SWAMIVIVEKANANDA SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

LECTURE NOTES ON

GEOTECHNICAL ENGINEERING

SEMESTER-3RD

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LECT.IN CIVIL

Introduction :-

Introduction to soil Mechanics

The word soil is derived from the latin word Sollum.

Defination of Soil :-

The term soil is defined as an uncosoule material composed of solid particles produce by the disintegration of rock.

The void space between the particle may contain the air, water or both.

The term soil mechanics was coled by

Importance of soil mechanics :-

All civil Engineering structure such as :- Building, Bridge, retaing wall, pavement, Dam, Drainage, pipeline, tunnel, are build on the soil.

Therefore, it is necessary to know the bearing of soil. A knowledge of She & Spelling capacity should be known.

Foundation & construction :-

Every civil engineering structure wheather it is a building, bridge, as a dam is founded on or below the surface of the earth.

They are two types :-

(i) Shallow foundation

(ii) Deep foundation

01. Shallow foundation :-

Shallow foundation is transmite the load to upper streate of the earth.

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02. Deep Foundation :-

The foundation is called deep foundation when the load trandmeted to deep below the ground.

origin & formation of Soil :-

→ Soil mineral at the basic of Soil.

→ There are product from ~~rock~~ through the process of weathering & natural cousion.

Weathering :-

The process of breaking down or desolving of rock and minerals on the surface of the earth is called weathering.

→ The rock cycle is a geological cycle, which is continously take place.

→ The cycle constics of distintegration, weathering corision, transportion, upheavel.

Formation of Soil :-

Soil are formed by physical disintregation & chemical disintregation.

Physical disintregation :-

Physical disintregation or mechanical weathering if rock :-

01. Temperature changes (due to thermal expansion)

02. Wedging

→ water in the pro or crack get frozen in cold climate.

→ Rock get broken into pieces due to wedging ~~fr~~action of ice.

Chemical Decomposition :-

Hydration :-

In this process rock minerals combine with water & transported to reaction.

Carbonation :-

It is a type of chemical decomposition in which carbon divide combines with rock minerals.

Oxidation :-

Oxidation occures when rock minerals combine with oxygen ion when disintregation.

Solution :-

Some of the rock mineral fam a solution with water and get dissolved in water chemical reaction take place & the soil is formed.

Major Soil deposition of India :-

Alluvial deposition :-

Material deposited by rivers is called alluvial deposition. It consist of silt, clay, Graval & some organic materials.

Black cotton soil :-

Chemical Black cotton consist of iron lime, maximum, Alumina etc. they have high shrinkness & swelling limits.

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Notes :-

The term soil mechanics coined by dr. Karl terzaghi in 1925.

Marine deposite :-

Marine deposite at soil formation heaven low shear strain & theire very soft may contain some organic material.

→ They are not good for construction.

→ They are highly compressible.

→ They are found along the Indian coast plane.

Lateritic Soil :–

Lateritic Soil are formed by decomposition of rock. The Soil are which in Iron & alluminium.

→ They are lateritic soil found in west bengal, Karnataka, Maharastra & Kerala.

Desert Soil :–

Desert Soil are form under severe arid condition

→ The soil is found Rajastan.

Classification of soil on particle :–

→ Clay → Gravel

→ Silt → cobble

→ Sand → Boulder

Clay :–

Clay are extrimely find particle having size less them 75 micron.

Silt :–

Sild are find particle of rock smaller than 75 micron having high capilarity.

Sand :–

It is composed of small rounded or angulare particles of wheather rock. It is passing through

4.75 mm Sieve but retain on 75 micron Sieve.

Gravel :-

Gravel are unconsolibated rock fragments having size very from 4.75 mm to 80 mm Sieve.

Cobble :-

They are a Small round Stone having size 80 to 300 mm.

Boulder :-

They are Large rock having size more than 300.

Factors affecting origin of soil :-

Clymate :-

The amount of rainfall, the rate of irosion.

Topography :-

The matercial are easily transfered in the Sloop surface.

Parent material :-

Granite are more resistance to wheathering. Sent Stone & lime Stone are less resistance to wheathering.

Plant & animal activity :-

Plant & animal activity produce huming acid that are powerful irosion agent.

Q. Explain the origin of Salt and Explain various Steps ?

⇒ <u>origin of salt :-</u>

Salts comes from two main sources: Sea water and the Sodium Chloride mineral holite (also known as rock salt) rock salt occurs in vast beds of Sedimentary evaporite minerals that result from the drying up of enclosed lakes, Playes and seas all life depends on its chemical properties to survive. It has been used by mumans for thousands of year, from food preservation to Seasoning Salt ability to preserve food was a founding contributor to the development of civilzation. It helped elimate dependence on sesonal availability of food, and made it possible to transport food over large distances. How ever salt was often difficult to obtain, so it was a highly valued trade item, and was considered a from of currency by certain people. Today, Salt is almost universally accesible, relatively, cheap, & often iodized.

<u>Explain various steps :-</u>

1. Brine is circulated through tube with stream condensing on the outer surface.

II. The first effect or vessel receives low-pressure steam into its steam chamber and the brine boils at a temperature directed by the inset steam pressure. As the brine boils in the first effect water evaporates producing further steam and causing salt crystals to grow. As the brine boils and the water starts to evaporate a thick salt slurry of brine and salt crystals is formed.

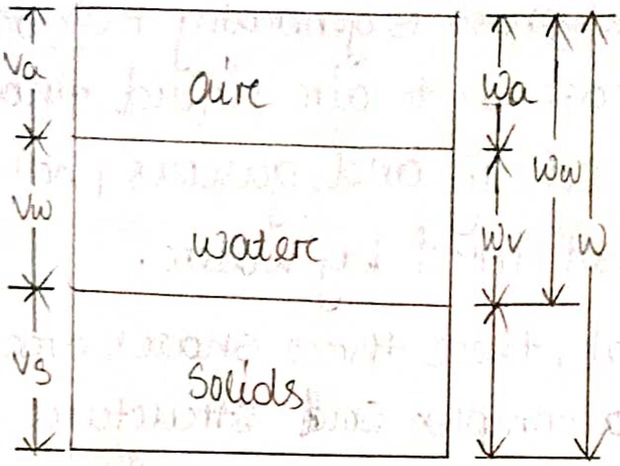
(III) This is fed to the second effect and circulated through a second heat exchange unit that utilises the exhaust steam from the first effect to evaporate further moisture from the brine to produce further crystals pressure and boiling temperatures becomes successively lower through the evaporate. The final ones operate under vacuume and enable the brine to boil much lower temperatures, which is more energy efficient.

(IV) The slurry from the final effect is fed in to a rotating centrifuge which spins off more moisture and the resulting and ried vacuume salt is stored in bulk. This salt is usually for supply to the chemical industry.

(V) For food and related industries a drier salt is required salt from the centifuges is fed into fluid bed drier coolers - rather like hair-driers - for further drying the salt is then sieved and graded before being transfered into large storage hoppers ready for distribution.

__Soil as a three phase system:-__

→ The generally three phase diagram for soil will help in understanding the terminology and also is the development of more useful relationship between the various quantities.



V_a = Volume of air

V_w = volume of water

V_v = volume of voids

V_m = Total volume of soil mass

W_a = weight of air (negligible or zero)

W_w = weight of water

W_v = Weight of material occupying void space

W_s = weight of solids

W = Total weight of solid mass

$W_a = 0$, therefore

$W_v = W_w$

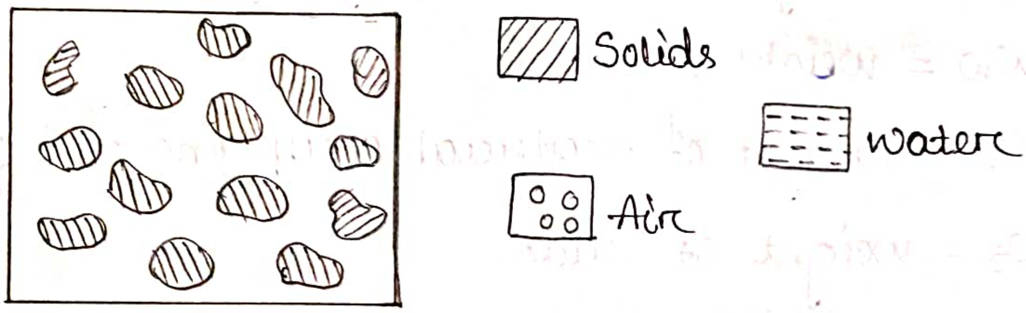
⇒ Three phase system of soil is nothing but the soil mass made up of solid, liquid gaseous matter the solid particles present are called as soil grains.

⇒ The free space or void present between the solid particles is generally filled partially with water and air.

⇒ Here liquid phase is generally referred as to water and gaseous phase as to air liquid phase fills the void partly or wholly and gaseous phase fill the voids which are not filled by water.

⇒ In general, these three phases are randomly mixed forming a complex soil structure as material. They do not occupy separate spaces for each phase.

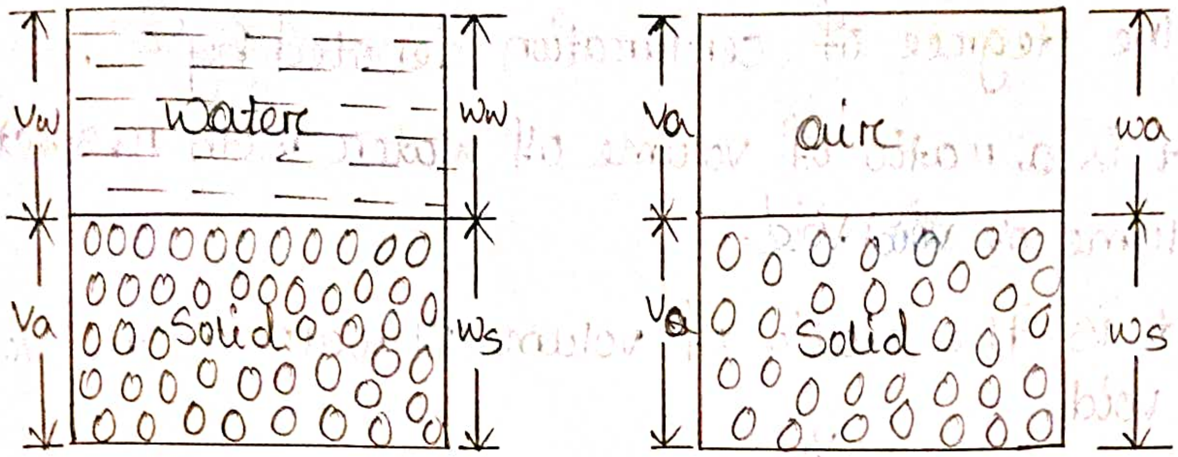
⇒ Relative percentage and the arrangements of these materials are responsible for the soil mass properties. Hence it is very much important to study the volumetric and gravimetric proportions of solids water and air in solid mass.



⇒ It is always conventional to write volume on the rights side and mass (weight) on the left side of the phase diagram.

Soil as a two phase System :-

⇒ The soil will behave as a two-phase system when its void space is filled by either water or air alone. Such condition is possible when the soil is either fully saturated or fully dry.



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Volumetric Relationship :-

01. void ratio (e) :-

It is defined as the ratio of the volume of void with respect to volume solid.

⇒ The void ratio is express as decimal like 0.4, 0.5 etc.

Porosity (n) :-

It is defined as the ratio of volume of void with respect to total volume.

⇒ Porosity is always express in percentage (%).

⇒ The porosity of soil is never exceed 100%.

Relation between void ratio & porosity :-

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

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

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Degree of centurcation :-

→ The degree of centurcation denoted by 'S'.

→ It is a ratio of volume of water with respect to volume of void.

→ It is the ratio of volume of water to the volume of void.

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

Percentage of air void :-

→ It is the ratio of volume of air to the total volume.

→ It is denoted by 'n_a'.

$$n_a = \frac{V_a}{V}$$

Air content :-

→ It is denoted by a_c.

→ It is defined as ratio of volume of air with respect to volume of void.

$$a_c = \frac{V_a}{V_v}$$

Water content :-

$$w = \frac{\text{weight of water}}{\text{weight of solid}}$$

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

Density :-

$$\text{density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\rho = \frac{m}{V}$$

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Volume mass relationship :-

01. Bulk mass density :-

The bulk mass density is defined as total mass per unit volume. $\rho = \frac{m}{V}$

02. Dry mass density :-

Mass. of Solid with respect to total volume.

$$\rho_d = \frac{M_s}{V}$$

03. Saturated mass density :-

It is defined as bulk mass density, when soil is fully saturated.

$$\rho_{sat} = \frac{M_{sat}}{V}$$

04. mass density of Solid :-

Mass density of Solid is defined as mass of Solid with respect to volume of Solid.

$$\rho_s = \frac{M_s}{V_s}$$

Volume weight relationship :-

01. Bulk unit weight :-

The bulk unit weight is defined as total weight per unit total Volume.

$$\gamma = \frac{W}{V}$$

It is express as N/m^3 or KN/m^3.

