Sub- Geotechnical Engineering

Sem. 3rd sem

Branch - Civil

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Lecture in Civil

(1) What is geotech Engineering or soil mechanics.?

It is one of the youngest despline of civil engg. involving the study of soil, it's behaviour & application as an engg material.

(2) What is soil

To an engg. soil is the aggregate un aggregate or cemented un-cemented deposites of mineral an organic paticles covering large portion of the earth curst.

→ It includes diff material boulder stands, gravel, clay & silts & the range in the particle sizes in a soil may extend from grain only a fraction of micron in diameter upto large size boulder.

(3) Origine / formation soil

(i) The formation of soil is as a result of the geological cycle continually taking place on the face of the earth.

(ii) The cycle consists of weatherin

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transportation & deposition.

(iii) physical weathering is caused by Periodical temprature changess, impacts & splitting action of flowing water, ice, wind & Plants etc.

(iv) chemical weathering is caused due to oxidation, hydration, carbonation & leaching by organic acids & water.

(v) The soil which is due weathering may be residual or transported.

(vi) Residual soil are those which remain in place over the parent rock & transported soil are those which are transported by agency such as water, wind, ice & gravity.

(vii) Water formed transported soils are termed as alluvial, marine, lacustrine.

* Alluvial soil is formed by transporting soil through running water.

* Marine soil is formed deposite as the bottom of C

* Lacustrine soil is formed depositeing

at the bottom lack.

viii) Soil formed due to transported by wind each aeoline soil or loess

(ix) Soil formed due to transported by ice or glassier is drift.

(x) Soil formed due to transported by gravity is calluvial soil or talus.

(xi) Soil formed due to deposition of decaying vegetable material, plance under excesiv; moisture is called cumulose soil such as peat or marck.

USE OF GEOTECH OR SOIL MECHANICS

Soil mechanics is for an engineering

(i) Foundation design & constraction.

(ii) Pavement design.

(iii) Design under ground stracture & earth retaining structure.

(iv) Design of Pavement embankments & excavation

(v) Design of damp.

imp Soil as a three phase system

(i) A soil is a three phase system consisting of soild particles (soil grains), water & air.

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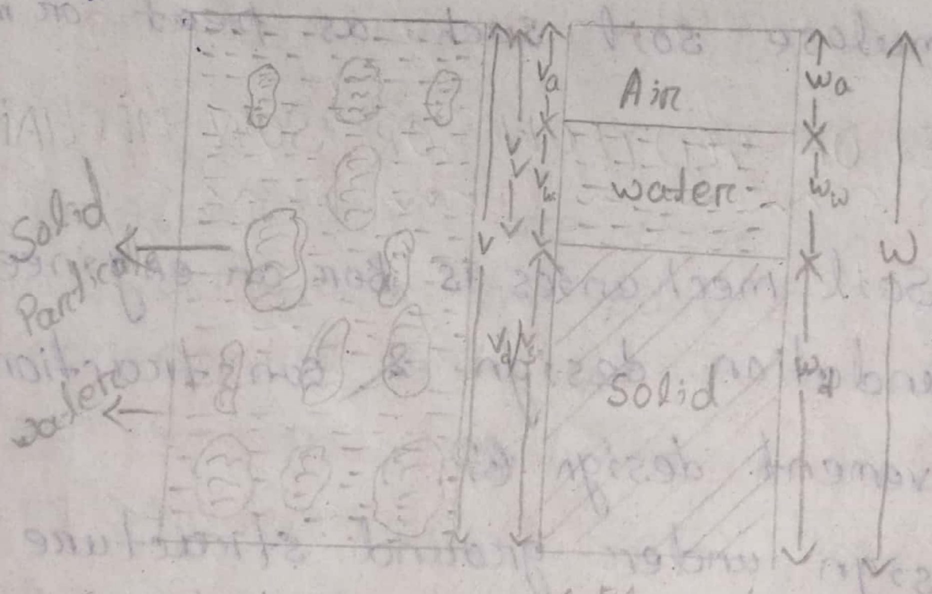
(ii) In general the soil mass has three constituents which don't ~~occupye~~ occupy separat spacess but are blended together forming a complex material but for calculation purpose it is always more easy two show these constituents occupying separet spacess.

