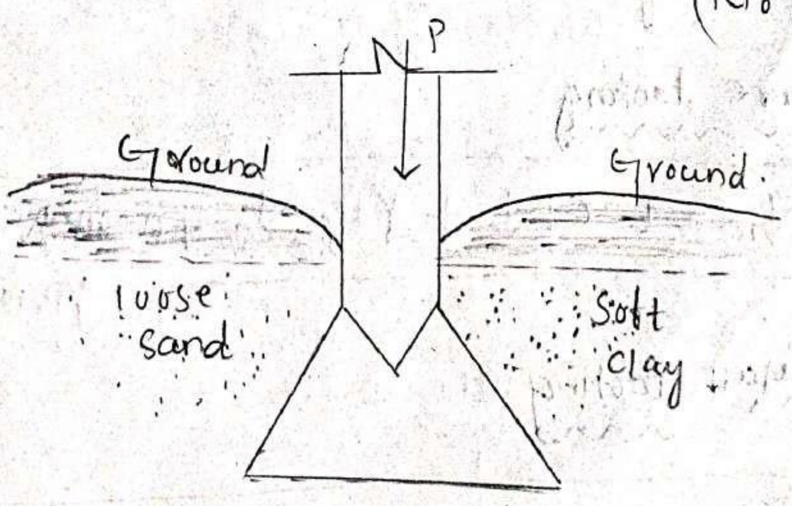
(ii) When the load is equal to bearing capacity of soil, the foundation movment occurs.

(iii) The failure surfaces generally extend outward from the foundation.

(iv) This type of failure is similar to the general shear failure.

③ Punching shear failure:-

(No upward movment of soil).



(Foundation only downward)

(i) Figure shows a footing resting on a loose sand or soft clay.

(ii) In this case, the failure surfaces Don't Extend of to the ground surfaces.

(iii) There is only vertical movement of footing.

Another Note:-

As the footing are seldon constructed an very loose sand, the punching shear failure rarely occurs in the practice.

(Date:- 24/12/21)

Bearing capacity of square and circular Footing:-

Based on Experimental Result Terzaghi's gives the following Equation for the ultimate bearing capacity for square and circular shallow footing.

(a) Square Footing.

$$q_u = 1.2CN_c + \gamma D_f N_q + 0.4\gamma B N_\gamma$$

(b) Circular Footing:-

$$q_u = 1.2CN_c + \gamma D_f N_q + 0.3\gamma B N_\gamma$$

(c) Strip Footing :-

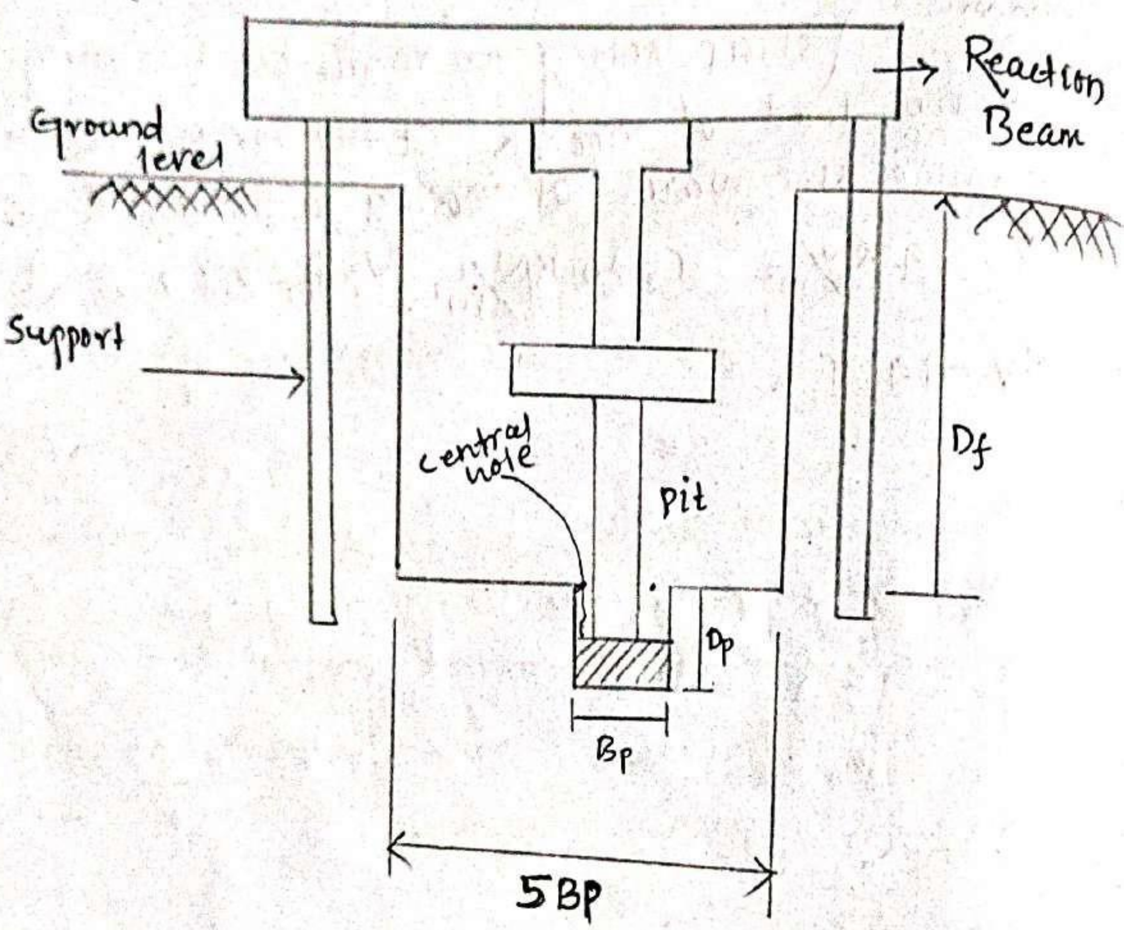
$$q_u = CN_c + \gamma D_f N_q + 0.5 B \gamma N_\gamma$$