02. Dry unit weight :-

The dry unit weight is defined as weight of Solid per unit total volume.

$$\gamma_d = \frac{W_s}{V}$$

03. Saturated unit weight :-

The Saturated unit weight is defined as bulk unit weight when the Soil is fully Saturated.

$$\gamma_{sat} = \frac{W_{sat}}{V}$$

04. Submerged unit weight :-

When the soil exist below water it is in Submerged unit weight.

$$\gamma' = \frac{W_{sub}}{V}$$

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SL. NO.	Realationship in mass Density	Relationship in unit weight
01	$n = e/(1+e)$	$n = e/(1+e)$
02	$e = n/(1-n)$	$e = n/(1-n)$
03	$na = nac$	$na = nac$
04	$\rho = \frac{(G+Se)\rho_w}{1+e}$	$\gamma = \frac{(G+Se)\gamma_w}{1+e}$
05	$\rho_d = \frac{G\rho_w}{1+e}$	$\gamma_d = \frac{G\gamma_w}{1+e}$

06	$\rho_{sat} = \frac{(G+e)\rho_w}{1+e}$	$\gamma_{sat} = \frac{(G+e)\gamma_w}{1+e}$
07	$\rho' = \frac{(G-1)\rho_w}{1+e}$	$\gamma' = \frac{(G-1)\gamma_w}{1+e}$
08	$e = wG/s$	$e = wG/s$
09	$\rho_d = \rho/(1+w)$	$\gamma_d = \gamma/(1+w)$
10	$\rho_d = \frac{(1-n_a)G\rho_w}{1+wG}$	$\gamma_d = \frac{(1-n_a)G\gamma_w}{1+wG}$

* Note $\rho_w = 1000\ Kg/m^3 = 1.0\ g/ml$.

$\gamma_w = 9810\ N/m^2 = 9.81\ KN/m^3 \sim 10\ KN/m^3$

Mass specific gravity :-

→ The mass specific gravity of a soil may be defined as the ratio of mass or bulk unit weight of soil to the unit weight of water at the standard temperature. This is denoted by the letter symbol G_m and is given by -

$$G_m = \frac{\gamma}{\gamma_w}$$

Specific gravity of solids :-

→ The specific gravity of soil solids is defined as the ratio of the unit weight of solids (absolute unit weight of soil) to the unit weight of water at the standard temperature. This is denoted by the letter symbol G & is given by -

$$G = \frac{\gamma_s}{\gamma_w}$$

Density index :-

Density index of a soil I_D, indicates the relative compactness of the soil mass. This is used in relation to coarse-grained soils and sands.

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

Where,

e_{max} = Voids ratio in the loosest state.

e_{min} = Voids ratio in the densest state.

e = natural voids ratio of the deposit.

→ This term is used for cohesionless soil only.

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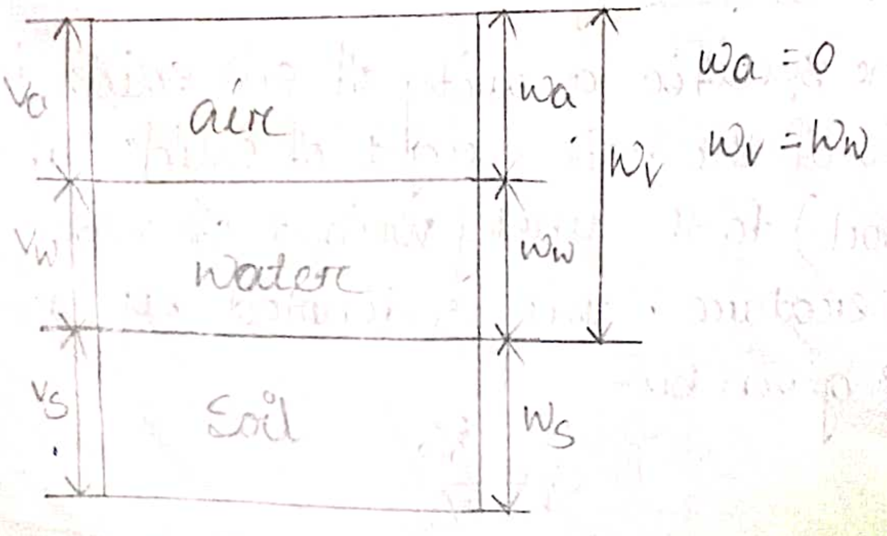
Index properties of Soil :-

Water content :-

→ Soil moisture content is defined as amount of water content is the ratio of weight of water to the weight of soil mass.



$$\text{Soil water content } (w) = \frac{\text{weight of water } (W_w)}{\text{weight of soil mass } (W_s)} \times 100$$

The importance of calculating moisture content of soil :-

→ Required for soil compaction control.

→ For determining liquid limit & plastic limit.

→ For calculation of strength & stability of soil.

Methods of determination of water content :-

→ The water content of soil is an important parametre which control the behaviour.

→ Most common method for determination of soil water content is oven drying method, Pycnometer method, calcium carbite method.

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Oven drying method :-

The moist accurate of for determination of moisture content of soil is oven drying method.

→ In a container is taken with weight W_1.

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Calculation :-

Weight W_1 = weight of an empty container with lead

W_2 = weight of container with lead + wet soil

W_3 = weight of dry soil + weight of container with lead

weight of dry soil = $W_3 - W_1$

weight of water in the soil = $w_2 - w_3$

water content (w) = $\frac{\text{weight of water}}{\text{weight of dry soil}} \times 100$

$$w = \frac{w_2 - w_3}{w_3 - w_1} \times 100$$

Specific gravity of soil :-

Specific gravity (G) of soil is defined as the ratio of rate of a given temperature to the weight of an equal volume of water at that temperature.

$$G = \frac{Vs}{Vw}$$

Then Indian standard specific temperature for calculating specific Gravity (G) 27°C.

Importance of specific gravity of soil :-

Specific gravity of soil is useful for determination of void ratio degree of saturation critical hydrolic garden zero air void unit weight of soil also further determination of particle size.

There are different method of finding specific gravity of soil :-

01. Density bottle soil
02. Pyenometre method
03. Measuring flash method

Pycnometre method :-

Calculation :-

Mass of water content $= m_3 - m_4$

A mass of Soil $= m_2 - m_4$

mass of equal volume of water $= m_4 - m_1 - (m_3 - m_2)$

$$G = \frac{m_2 - m_3}{(m_4 - m_1) - m_3 - m_4}$$

m_1 = mass of pycnometre

m_2 = mass of pycnometre + Soil

m_3 = weight water + weight of Soil + weight of pycnometre

m_4 = water + pycnometre

Particle size distribution :-

Soil compose of soil drains of different shape & Size in varying properties.

→ In order to determination the percentage of various size of soil present in a given soil sample mechanical soil analysis & particle soil analysis created out.

Soil

↓

- Coarse Grained Soil
- Fine grained Soil

fine grained Soil :-

Soil particle having size less than 0.075 mm is called fine grained soil.

croose grained Soil :-

A croose grained Soil are having size greater than 0.075 mm or particle Size between 0.075 mm to 80 mm is known as croose grained soil.

Mechanical analysis :-

→ By mechanical analysis is also known as Particle Size analysis.

→ It is a method of separation of soil into different particle size.

→ The mechanical analysis is done in two test.

01. Sieve analysis

02. Sedimentary analysis

01. Sieve analysis :-

Analysis is done for croose grained soil.

02. Sedimentary analysis :-

This analysis is also called wet analysis having size less than = 0.2 micron.

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Pycnometre method :-

This is a quick method to determine the wather content of the soil whose specific gravity (G) is given

→ pycnometre is the most common method used to determine the specific Gravity of soil.

Apparatus Required :-

Pycnometre of about 900 mm capacity fitted with conical glass of having a hole of 6 mm diametre.

→ A thermo statically control oven to maintain a temperature 105° to 110°c.

Test procedure :-

→ Take a clean dry pycnometre & find it mass with its cap & washer (m_1).

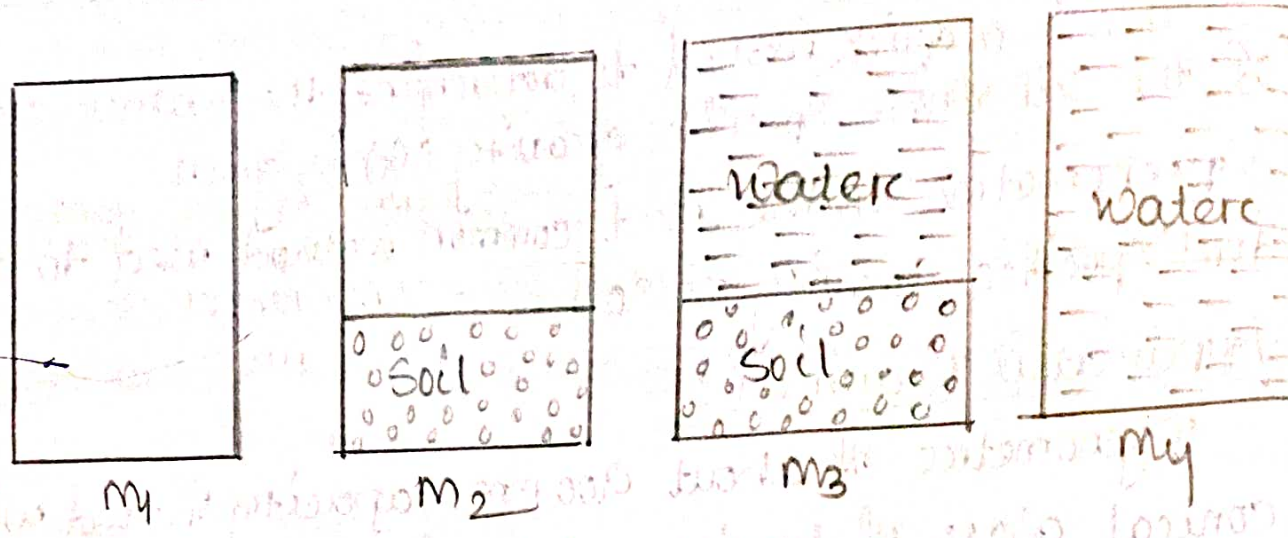
→ Put about 200 gm to 400 gm of wet soil in the pycnometre & find its mass with its cap & washer (m_2)

→ Fill the pycnometre to half of its height mix it throughly with the glass rod & fill the pycnometre flush.

→ Empty pycnometre clean a throughly & fill with clean water to the conical cave up to the conical cave.

Determination

m_1	mass of pycnometre
m_2	mass of pycnometre + soil
m_3	mass of pycnometre + soil + water
m_4	mass of pycnometre + water



Calculation :—

mass of water content $= m_2 - m_3$

mass of soil $= m_2 - m_1$

mass of equal volume of water $= (m_4 - m_1) - (m_3 - m_4)$

$$W = \left[\left(\frac{m_2 - m_1}{m_3 - m_4}\right)\left(\frac{G-1}{G}\right) - 1\right] \times 100$$

Oven drying method :—

It is a most aqurcate method use in laboratory

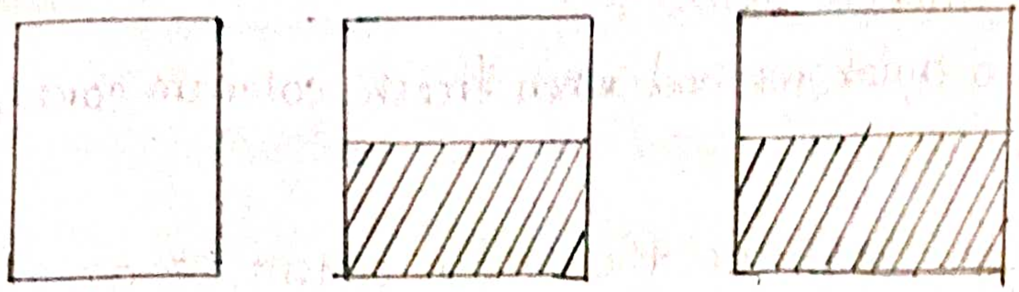
→ Soil sample in a clean container & put it in a oven maintaining the temperature 105° to 110° c.

→ The soil sample is cap for 24 hour.

→ A container is taken with the lead of mass m_1.

→ After filling a soil sample & take mass m_2.

→ After oven drying for 24 hours take the mass of container & drying soil sample is m_3.



m_1 (Empty container with lead)

m_2 (container with soil sample)

m_3 (container with soil sample oven drying for 24 hours.)

<u>Calculation :–</u>

weight of the empty container with lead = m_1

weight of container with lead + wet soil = m_2

weight of container with lead + dry soil = m_3

weight of dry soil = $m_3 - m_1$

weight of water in the soil = $m_2 - m_3$

$$w = \frac{m_2 - m_3}{m_3 - m_1} \times 100$$

<u>Sand bath method :–</u>

→ This the filled method to determine the water content where oven is no use.

→ Sand bath is heated over a Kerosine stoved.

<u>Alcohol method :–</u>

→ This alcohol method this is the filled method.

→ water contain is determine from

$$w = \frac{m_2 - m_3}{m_3 - m_1} \times 100$$

Calcium carbide method :-

It is a quick method when fresh calcium carbide is use.

Q: In order to determine the water content 370 gm of wet sand sample water placed in a pycnometre. The mass or the pycnometre sand & water full to the top of the conical cap wash found to be 2148 gm. The mass of Pycnometre with clean water 1932 taking $G = 2.65$ determine the water content of the sample?