Fig



(Element of Natural Soil) (Element of separate into three phases)

V = Total valume of Soil mass

V_a = Valume of air

V_w = Valume of water

V_s = Valume of Solid

W = Total weight of soil mass

W_a = weight of air

W_w = weight of water

W_d = weight of solid

V_v = Volume of void

* The void space between the solid Particles or soil grains is filled Partly with water & Partly with air.

* If the voids are filled with air only then the soil mass is taken as dry soil mass.

* If the voids are complitly filled with water them the soil mass is taken as saturated soil.

$W = W_a + W_w + W_d$

(If $W_a = 0$)

$W = W_d + W_w$

weight of saturated soil $= W_d + W_w$

Volume of saturated soil $= V_w + V_d$

If $W_w = 0$

Weight of dry soil $= W_d + W_a$

Volume of dry soil $= V_d + V_a$

In case of negligible air content

Weight of dry soil $= W_d$

Volume of dry soil = V_d

Water content

The water content or moisture content

It is defind as the ratio of weight of water to weight of soil solids in a given mass of soil.

(ii) It is denoted by (w)

$$w = \frac{W_w}{W_d} \times 100$$

(iii) It is generally expresed as Persentge

Density of soil

Density of soil is defind as the mass of soil per unit volume

(a) bulk density

The bulk density or moist density is defind as the total mass of the soil per its total volume

(i) $\rho = \frac{M}{V}$

ρ = density

M = mass of soil

V = volume " "

It is expresed in kg/m^3

Dry density

It is defind as the mass of soilds / total valume. of the solid mass.

(ii) $\rho_d = \frac{M_d}{V}$

Density of solid

It is defind as the mass of soil solids / valume of solids.

(ii) $\rho_s = \frac{M_d}{V_d}$

Saturated density

When the soil is saturated. it's bulk density is called saturated density.

Hence, saturated density is the ratio of total soil mass ~~with dot~~ to it's total valume.

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

Submerged density

Submerged density is defind as the " mass of soil solid

~~unit~~ of total volume.

$$\rho' = \frac{(M_d)_{sub}}{V}$$

* $$\boxed{\rho' = \rho_{sat} - \rho_w}$$

ρ' = Submerged density

ρ_{sat} = Saturated "

ρ_w = water density

Unit weight ~~soil~~ soil

It unit weight is defined as weaight / volume.

bulk unit weight

It is the total weight of a soil / it's total volume.

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

dry unit weight

It is the weight of solid / total volume.

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

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Unit weight of solids

It is the weight of soil solids / volume of solids.

$$\gamma_s = \frac{W_d}{V_s \text{ or } V_d}$$

Saturated unit weight

It is the ratio of total weight of a saturated soil to it's total volume.

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

Submerged unit weight

It is the submerged weight of soil solids / total volume.

$$\gamma' = \frac{(W_d)_{sub}}{V}$$

* $\gamma' = \gamma_{sat} - \gamma_w$
* Density of water $\rho_w = 1 gm/cm^3$
* unit weight of water $(\gamma_w) = 9.81 \, KN/m^3$

Specific gravity

Specific gravity is defind as the ratio of unit weight of a given volume solids to the unit weight of water at a given temperature

or,

Specific gravity is defind as the ratio of the density of soil solid to the density of water at a given temperature.

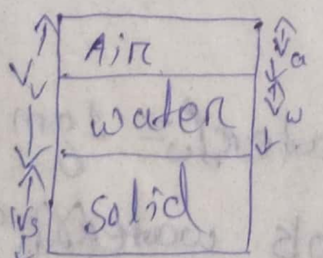
→ It is denoted as 'G'

$$G = \frac{\gamma_s}{\gamma_w} \text{ or } G = \frac{\rho_s}{\rho_w}.$$

Voids ratio

It is defind as the ratio of volume of voids to the volume of soil solids.