Problem-1

A strip footing is required to carry a net load of 900 KN at the depth of 1m. determine the width of footing, take $\phi = 30^\circ$, $\gamma = 19\ KN/m^3$, $C = 20\ KN/m^2$, $N_c = 37.2$, $N_q = 22.5$, $N_\gamma = 19.7$.

PLATE LOAD TEST:-

(i) The Bearing capacity can be determine by conducting a plate load test at the site.



{Trenches - Erthwork In Excavation}

→ The conduct a plate load test a pit size of 5Bp X 5Bp

where, B = width of Excavation
P = pit

→ The depth of foundation (D_f) is represented as

→ The size of the Plate usually $0.3m^2$.

→ The Plate is made of steel and is 25 mm thick.

→ A central hole of size ($B_p \times B_p$).

→ A depth of central hole is represented are 'D'.

→ relation in foundation

$$\frac{B_p}{D_p} = \frac{5B_p}{D_f}$$

$$B_p \Rightarrow B_p \times D_f = D_p \times 5B_p$$

$$D_p \Rightarrow D_p \times 5B_p = B_p \times D_f$$

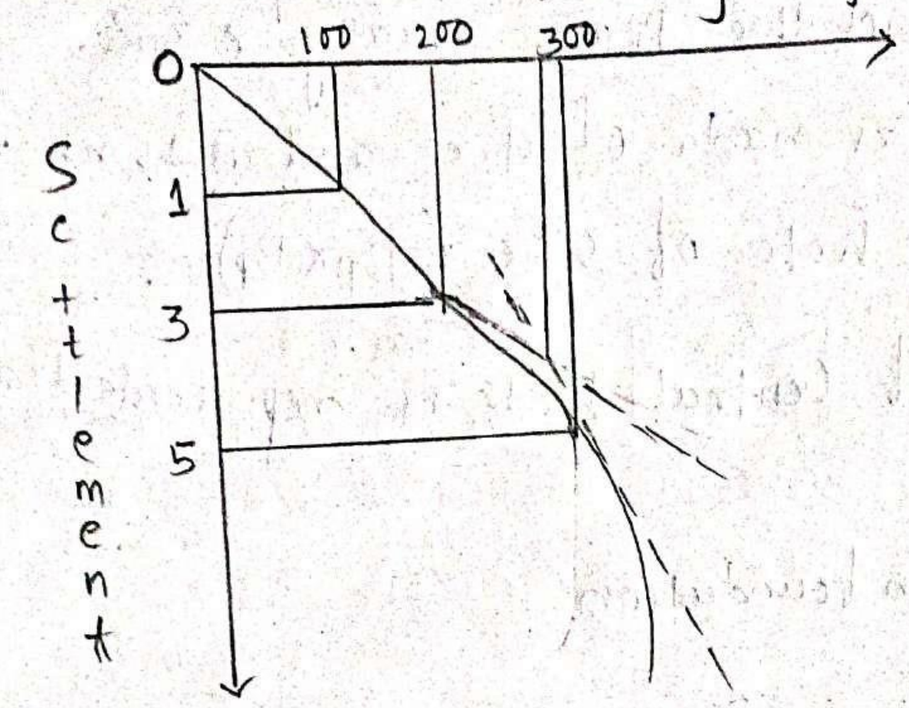
→ For conducting the plate load Test, The plate is place in the central hole foundation and load is applyied by Jack.

→ The reaction To the Jack is provided by the by the reaction Beam.

→ Then load is applyied in incremental order about 20%.

→ The settlement is recorded after 1, 5, 10, 20 40, 60 and 60 min.

Load and Settlement:-



Problem-2

Determine the bearing capacity of Square footing of 2m width and 1m of the foundation depth The soil has unit weight (γ) 18 KN/m^3, $C = 15\ KN/m^3$, $N_c = 14.8$, $N_q = 5.$[illegible]

$\gamma = 3.2$. use the Tirzaghis Theory:-