Ans → Given data,

weight of soil sample $= m_2 - m_1 = 370$ gm

$m_3 = 2148$ gm

$m_4 = 1932$ gm

$G = 2.65$

$$w = \left(\left(\frac{m_2 - m_1}{m_3 - m_4} \right) \left(\frac{G-1}{G} \right) - 1 \right) \times 100$$

$$= \left(\left(\frac{370}{2148 - 1932} \right) \left(\frac{2.65 - 1}{2.65} \right) - 1 \right) \times 100$$

$= 6.65$

DA - 11.09.23

Consistency of Soil :-

Consistency of soil denote degree of firmness of the Soil which may be done as soft firm, stiff or hard.

→ In 1911 a Swedish agriculture engineer atterbert mention that soil can aggist in 4 step.

01. Liquid

02. Plastic

03. Semisolid

04. Solid

Solid —increase in water content→ semisolid —|→ plastic —|→ liquid

Shrinkage limit | Plastic limit | Liquid limit

Liquid limit :-

→ Liquid limit is denoted by LL/WL. It defined as limit or water content at which the soil is about to change from plastic step into liquid step.

→ Liquid limit is defined as minimum moisture content or minimum water content at which soil tence to flow as a liquid.

Plastic limit :-

Plastic limit is denoted by PL/ wp. It is the minimum water content at which soil just begin to road crumble when rolled into a thread approximately 3 mm in diametre.

Shrinkage Limit :-

The Shrinkage limit is denoted by SL or WS. It is lowest of water content at which the soil can steel be completly saturated.

→ It can be also it is the maximum water content at which furthere reduction in water content will not decrease the volume of soil.

Attercberts limits :-

All the thing plastic limit, liquid limit & Shrinkage limit is called attercberts limits.

Note :-

we can determine the liquid limit casagrande apparatus & cone penetration method.

→ The plastic limit is determine by rolling out a frame of fine person of soil on a hard noporous surveying we have to rodled the soil upto 3mm diametre.

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Shrinkage ratio :-

Shrinkage ratio is defined as the ratio of the given volume that change express as percent of the dry volume to the corresponding change in moisture content from the initial volume.

Volumetric Shrinkage :-

Volumetric Shrinkage is defined as the decrease in the volume of soil mass express as the percentage of dry volume of the soil when the water content.

Degree of Shrinkage :-

Degree of shrinkage is express as the ratio of the difference between & the final volume.

Plasticity Index :-

Plasticity index is the range of within which the soil exibit with the soil plasticity.

→ plasticity Index is denoted as PI.

$$PI = LL - PL = WL - WP$$

→ Plasticity Index for soil is zero '0'.

Shrinkage Index :-

Is defined as the difference between the plasticity index and the shrinkage limit of the soil.

$$SI\ (IS) = IP - WS$$

or

$$\frac{\frac{V_1 - V_2}{Vd} \times 100}{W_1 - W_2}$$

where, V_1 = volume of soil mass is initial water content.

V_2 = volume of soil mass is final water content.

Vd = volume of dry soil

w_1 , w_2 = water content

Liquidity Index :-

The liquidity index is the ratio of natural water content of a soil minus its plastic limit to its Plasticity Index.

$$I_L = \frac{w - w_P}{I_P}$$

Consistency Index :-

Is denoted by I_C.

The consistency index is defined as the ratio of the liquid limit minus the natural water content to the plasticity index of the soil.

$$I_C = \frac{w_L - w}{I_P}$$

Co-efficient of uniformity :-

→ It is denoted by C_u.

→ The co-efficient of uniformity is a dimension less ratio that measures range of particle size in soil.

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

D_{60} = 60 % of soil particle final than total mass.

D_{10} = effective size

Co-efficient of curvature :-

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

Note :-

→ For uniformly graded soil $c_u = 1$

→ For well graded soil $c_c = 1$ to 3

→ For well graded soil c_u must be greater than 4.

→ for gravels c_u is greater than 6.

→ for c_u is greater than 4.

unit - 4

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classification of soil :-

Soil does n't exist as a single component such as gravel, sand, silt. soil is a mixture of heterogeneous particle.

purpose of soil classification :-

classification of soil in necessary for an approximate but fairly accurate idea of the average properties of soil.

→ The purpose of classification of soil is to arrange various type of soil in two groups according to the engineering and other characterstic.

→ The classification of soil is also done to adentify the suitability of soil for construction of dam highway building.

System of classification of soil :-

01. primary classification

02. classification by origin

03. classification by structure

04. Grain size / textural classification

05. Indian standard soil classification

06. The MIT classification

07. International Soil classification

01. primary classification :-

→ primary classification is necessary for under standing the behaviour of soil.

→ In this approach soil are classified as Sand, gravel, clay, silt, cobbal.

02. classification by origin :-

→ Based on constituents soil are 2 type.

01. organic

02. Inorganic

→ Based on there geological origin.

01. Residual soil

02. Transported soil

03. Alluvia soil

04. Glacier soil

05. Aeoline soil

06. marcaine soil

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Alluvia Soil :-

Alluvia Soil at the Soil which are transported

Glacier Soil :-

Soil transported by glacier.

Aeoline Soil :-

Soil transported by wind.

Marine Soil :-

Soil transported by sea.

Classification by structure :-

Depending upon the grain size & the condition under which soil are form & deposited in there natural state.

They are :-

01. Single grain Structure
02. Soil of honeycum Structure
03. Soil of fraculate Structure
04. Depressed Structure

01. Single grain Structure :-

An arrangement compose of single grain soil particle.

Single grain particles are totally not attach any one or

02. Honey cum Structure :-

The honeycum structure usually develop when Soil particle are between 0.002 mm to 0.02 mm.

03. Flocculent Structure :-

An arrangement compose the flocs of soil particle insteed of indivisual soil particle.

The particles are oriented edge to edge or edge to face or parallel orientation.

04. Depressed Structure :-

The soil in depressed structure generally heaven low shear strain, high compressivelity & low Permeability.

Indian Standard classification of soil :-

As per Indian standard classification of soil we use the code IS 1498-1970.

→ The Indian standard classification of soil are based on both grain size analysis and physical properties of soil.

IS classification of soil :-

In IS system soil are devided into 3 types :-

01. coarse grain soil.

02. Fine grained soil

03. Highly organic or other masonary soil

Coarse grained soil :-

→ coarse grained soil are gravel & Sand.

→ The Soil are larger than 75 micron coarse grained soil are further devided into 2 types.

01. Gravel

02. Sand

Gravel :-

The size of these soil are vaary from 4.75 mm or more than 75 micron.

Sand :-

The size of sand is smaller than 4.75 mm. Both gravels & sand are further devided into W, P, M & C.

where,

W = well graded

P = poorly graded

C = well graded with excellent clay

M = containing fine material not included with other group

IS classification for fine grained soil :-

Fine grained soil are having size varry between 0.002 mm to 0.075 mm or > 75 μ (micron).

Natural classification :-

In the grained soil classification soil are designated according to

Term such as gravel, sand, silt, clay are use to indicate grained size.

There are various grained size classification.

01. US Bureau of soil & public road administation system.

02. International soil classification

03. MIT classification

04. Indian standard classification

01. US Bureau of soil & public road administation system :-

	0.005 mm	0.05 mm	0.10 mm	0.25 mm	0.50 mm	1.0 mm	2.0 mm
Clay	Silt	Very fine	Fine	Medium	Coarse	Fine gravel	Gravel

02. International soil classification :-

	0.0002	0.0006	0.002	0.006	0.02	0.05	0.1	0.2	0.5	1.0	2.0 mm
Ultra clay (colloids)	F	C	F	C	F	C	F	M	C	VC	Gravel
	Clay		Silt		mo (maila)		Sand				

(c) M.I.T classification :-

Size (mm)	0.0002 – 0.006	0.006 – 0.02	0.02 – 0.06	0.06 – 0.2	0.2 – 0.6	0.6 – 2.0	above 2.0mm
Clay (size) (colloids)	Fine	med	coarse	Fine	med	coarse	Gravel
	Silt (size)			Sand			

(d) IS classification (IS 1498-1970) :-

Size (mm)	below 0.002mm	0.002 – 0.075	0.075 – 0.425	0.425 – 2	2 – 4.75	4.75 – 20	20 – 80	80 – 300	above 300
	Clay (size)	Silt (size)	Fine	med	Coarse	Fine	Coarse	Cobble	Boulder
			Sand			Gravel			

Dt-15.09.23

Permeability :-

Permeability is defined as the property of a Porous material which permit the passage or seepage of water through its inter connecting voids.

→ A material having continuous voids is called permeable.

→ Gravels are highly permeable while stiff clay is least permeable.

→ This type of clay or material called Impermeable.

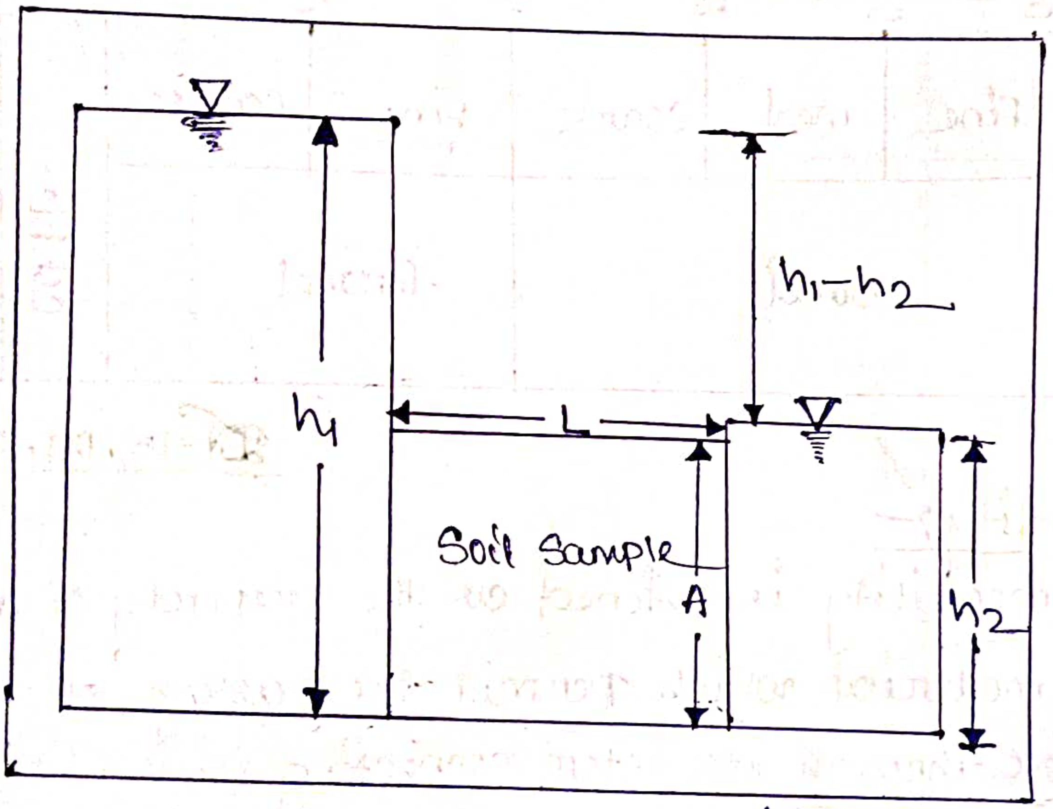
→ permiability is the flow of free water or gravination water flow throught the soil.

Dt - 22.09.23

Darcy's law :-

The law of flow of water through of soil was study by Darcy since 1856.

→ H. Darcy of France performed a classical experiment 1856. To study the properties of the flow of water through a sand filter bed.



Flow of water through soil

→ By measuring the value of the rate of flow or discharge (q) for various values of the length of the sample L.

→ The pressure of water at top and bottom of the soil sample is h_1 and h_2.

→ Darcy found that q was proportional to $(h_1 - h_2)/L$ or the hydraulic gradient i.

$$q = K \left[\frac{(h_1 - h_2)}{L}\right] \times A$$

$$q = K \cdot i \cdot A$$

Where, q = The rate of flow or discharge

K = A constant, known as Darcy's coefficient of permeability

h_1 = The height above datum which the water rose in a standpipe inserted at the entrance of the sand bed,

h_2 = The height above datum which the water rose in a standpipe inserted at the exit end of the sand bed.

L = Length of the sample

A = The area of cross section of the sand bed normal to the general direction of flow,

i = $(h_1 - h_2)/L$ the hydraulic gradient

→ The above equation is known as Darcy's law and is valid for laminar flow only.

→ ~~The~~ Darcy's law becomes inadequade for liquid flow at high velocity or gas flow at very low or at very high velocity.

→ K is also refferred to as the coefficient of permeability or simply permeability.

→ Darcy's coefficient of permeability a quantitative means of comparison for estimating the facility with which water flows through different soils.

Factors affecting permeability :-

→ The permeability of soil is depends on the soil characteristics. Such as,

01. Grain size
02. Void ratio
03. Effect of structural arrangement of particles and stratification.
04. Effect of degree of saturation and other foreign matter
05. Effect of properties of pore fluid

Grain Size :-

→ It is logical that the smaller the grain size the smaller the voids and thus the lower the permeability.

→ A relationship between permeability and grain size is more appropriate in case of sand and silts than that of other soils.

→ Since the grains are more nearly equidimensional and fabric changes are not significant.

Void Ratio :-

→ Increase in the void ratio leads to an increase in the permeability of a soil for two distinct reasons.

→ It cause an increase in the percentage of cross sectional area available for flow.

→ It causes an increase in the dimension of the pores, which increases the average velocity, through an increase in the hydraulic mean radius.