It is denoted is $e = \frac{V_v}{V_s}$



V_v = volume of voids

V_s = " " soil solids

Porosity

It is defind as the ratio the of volume of void to the total volume of soil mass.

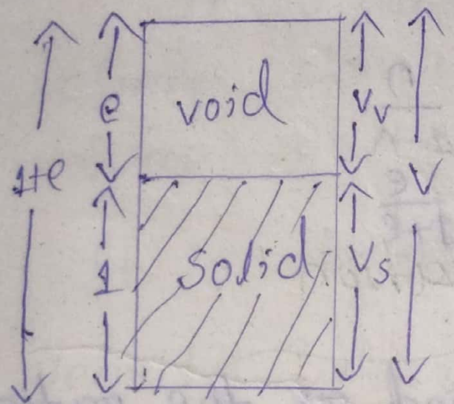
→ It is denoted by 'n' $= \frac{V_v}{V}$

where,

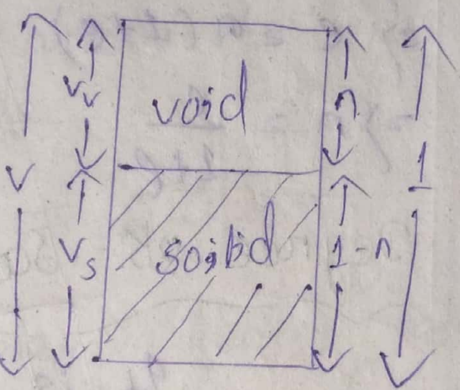
V_v = Volume of void

V = Total volume of soil mass

Relationship bet^n voids ratio & Porosity



(Soil element in term of 'e')



(Soil element in terms of 'n')

$V_v = e$

$V_s = 1$

$V = 1+e$

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

$\Rightarrow e = \frac{n}{1-n}$ — (i)

$V = 1$

$V_v = n$

$V_s = 1-n$

$$n = \frac{V_v}{V}$$

$$\Rightarrow \boxed{n = \frac{e}{1+e}} \quad \text{— (ii)}$$

Combining equ (i) & (ii)

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

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

$$\Rightarrow e(1-n) = n$$

$$\Rightarrow e - en = n$$

$$\Rightarrow e = n + en$$

$$\Rightarrow e = n(1+e)$$

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

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

Degree of Saturation

It is defind as the ratio of the volume water Present in a Soil mass to the volume of voids.

→ It is denoted as $(S) = \frac{V_w}{V_v}$

* For saturated soil the degree of saturection is ~~warm~~ one.

$$S = \frac{V_w}{V_v} = \frac{V_v}{V_v} = 1 \quad (\because V_v = V_w)$$

** For dry soil the degree of saturation is '0'.

$$S = \frac{0}{V_v} \quad (\because V_w = 0)$$

$\Rightarrow S = 0$

% of air voids

It is defind as the ratio of volume of air voids to the volume of soil mass.

It denoted as $n_a = \frac{V_a}{V} \times 100$

It is expresed as %.

Air content

It is defind as the ratio of volume of air voids to the volume of voids.

→ It is denoted as $a_c = \frac{V_a}{V_v}$

Density Index or Relative density or degree of density

It is defind as the ratio of the difference bet^n the voids ratio of the soil in it's loosest state (e_{max}) & it's natural voids ratio (e) to the difference bet^n the voids ratio in the loosest state & densest state (e_{min})