Effect of structural arrangement of particles & stratification :—

→ The structural arrangement of the particles may vary, at the same voids ratio, depending upon the method of deposition or compacting the soil mass.

→ The structure may be entirely different for a disturbed sample as compared to an undisturbed sample which may possess stratification.

→ The effect of structural disturbance on permeability is much pronounced in fine grained soils.

→ Stratified soil masses have marked variations in their permeability's in direction parallel and perpendicular to stratification, the permeability parallel to the stratification being always greater.

Effect of degree of saturation and other foreign matter :—

→ The permeability is greatly reduced if air is entrapped in the void thus reducing its degree of saturation.

→ The dissolved air in the pore fluid may get liberated, thus changing the permeability.

→ organic foreign matter also has the tendency to move towards critical flow channels and choke them up, thus decreasing the permeability.

Effect of absorved water :-

→ The absorbed water surrounding the final soil particles is not free to move, and reduces the effective pore space available for the passage of water.

Effect of properties of pore fluid :-

→ Permeability is influenced by both the viscosity and the unit weight of the fluid.

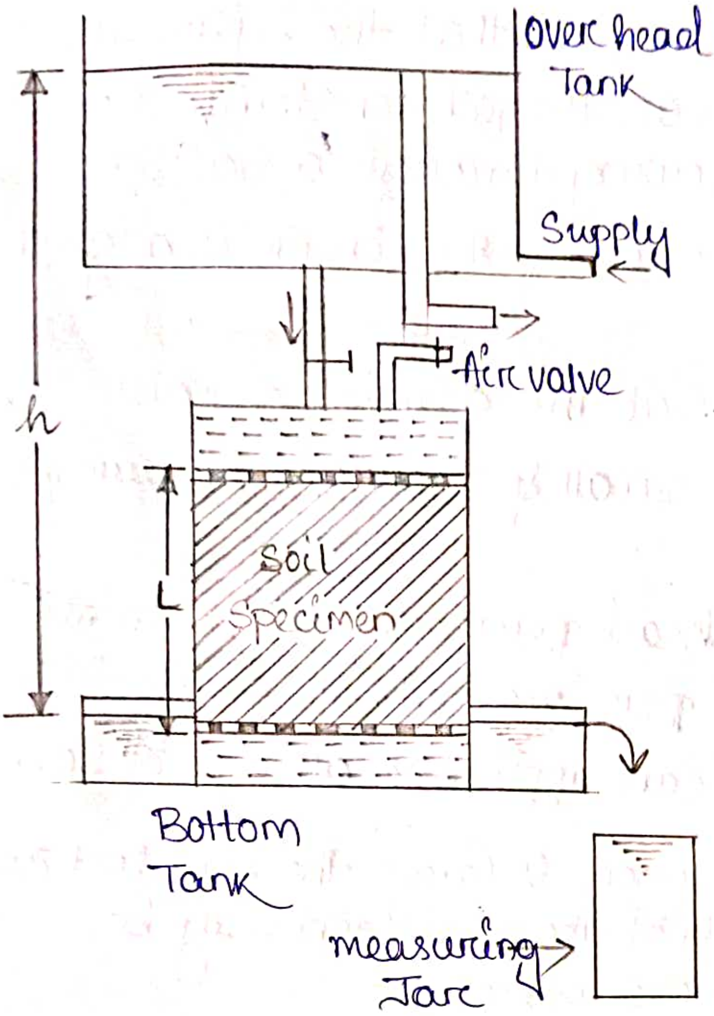
→ permeability is directly proportional to the unit weight and inversely proportional to the viscosity of the fluid.

Dt - 23.09.23

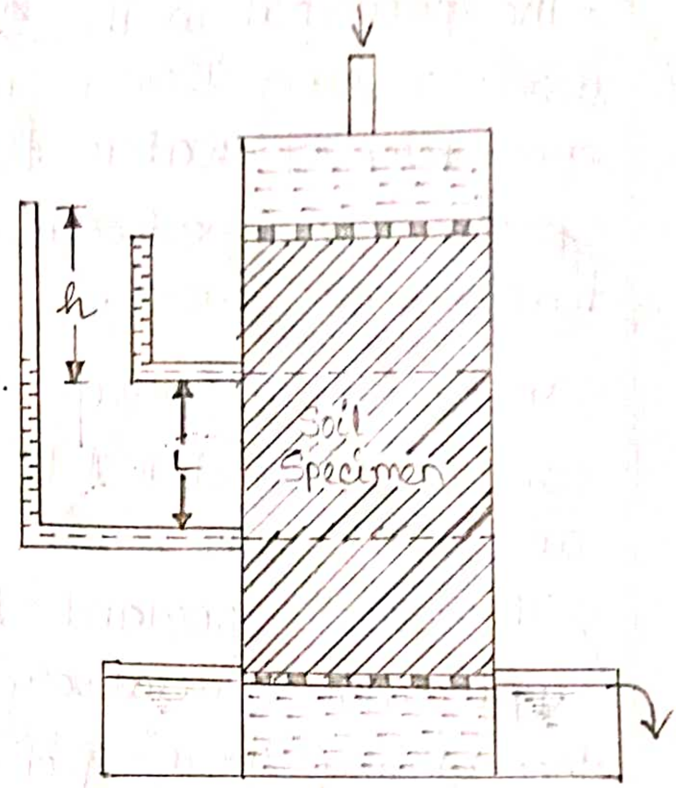
Constant head permeability test :-

→ The co-efficient of permeability of a relatively more permeable can be determine the laboratory by constant head permeability test.

→ The test in coducted an instrument is constant head permeability.



(a)



(b)

Apparatus Required :-

→ It consist of a metalic mould of 100 mm diameter.

→ 127.3 mm effect height & 1000 mm capacity.

→ Experiment process :-

→ The Soil sample is placed inside the mould between to porouseable should be atleast 10 time more permeable then the Soil.

→ The porouseable should be dried before these are placed in the move.

Dt-25.09.23

→ The principal in this setup is that the hydraulic head causing flow is maintained constant the quantity of water flowing through a soil specimen of non-cross sectional area & the length is a given time is measured.

→ In highly impervious soil the quantity of water that can be connected will be small & accurate measurement are ~~ra~~ difficult made

→ Therefore constant head permeability is mainly applicable to relatively pervious soil. All though theorytically speaking it can applicable all type of soil.

→ If the length of the specimen is large the head lost over a choosen convient length of the specimen may be obtained by inserting piezometere.

→ If q is the total quantity of low in a time metre (t) & having the soil specimen of length L of Area A.

According to Darcy's law

we know $q = KiA$ —— ①

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

Here we know,

$$i = \frac{h}{L}$$

Putting the value of i in equation (1)

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

where, K = darcy's co-efficient of permeability

L = Length of the soil specimen

A = Area of the Soil Specimen

h = hydraulic head

Q) From the constant head permeability test L = 30cm, area of specimen = 175 cm², constant head difference h = 50 cm water collected in a 5 min period is 350 cub.cm, Find hydraulic conductivity in cm/sec.

Ans ⇒ Concept,

From darcy's law $q = KiA$

q = discharge

K = permeability

i = hydraulic gradient $= \frac{h}{L}$

A = Area of cross-section

Calculation,

Given data,

$L = 30$ cm

$h = 50$ cm

$t = 5$ min $\times 60 = 300$ Sec

$A = 175$ cm²

$Q = 350$ cm³

$$K = \frac{QL}{thA} = \frac{350 \times 30}{175 \times 300 \times 50} = 0.004$$

Falling head permeability test :–

The constant head permeability test is used for cross-grained soil only where and resonable discharge collected in a given test.

Where the falling head test is used for less permeable soil used for where the discharge is small.

-> A stand pipe of known cross-sectional A is heated over the fitted over and water is allow to run down

-> The water level in the stand by which is constantly formed as water flows.

-> Observation as started after stady state of flow has statly.

-> The head and any time distance t is required to the equal different water level.

Let h_1 & h_2 be head time interval t_1 & t_2. where $t_2 > t_1$

Let it be head at any intermiate time interval t > dt.

From darcy's law

$$i = \frac{h}{L}$$

$$q = KiA$$

$$= K\frac{h}{L}A$$

$$K\frac{h}{L}A = \frac{A - dh}{dt}$$

$$K\frac{h}{L}A = -A\frac{dh}{dt}$$

$$\Rightarrow \left(\frac{KA}{AL}\right)dt = \frac{-dh}{h}$$

$$\Rightarrow \int_{t_0}^{t_1}\left(\frac{KA}{aL}\right)dt = \int_{h_0}^{h_1}\frac{-dh}{h}$$

$$= \frac{KA}{dL} \int_{t_0}^{t_1} dt = -\int_{h_0}^{h_1} \frac{dh}{h}$$

$$= \frac{KA}{dL}(t_1 - t_0) = \log_{10}\left(\frac{h_0}{h_1}\right)$$

$$\Rightarrow K = \frac{2.3\, At}{A(t_1 - t_0)} \log_{10}\left(\frac{h_0}{h_1}\right)$$

Dt - 27.09.23

Shepage velocity :-

The discharge velocity is not the actual velocity it is a velocity obtained by dividing the total discharge with the total cross-sectional area.

→ As the flow testless only through voids the actual velocity through the voids is much greater than the discharge velocity the actual velocity is known as Shepage velocity.

Difference between laminar flow & terbunal flow :-

Laminar flow	Terbunal flow
→ Laminar flow is smooth.	→ Terbunal flow is irregular.
→ Fluid particle move in smooth and orderly layer with wheel define split line.	→ It exibit irregular motion with fluid particles moving in un predictable pattern.
→ velocity of fluid particles remain constant as the flow fluid is characterise by low velocity gradient.	→ There are large velocity with significant variousn with flow speed and ire reaction.

Quick sand condition :-

→ Quick sand condition occurs when the upward shepage pressure in soil becomes equal to summerge unit weight of the soil.

Unit - 6 Compaction & consodelation

Compaction :-

compaction is the process by which the soil particle are rearrange & packed together into a closer strain.

→ The compaction process may be done by rolling, temping or vibration.

→ compaction is refers to reduction in air voids due to pressure for short duration.

Objective & method of compaction :-

To increase the dry density of soil to reduce the tendency for settlement of under loading to reduce permeability & compresibility of soil.

→ To increase the stability & bearing capacity of soil.

→ To decrease the presence of air void in the soil.

→ To decrease the water absorption capacity of soil.

Method of soil compaction :-

→ The tenque of vibration is largely use for compaction process.

→ Smooth wheel roller, neumatric tayer roller, Sheep roller, Sheep hood roller, vibratory roller are used for field for compaction of soil.

→ Some of the usual compaction test use in the laboratory to determine water density relation soil are Standard & modify protounting Jodhput compacter test, harward miniature compaction test.

Laboratory method of compaction :- Dt - 28.09.23

→ compaction test are conducted in the laboratory to determine the relationship between moisture contain & dry density of the soil.

→ Laboratory compaction process may involve starting load, kneading & vibration.

→ Some common test which are conducted in laborator standard proper test modify proper test is compaction test, harvard miniature compaction test, abbost compaction test, Jodhput mini compaction test.

zero air void line :-

A line which shows the water content dry density relation for the compacted soil containing a constant percentage air void is known as zero air void line.

$$\rho_d = \frac{(1-n_a) G \rho_w}{1+wG} \quad \text{or} \quad \rho_d = \frac{G\rho_w}{1+wG} \quad \text{or} \quad \frac{G\rho_w}{1+\frac{wG}{S}}$$

na = percentages in air void

w = water content of compacted soil

ρ_d = dry density corresponding to water content in compacted soil

G = Specific gravity

ρ_w = density of water = 1gm = 1000 Kg/m3

→ The line showing the dry density as a function of water content of soil containing no air voids is called zero air void line / saturation line.

Compaction curve :-

The curve ploated between water content and the corresponding dry density is called compaction curve.

optimum water content :-

The dry density gauge increase in as the water content is increase the maximum density increase these the water content corresponding to the maximum density.

Factors affecting compaction :-

The various factor which affect the compact density are water content amount & type of compaction method of compaction, type of soil addition of mixture.

Water content :-

When the water content is increase the compacted density gauge are increase till the maximum dry density is archive.

→ The increase in water content expanssion of double air & reduction the net attractive force and increase in interparticle deposition.

→ After the optimum water content is it the air voids approach approximately a constant value as further the increase in water content.

Compact soil

Compaction is the process by which the soil particles are artificially arranged and packed together into a closer state by mechanical in order to decrease void and increase its density.

Benefits of compaction :-

1. Increases density
2. Increases strength characteristics.
3. Increases load bearing capacity.
4. Increases stability of slopes & embankment
5. Decreases Permeability.
6. Reduces water seepage

Factors affecting Compaction

(1) Water Content.
(2) Amount of compaction.
(3) Method of compaction.
(4) Types of soil.
(5) Addition of admixtures.