→ It is denoted as I_D

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

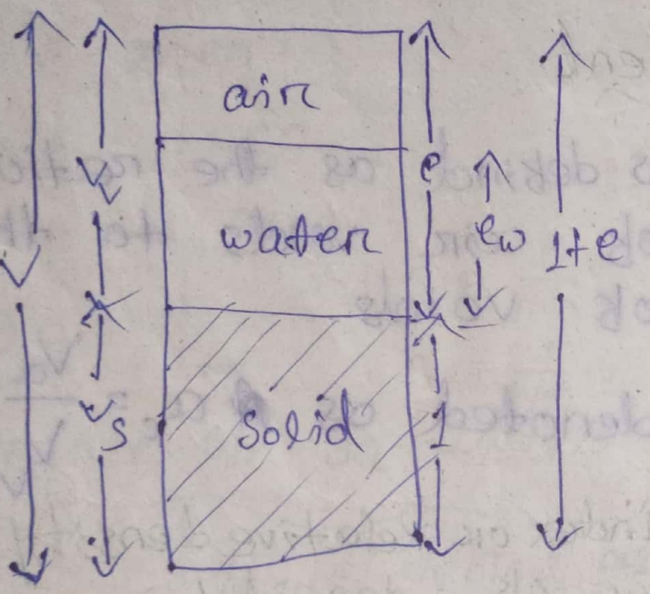
Relationship bet^n e, w, G & S

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

w = water content = $\frac{W_w}{W_d}$

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

S = Degree of saturation = $\frac{V_w}{V_v}$



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

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

$$\Rightarrow \boxed{e_w = Se} \quad \text{--- (i)}$$

Let the soil mass is fully saturated :-

then $V_v = V_w$

$\Rightarrow e = e_w$

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

$\gamma_w = \frac{W_w}{V_w}$

$\Rightarrow \gamma_w = \frac{W_w}{e_w}$

$\Rightarrow W_w = \gamma_w e_w$

$\gamma_s = \frac{W_d}{V_s}$

$\Rightarrow W_d = \gamma_s V_s$

$\boxed{\Rightarrow W_d = \gamma_s \times 1}$

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

$\boxed{\Rightarrow \gamma_s = G\gamma_w}$

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

$\Rightarrow w = \frac{\gamma_w e_w}{\gamma_s}$

$\Rightarrow w = \frac{\gamma_w e_w}{G\gamma_w}$

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

$\Rightarrow \boxed{e_w = wG}$ — (ii)

imp

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

$\boxed{\gamma_w = \frac{W_w}{V_w}}$

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

$\gamma_s = \frac{W_d}{V_s}$

Combaining equ (i) & (ii)

$$Se = wG$$

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

Relation bet "γ_d", 'G' & 'e' or 'n' →

γ_d = dry unit weight of soil = $\frac{W_d}{V}$

G = Specific gravity of soil = $\frac{\gamma_s}{\gamma_w}$

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

n = Porosity = $\frac{V_v}{V}$

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

~~$(W_d = \gamma_s \times V_s)$~~

$$\left(\gamma_d = \frac{W_d}{V_s}\right)$$

$$(W_d = \gamma_s \times V_s)$$

$$\Rightarrow \gamma_d = \frac{\gamma_s \times V_s}{V}$$

$$\Rightarrow \gamma_d = \frac{\gamma_s \times 1}{1+e}$$

$$\Rightarrow \gamma_d = \frac{G\gamma_w}{1+e} \quad (\because \gamma_s = G\gamma_w)$$

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

$$\Rightarrow \boxed{e = \frac{G\gamma_w}{\gamma_d} - 1}$$

$\gamma_d = \frac{\gamma_s \times V_s}{V}$

$$\Rightarrow \boxed{\gamma_d = G\gamma_w(1-n)}$$

$\Rightarrow$ ~~$1-n = \frac{G\gamma_w}{\gamma_d}$~~ $1-n = \frac{G\gamma_w}{\gamma_d}$

$\Rightarrow n =$

$\Rightarrow$ Relation bet^n γ_d, γ & w $\rightarrow$

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

(Add 1 in both side)