Effect of water content

(i) With increase in water content, compacted density increase upto a stage.
(ii) The maximum density achived is called MDD and the corresponding water content is called OMC.
(iii) Increase in water content results in expansion of double layer and reduction in net attractive force between particles, water reduces in void space
(iv) particles slides over each other easily and increasing lubrication results, helding in dense passing.
(v) After OMC is reduced air voids remain constant further increase in water, increases the void space, there by decreasing

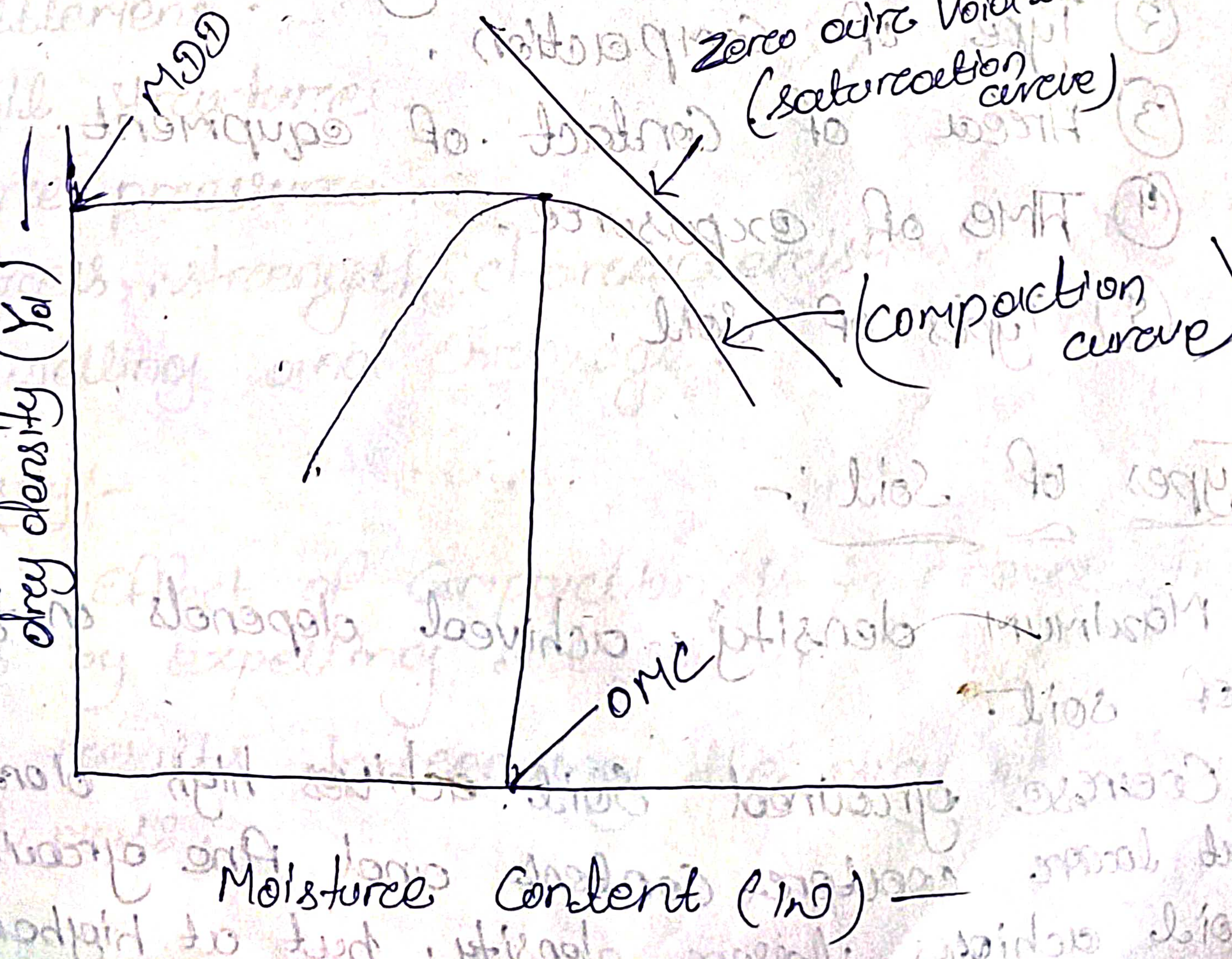
Maximum dry density (MDD)

i) The dry density corresponding to optimum moisture content is called Maximum dry density.

ii) The peak dry unit weight is called MDD.

Optimum Moisture Content :- (OMC)

OMC of soil is the moisture content at which maximum dry density is achived under a specific compaction factor.



Amount of Compaction

Effect of increasing compacting effort is to increase MDD and reduce OMC.

-> There is no linear relationship between compactive methods and MDD.

Method of Compaction

IMP

The dry density achieved by the soil depends on the following characteristic of compacting method

1. Weight of compacting equipment.
2. Type of compaction.
3. Area of contact of equipment.
4. Time of exposure.
5. Types of soil.

Types of Soil :-

1. Maximum density achived depends on types of soil.
2. Coarse grained soil achives high density at lower water content and fine grained soil achives lesser density but at higher water content.

Addition of admixture

(i) Stabilizing agents are the admixtures added to soil.

(ii) The effect of adding those admixtures is to stabilize the soil.

Effect on compaction on soil property :-

1. Density
2. Sheare strength.
3. permeability.
4. Bearing capacity.
5. Settlement.
6. Soil structure.
7. pore pressure.
8. Stress, strength characteristics.
9. swelling and shrinkage.

Density :-

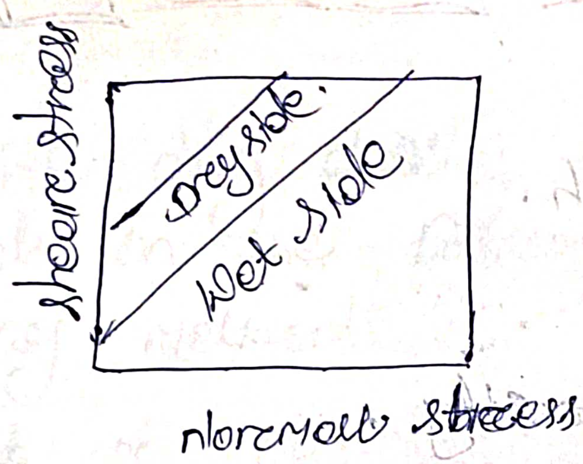
Effect of compaction is to reduce the voids by expelling out air.

-> This results increasing the dry density of soil mass.

Sheare strength

Due to compaction sheare strength increases in granulare soils.

→ But in clays; sheare strength depends on drey density, water content, soil structure, Method of compaction, etc.



permeability

→ Increase the drey density reduces the void space, their by reducing permeability

→ At same density soil compacted upto optimum is more permeable.

→ Increase compacting efforet reduces permeability.

Bearing capacity

→ Due to compaction it increases the density and number of contacts between soil particles.

→ Hence, bearing capacity increase

Settlement

→ If compaction increases, density increases and decreases void ratio.

→ This results reduce in settlement.

Soil structure

→ In fine grained soil, on dry side of optimum, the structure is flocculated.

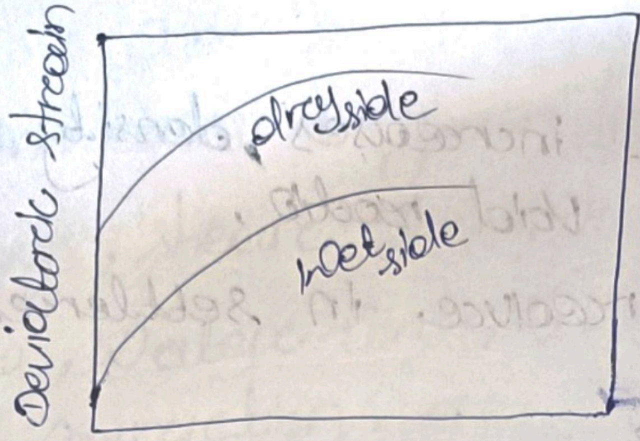
→ In coarse grained soil, the structure is maintained.

pore pressure

clayey soil compacted up to optimum dry density developed less pore water pressure

stress strength characteristic :-

The strength on modulus of elasticity of soil on the dry side of optimum will always be better than on the wet side of the same density.



Swelling and shrinkage:-

The effect of compaction is to reduce the void space. Hence the swelling and shrinkage are reduce.

Standard proctor compaction test:-

→ It is a cylindrical metal mould with detachable base plate having internal diameter 101.6 mm, internal height 116.8 mm and volume 945000 mm^3.

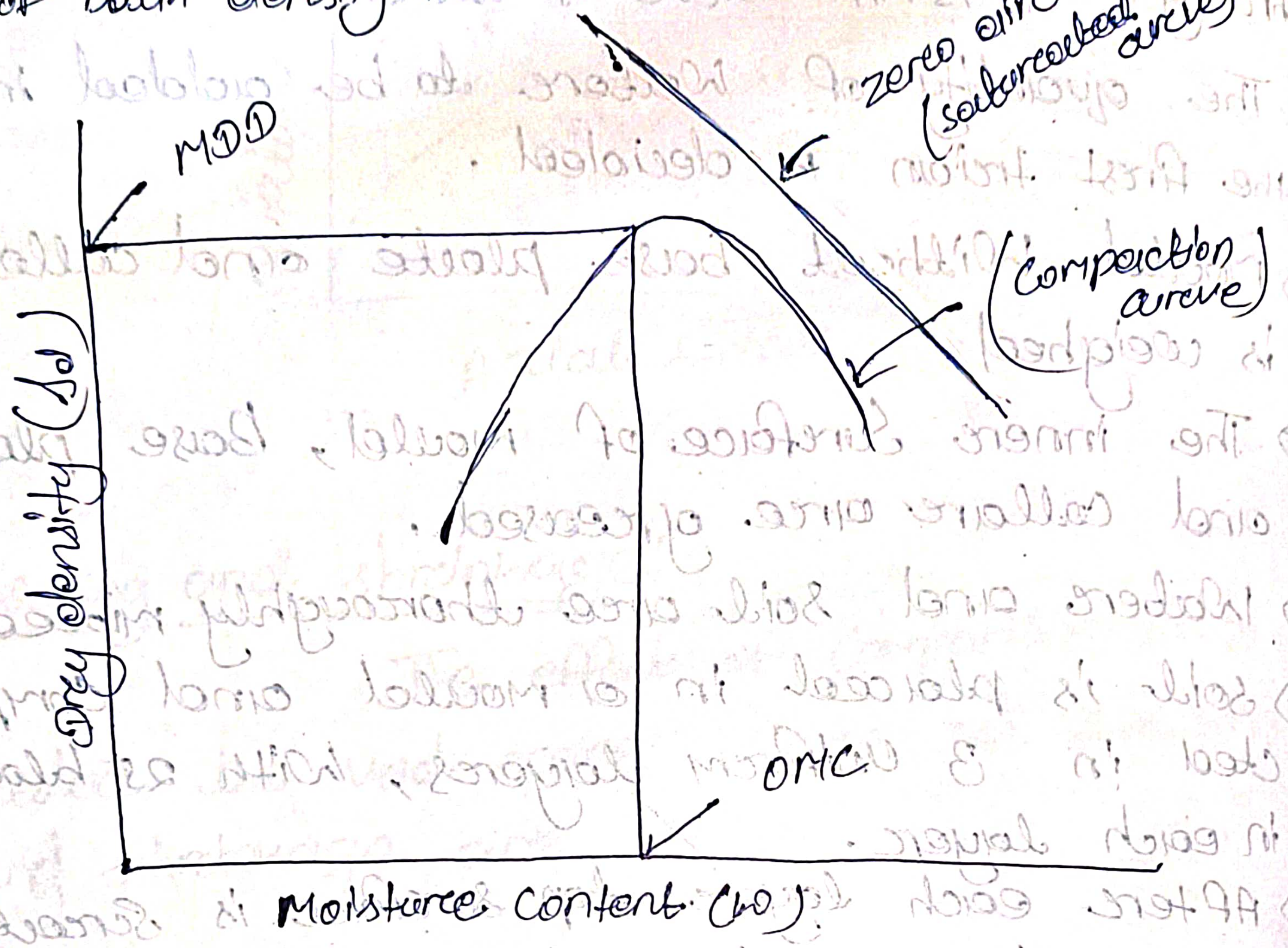
→ collar of 50 mm effective height Rammer of weight 2.5 kgf (25 N) with a height fall of 304.8 mm

procedure

About 3 kg of dry soil passing through 4.75mm sieve is taken.

- The quantity of water to be added in the first trial is decided.
- Mould without base plate and collar is weighed
- The inner surface of mould, Base plate and collar are greased.
- Water and soil are thoroughly mixed.
- soil is placed in a mould and compacted in 3 uniform layers, with 25 blows in each layer.
- After each layer top surface is scratched to maintain integrity of layers.
- The height of top layer is so controlled that after compaction soil slightly attach in to collar.
- excess soil is scrapped
- Mould and soil are weighed (W)
- A representing sample from the middle is kept for the determination of water content
- The procedure is repeated with increasing water content

→ The number of trials should be atleast 6 with a fall after the decreasing of bulk density.



Zero aire void line:-

A line which shows the water content and dry density relation for the compacted soil containing a constant percentage air voids is known as zero air void line.

→ It can be established from the following relation.

$$\gamma_d = \frac{(1-n_a)\,G\gamma_w}{1+wG}$$

→ The bulk density (ρ) and the corresponding dry density (ρ_d) for the compacted soil are calculate from the following relation.

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

Modified compaction test

In early days compaction archeived in field was releatively less

→ With improvement in knowledge and technology higher compaction become a necessity in field.

→ Modified compaction procedure was developed during world war.

Difference between standard and modified compaction

Standard procedure test	Modified procedure test
(i) 305 mm height of drop	(i) 450 mm height of drop.
(ii) 25 N hammer	(ii) 45 N hammer.
(iii) 25 blows / layer	(iii) 25 blows per / layer.
(iv) 3 layer	(iv) 5 layer.
(v) Mould size = 945 ml	(v) Mould size = 945 ml
(vi) Energy 5160 N - mm / m3	(vi) Energy 2726000 N - mm / m3

Compactive energy

$$\frac{\left(\text{n/o of blocws per layers}\right) \times \left(\text{n/o of layer}\right) \times \left(\text{weight of hammer}\right) \times \left(\text{Height of drop of hammer}\right)}{\text{Volume of mould}}$$

Field compaction Method:-

Mainly the compacting improvement are classified into 3 catagories:-

(i) Rollers
(ii) Rammer
(iii) Vibrators.

-> Rollers are five types.

Consolidation

Consolidation is the process in which reduction in volume taken place by the gradual expulsion or absorevation of water under long term static loads.

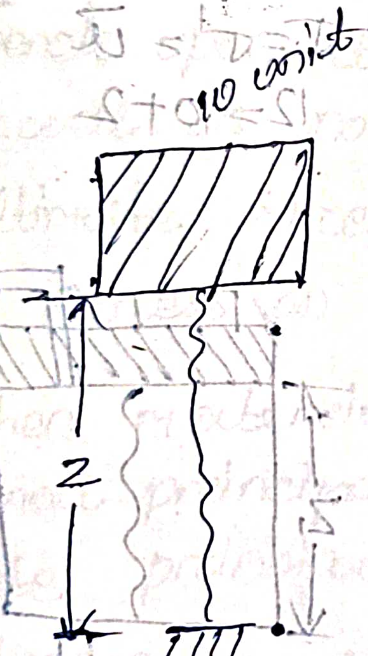
Compaction	Consolidation
(i) compaction is the process when mechanical pressure is use to compressed to soil mass	(i) Consolidation is a process steadi and static pressure causes compression of saturated soil
(ii) Dynamic load by rapid mechanical method like tamping, rolling and vibrate are	(ii) Starting and loading is applied for long interevation soil consolidation
(iii) In compaction process soil volume is reduce by reemoving are void from saturated and drey soil.	(iii) In consolidation process soil volume is reduced by squeezing out pore water from saturated soil.
(iv) Compaction	(iv) consolidation of soil is used for clayeb soil.
(v) It is intentionaly done.	(v) It is a natural process

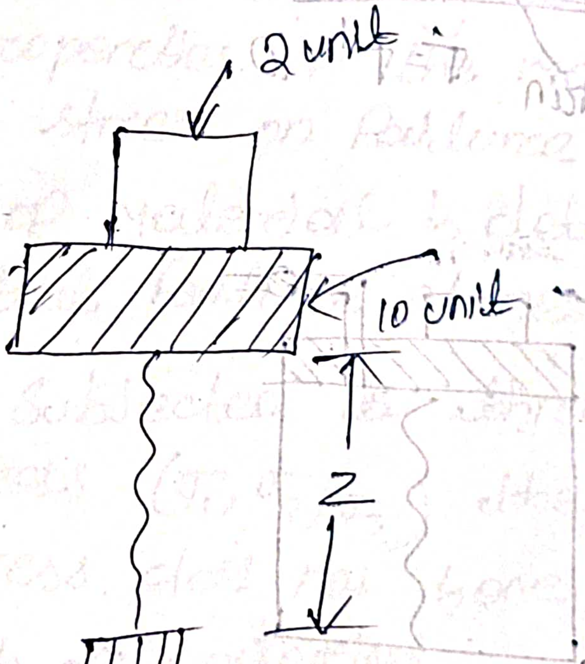
Terezaghi's Spring analogy

The mechanics of consolidation was demonstrated by Terzaghi's with the help of a piston and spring arrangement.

→ A spring with a piston on his top be considere.

→ Let the length be ('z' not) z_0, when 12 unit pressure is applied the spring got deforms. (the length is decreased)





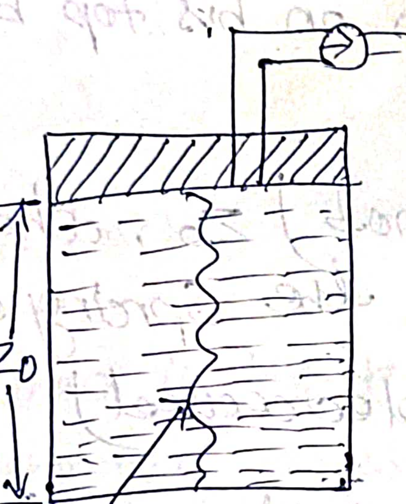
→ now consider the case that ~~both~~ whole system of spring and piston placed in a cylinder full of water.

→ now Increase the pressure and valb is closed then there will no deformation in the spring

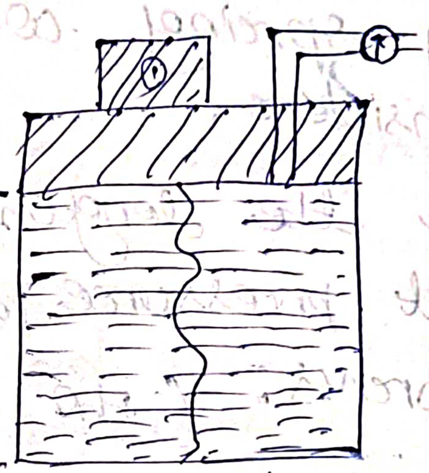
→ now loses the valb then we will observe the spring will be deform

→ The analogy can be applied to consolidation process of the soil mass. The grains can be considered as the spring.

→ Voids filled with water represent the cylinder.

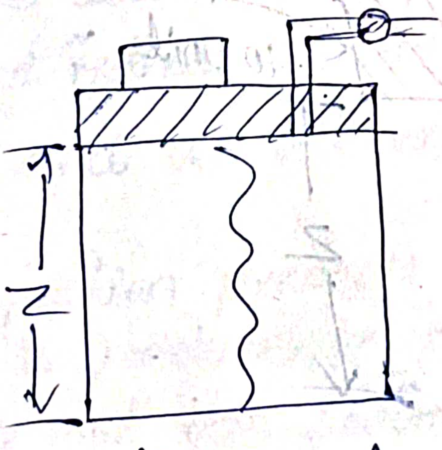


Spring $\sigma = \sigma' = 10$

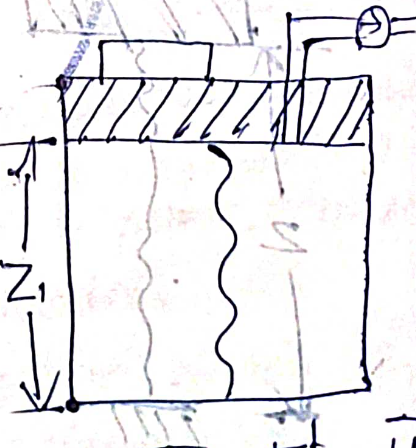


$\sigma = \sigma' = \bar{u}$

$12 = 10 + 2$



$12 = 10 + \Delta\sigma' + 2 - \Delta\sigma'$



$\sigma = \sigma' = \bar{u}$

$= 10 + 0$

Sheare strength

The sheare streength of soil is the resistanc deformation by continuous sheare deplacement of soil particle ore on masses upon the action of a sheare stress.

Mohre's Coulomb failure Theory :-

→ Materials fails essentially by sheare.

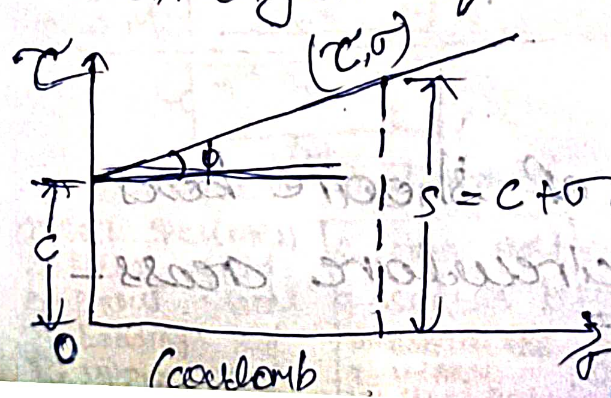
→ The critical sheare stress causing failure depends upon the properties of the material as well as normal stress on failure plain.

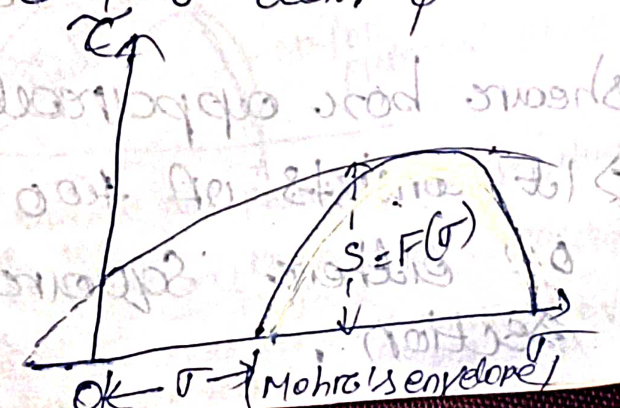
→ Ultimate streength of material is determined by stress on potential failure plane.

→ When material is subjected to three dimensional principal stress ($\sigma_1, \sigma_2, \sigma_3$) the intermediate principal stress does not have any influence on strength of material.

$$\tau_f = F(\sigma) = s$$

strength equation $(s) = c + \sigma \tan \phi$





$\tau_f = S =$ sheare stress on failure plane

$F(\sigma)$ = function of normal stress.

c = empirical constant.

ϕ = Angle of internal friction.

Measurement of sheare strength

The measurement of sheare strength of soil involves the certain test observations at failure with the help of strength envelope.

→ shearing resistance can be determined by following four methods in the laboratory.

1. Direct sheare test
2. Triaxial sheare test
3. Unconfined compression test
4. Vane sheare test

① Direct sheare test

The test is performed by sheare box apparatus.

→ It consists of two pieces of sheare box of either square or circular cross-section.

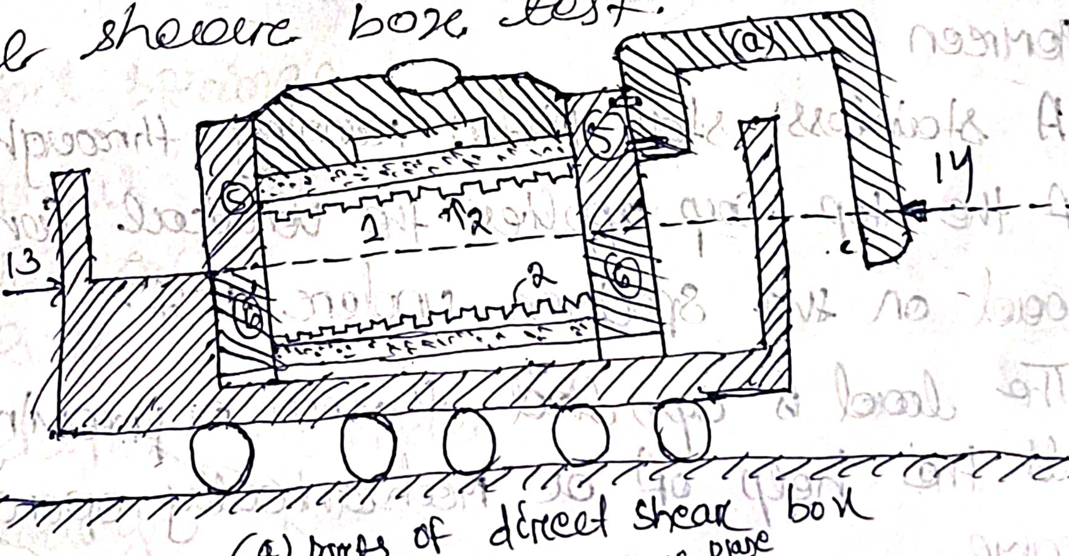
→ Lower half of box is rigidly held in position in a container which rest over roller and which can be pushed forward by geared jack.

→ Upper half But against a proving ring. Joint between two parts of box is at the double of centre of specimen.

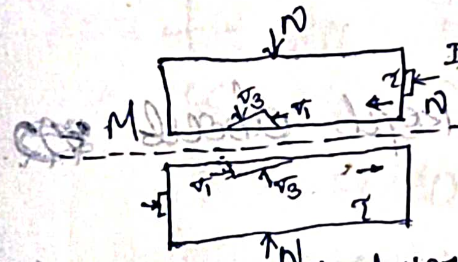
→ normal load is applying from loading yoke bearing upon steel ball of pressure pad.

→ shearing force applied to lower box by geared jack. The deformation of proving ring indicates the shearing force.

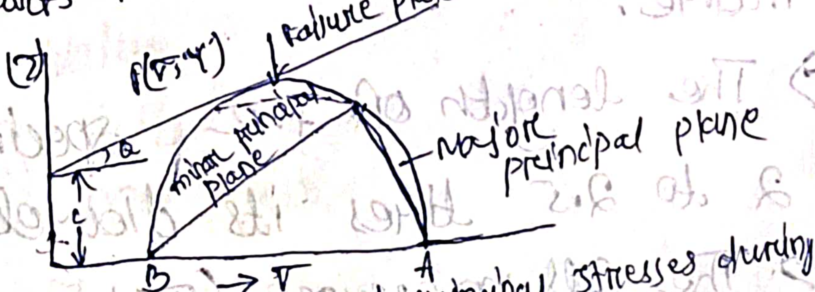
→ This type of test is called strain controlled shear box test.



(a) parts of direct shear box



(b) Principle of direct shear box



(c) Mohr's envelope and principal stresses during the test

1- soil specimen
2- Metal grid
3- porous stones
4- Loading pad
5- upper part
6- Lower part
7- screws to fix two halves of shear box
8- container for shear box
9- U-ARM
10- steel Bal
11- Loading yoke
12- Rovers
13- shear force applied by jack
14- shear resistance measured by proving ring.
(shear box test)

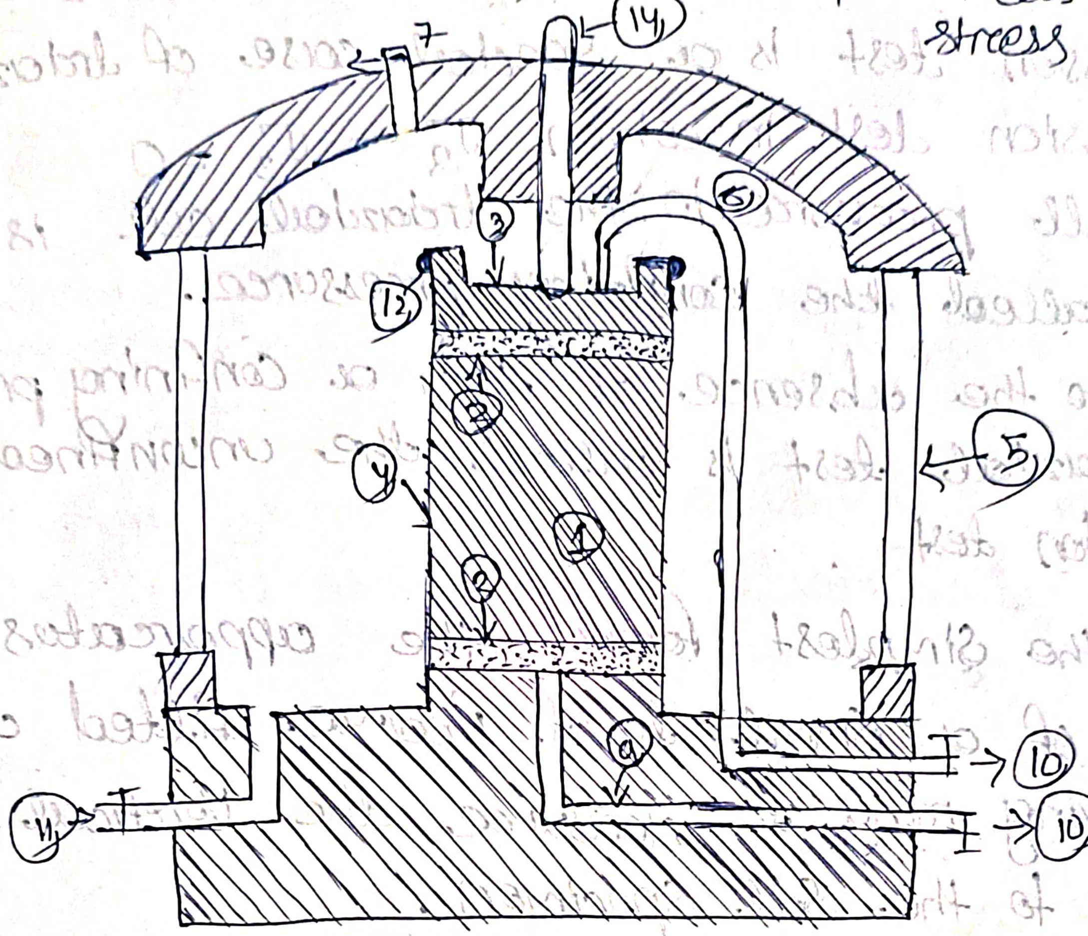
Treiaxial Compression / sheare stress

Treiaxial stress on specimens of cohesion less soil can be conducted using the procedure fore cohessive soil.

- The test equipment specially consists of a high pressure cylindrical cell are athere transparent material Atteol between the base and top cap.
- Three outlet connections are generally preavided through the base.
- A separate compressor is used to apply fluid pressure in the sale.
- The cylindrical specimen is enclosed in a rubber Memreen.
- A stainless steal piston running through the center of the top cap applies the vertical compressive load on the specimen undere test.
- The load is applied through a proving reing, with the help of a mechanically operated load freame.
- The length of the specimen is kept about 2 to 2.5 times its diameter
- The cell pressure ($\sigma_3 = \sigma_2$) acts all around the specimen.

The verticall stress $= \sigma_1 - \sigma_3$

Total stress $= (\sigma_1 - \sigma_3) + \sigma_3 = \sigma_1$ = measure principal stress



(The Triaxial cell)

1- Soil specimen
2- Porous Disc
3- Top cap
4- Rubber membrane
5- Perspex cylinder
6- Loading RAM
7- Air release value
8- Top Drainage tube
9- Bottom drainage tube
10- Connections for drainage or pore pressure measurement
11- Cell fluid inlet
12- Rubber rings
13- Sealing ring
14- axial load through

Unconfined Compression test :-

The unconfined compression test is a special case of triaxial compression test in which $\sigma_2 = \sigma_3 = 0$

→ The cell pressure in the triaxial cell is also ~~cale~~ called the confining pressure.

→ Due to the absence of such a confining pressure the uniaxial test is called the unconfined compression test.

→ It is the simplest form, the apparatus consists of a small load frame fitted with a proving ring to measure the vertical stress applied to the soil specimen.

→ The deformation of the sample is measure with the help of a separate by goes.

→ The ends of the cylindrical specimen are hollowed in the form of cone.

→ During the test, load verses deformation readings are taken and a graph is plotted.

→ In such a case, the load corresponding to 20% strain is arbitrarily taken as failure load.

Vane sheare test

→ Vane sheare test is a quick test used in the labreatorey ore in the field, to determine the undreained sheare streength of cohessive ~~test~~ soil.

→ The vane sheare testere is consists of foure thin steel plates, called Vanes, weldeal orethogonally to a steel reod.

→ A ~~torek~~ toreque measureing arrerangement, such as a calipreated torsion spreing is attached to the reod.

→ The reatation of the vanesheare the soil along a cylindrical surface.

→ The reatation of the spreing in degrees in indicated by a pointed moving on a greaduated dreying attached to the wheel shaft.

→ The torque (T) is calculated by multiplying the diel reading with the spreing constant.

Earth pressure on retaining structures

A retaining wall are retaining structures is used for maintaining the ground surface at different elevations on either side of it.

→ The material retain are supported by the structure is called back fill.

Types of earth pressure :-

The lateral earth pressure may be of three types

1. Active earth pressure.
2. passive earth pressure.
3. pressure at rest

Active earth pressure :-

→ Due to excessive pressure of the retained soil the retaining wall tends to move away from the back fill.

→ The certain person of back fill located immediately behind the retaining wall gets separated from the soil mass results the pressure on retaining decreases.

→ The wedged shaped portion of the backfill tending to move with the wall called failure wedge.

→ The minimum pressure exerted by the soil on the retaining wall called Active earth pressure.

passive earth pressure:-

→ When the wall moves toward the backfill there is an increase in the pressure on the wall.

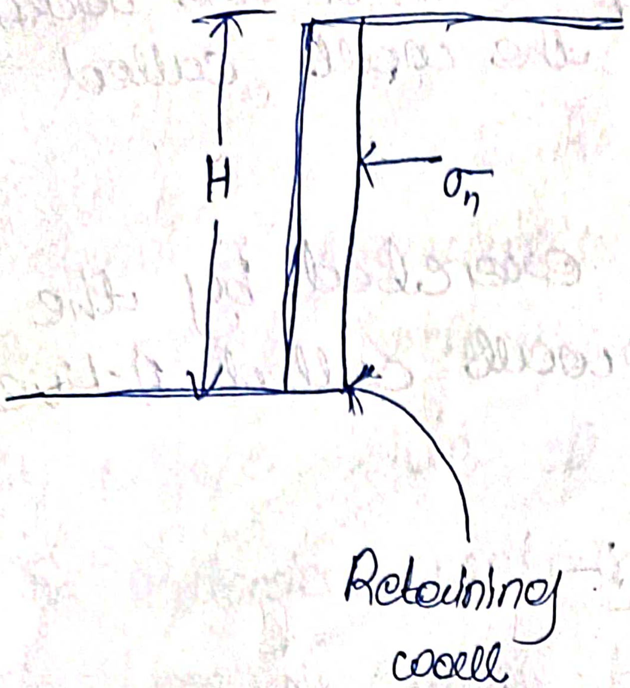
→ The increase continues until a maximum value has reached after which there is no increase in the pressure and the value will become const.

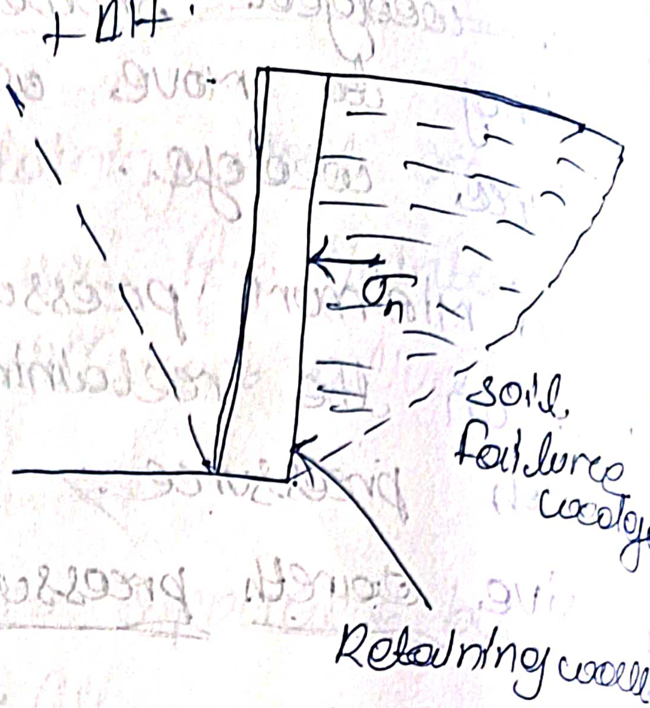
→ This kind of pressure is called passive earth pressure.

pressure at rest

→ When the wall is at rest and material in its natural state. Then the ~~process~~ pressure applied by material is known as earth pressure at rest

→ It is represented by P_0



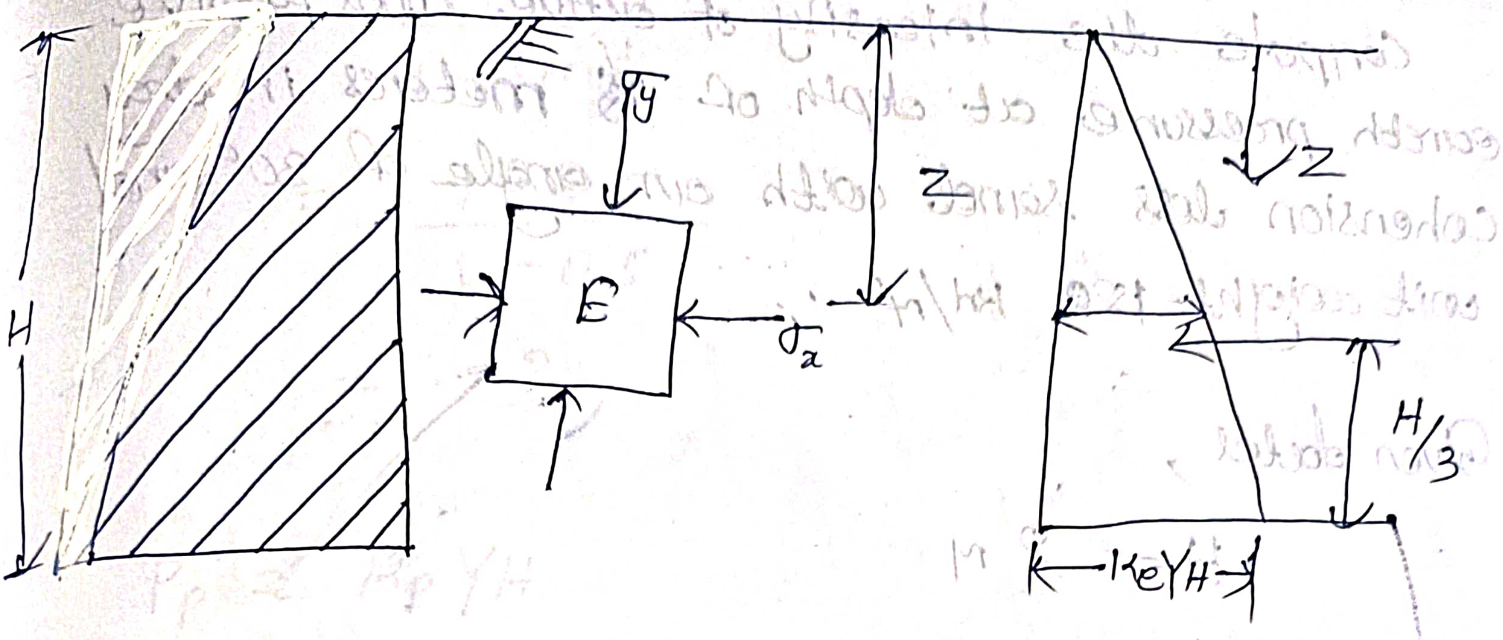


Rankine's earth pressure theory:-

(i) Rankine's theory assumed that there is no wall friction then $(\delta = 0)$

(ii) The ground and failure surface are straight planes & that the resultant force acts parallel to the backfill slope.

(iii) In case of retaining structure the earth retained may be filled up the eareth in natural soil.



Active eareth pressuree:-

$$P_a = K_a \gamma H$$

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

passive eareth preissuree:-

$$P_p = K_p \gamma H$$

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

preessuree at reest:-

$$P_0 = K_0 \gamma H$$

$$K_0 = 1 - \sin\phi$$

problem

Compute the intensity of active and passive earth pressure at depth of 8 meters in dry cohension less sand with an angle of 30° and unit weight 18 kN/m³.

Given data,

$H = 8\ m$

$\phi = 30^\circ$

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

Active earth pressure

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

$$= \frac{1 - \sin 30^\circ}{1 + \sin 30^\circ}$$

$$= \frac{1 - 0.5}{1 + 0.5}$$

$$= 0.33$$

$$P_a = K_a \gamma H$$

$$= 0.33 \times 180 \times 8$$

$$= 47.52\ kg/m^2.$$

passive earth pressure

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

$$= \frac{1+0.5}{1-0.5}$$

$$= 3$$

$$P_p = K_p \gamma H$$

$$= 3 \times 18 \times 8$$

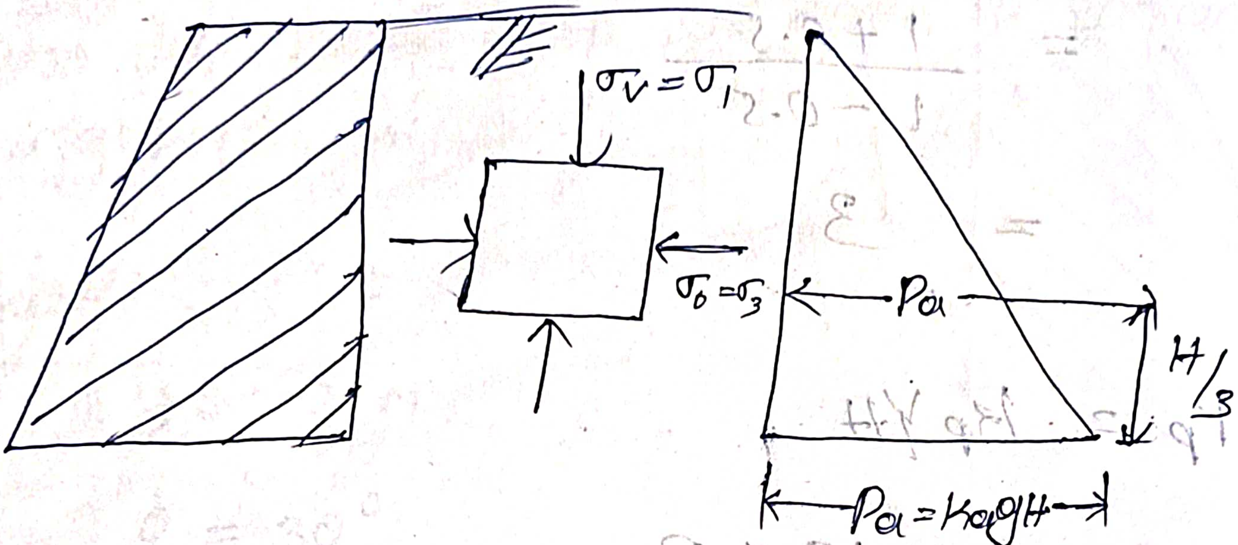
$$= 432 \text{ kN/m}^2$$

Rankine's Formula for back fill with no surcharge and backfill with uniform surcharge

Rankine's assumptions

1. Soil mass is semi infinite, Homogenious and cohension less
- → ground surface is plane may be horizontal or inclined.
- → Back is vertical and smooth.

Drey ore moist backfill with no Surechairege :-



$$\sigma_1 = \sigma_3 \tan^2\left(45^\circ + \frac{\phi}{2}\right)$$

$$\frac{\sigma_3}{\sigma_1} = \frac{\sigma_h}{\sigma_v} = \frac{1}{\tan^2\left(45^\circ + \frac{\phi}{2}\right)}$$

$$= \cot^2\left(45^\circ + \frac{\phi}{2}\right)$$

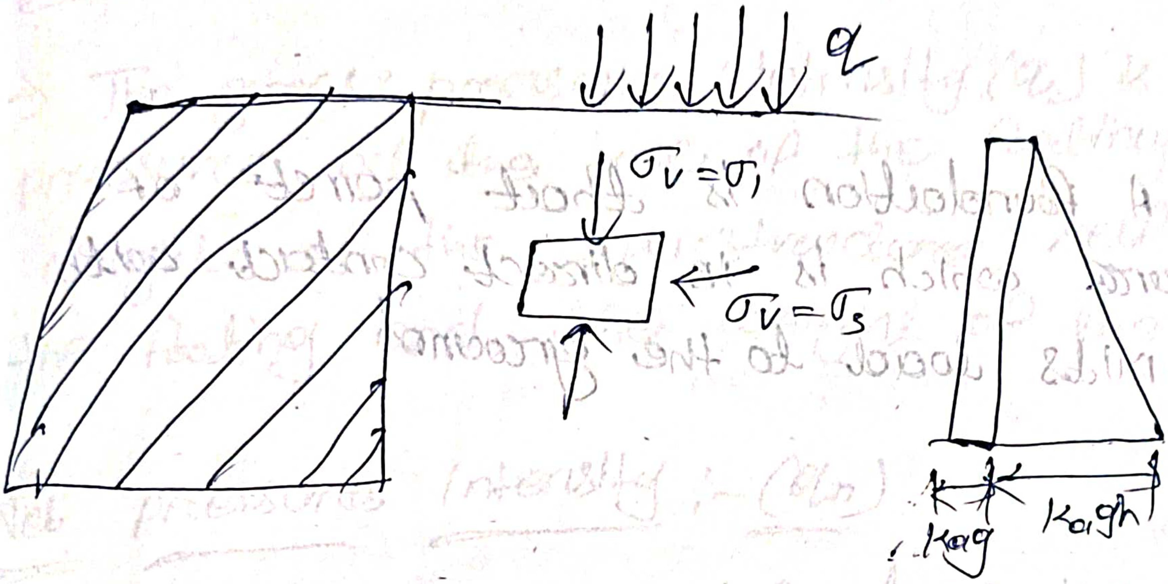
$$\boxed{K_a = \frac{1 - \sin\phi}{1 + \sin\phi}}$$

$$P_a = gz \cot^2\left(45 + \frac{\phi}{2}\right) = K_a g \times z$$ (active earth pressure at a depth)

Total earth pressure

$$P_a = \frac{1}{2} K_a g H^2$$ active $gH/3$ above the base of wall.

Backfill with uniform charge :-



$$P_a = K_a \gamma z = K_a q$$

$$K_a \gamma z = K_a q.$$

$$z_e = \frac{q}{\gamma}.$$

Height equivalent to uniform intensity of surcharge.

Foundation:-

A foundation is that part of the structure which is in direct contact with and transmits load to the ground

Footing:-

A footing is the person of the foundation of a structure that transmits load direct to the soil.

Foundation soil:-

Bearing capacity:-

-> The supporting power of a soil or rock is refer to as its bearing capacity.

-> The term bearing capacity is also defined as vertical pressure that can be applied to

Gross pressure Intensity (q) :-

→ The gross pressure intensity (q) is the total pressure at the base of the footing due to weight of the superstructure, self weight of the footing and the weight of the earth fill.

Net pressure Intensity :- (q_n)

It is defined as the excess pressure or the difference in intensities of the gross pressure after the construction of the structure and the original over burden pressure.

→ If ~~capital~~ 'D' is the depth of the footing then $q_n = q - \gamma D$

γ is the unit weight of the soil above the foundation base.

→ ~~Ultimate bearing~~

Ultimate bearing capasity.

→ the ultimate bearing capacity is defined as the minimum gross pressure intensity at the base of the foundations at which the soil fails in shear.

→ The ultimate bearing

Net ultimate bearing capacity

→ It is the minimum net pressure intensity causing shear failure of the soil

→ The ultimate bearing capacity and the net ultimate ~~bearing bear~~ capacity are connected. For net ultimate bearing capacity:

$$q_{nf} = q_f - \bar{\sigma}$$

when $\bar{\sigma}$ = effective surcharge at the base lable of the foundation.

Safe bearing capacity :-

The maximum pressure which the soil can carry safely without risk of shear failure is called the safe bearing capacity.

→ It is equal to the net safe bearing capacity plus original over burden pressure.

$$q_s = q_{ns} + \gamma D$$

$$q_s = \frac{q_{nf}}{F} + \gamma D$$

→ It is equal to the ultimate bearing capacity

$$\frac{q_f}{\text{factor of safety}(F)}$$

Allowable bearing capasity (q_a)

It is the net loading Intensity at which neither the soil fails in sheare nore there is excessive settlement the structure.

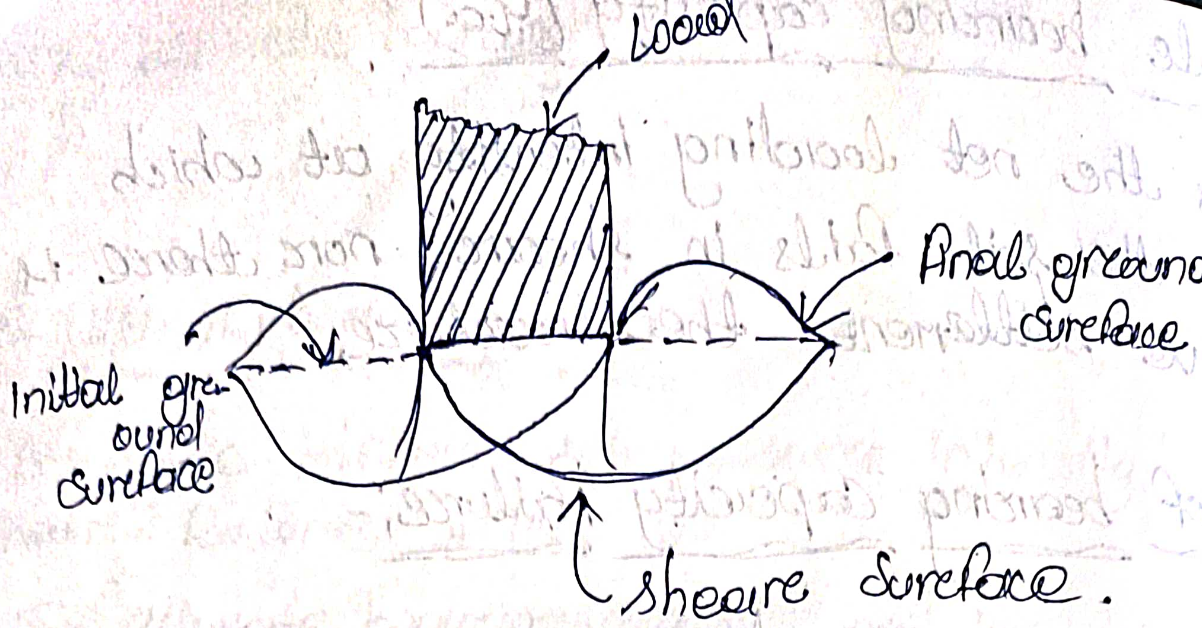
Types of bearing capacity Failure:-

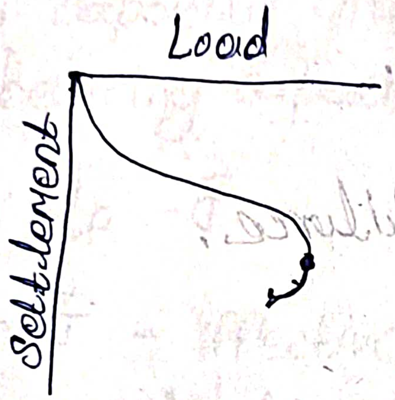
There are 3 modes.

(i) General failure.
(ii) Local failure.
(iii) punching sheare failure.

General failure:-

→ There is a continuous sheare failure of the soil from below the footing to the ground surface.
→ A general sheare failure ruptures & Pushes of the soil on both side of the footing.
→ For actual failures in the field the soil often pushed up on only one side of the footing with subsequent tilting of the structure.
→ A general sheare failure occurs for soil that are dense & hard state.



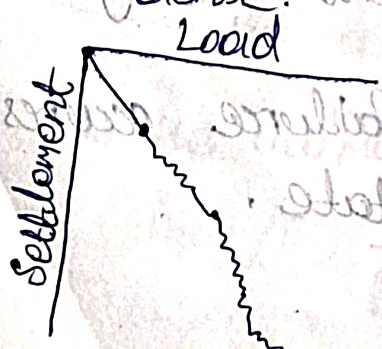


Local sheare failure

→ Local sheare failure involves rupturee of the soil only immediately below the footing.

→ Local sheare failure can be considered as a transitional phase between general sheare & punching sheare.

→ A local sheare failure occures for soils that are in a medium dense.



punching sheare failure!-

-> A punching sheare failure does not developed the distinct sheare surface associated with a general sheare failure.