$\Rightarrow 1+w = \frac{W_w}{W_d} + 1$

$\Rightarrow 1+w = \frac{W_w + W_d}{W_d}$

$\Rightarrow 1+w = \frac{W}{W_d}$

$$\Rightarrow \boxed{W_d = \frac{W}{1+w}}$$

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

$$\Rightarrow \gamma_d = \frac{\left(\frac{W}{1+w}\right)}{V}$$

$$\Rightarrow \gamma_d = \frac{W}{V} \times \frac{1}{1+w}$$

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

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

γ_d = dry unit weight

γ = unit weight of soil

w = water content

Relation bet^n γ, G, e & S

γ = unit weight of soil $= \frac{W}{V}$

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

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

S = degree of Saturation $= \frac{V_w}{V_v}$

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

$$\Rightarrow \gamma = \frac{W_w + W_d}{V}$$

$$\Rightarrow \gamma = \frac{\gamma_w V_w + \gamma_s V_s}{V}$$

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

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

$$\Rightarrow \boxed{\gamma = \frac{\gamma_w (G+eS)}{1+e}}$$

If the soil sample is fully Saturated

$$\gamma_{sat} = \frac{\gamma_w (G+e\times 1)}{1+e}$$

$$\Rightarrow \boxed{\gamma_{sat} = \frac{\gamma_w (G+e)}{1+e}}$$

Reletion

- $\rightarrow e_w = Se$
- $\rightarrow W_d = G\gamma_w \times 1$
- $\rightarrow \gamma_s = $ ~~1x+γ_w~~ $G\gamma_w$
- $\rightarrow e_w = wG$
- $\rightarrow Se = wG$
- $\rightarrow \gamma_d = \frac{G\gamma_w}{1+e}$
- $\rightarrow W_d = \frac{W}{1+W}$
- $\rightarrow \gamma_d = \frac{\gamma}{1+w}$

- $\rightarrow \gamma = \frac{\gamma_w (G+eS)}{1+e}$
- $\Rightarrow \gamma_{sat} = \frac{\gamma_w (G+e)}{1+e}$

Formula

(1) Water content (w) = $\frac{W_w}{W_d}$

(2) bulk density (ρ) = $\frac{M}{V}$

(3) dry density (ρ_d) = $\frac{M_d}{V}$

(4) density of solid (ρ_s) = $\frac{M_d}{V_d}$

(5) Saturated density (ρ_{sat}) = $\frac{M}{V}$

(6) Submerged density (ρ') = $\frac{(M_d)_{sub}}{V}$ / $\rho_{sat} - \rho_w$

(7) unit weight of soil (γ) = $\frac{W}{V}$

(8) dry unit weight (γ_d) = $\frac{W_d}{V}$

(9) unit weight of solid (γ_s) = $\frac{W_d}{V_d}$

(10) saturated unit weight = $\gamma_{sat} = \frac{W}{V}$

(11) Submerged unit weight γ' = $\frac{(W_d)_{sub}}{V}$

(12) specific gravity (G) = $\frac{\gamma_s}{\gamma_w}$ / $\frac{\rho_s}{\rho_w}$

(13) voids ratio (e) = $\frac{V_v}{V_s}$

(14) Porosity (n) = $\frac{V_v}{V}$

(15) degree of saturation (S) = $\frac{V_w}{V_v}$ ($V_w = 1$)

(16) % of air voids (n_a) = $\frac{V_a}{V} \times 100$

(17) Air content (a_c) = $\frac{V_a}{V_v}$

(18) $e = \frac{n}{1-n}$ (10)

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

Q:1 A soil sample has a porocity of 40%. the specific gravity of soil 2.7. Calculate

(a) voids ratio ?

(b) dry density ?

(c) Unit weight ?

the soil is fully saturated.

Given data

Sol^n

Porocity (n) = 40% = $\frac{40}{400}$ = 0.4

G = 2.7

S = 1

(a) voids ratio = e = $\frac{n}{1-n}$ = $\frac{0.4}{1-0.4}$ = 0.66

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

$\Rightarrow \gamma_d = \frac{2.7 \times 9.81}{1+0.66} = 15.95\ kN/m^3$

(c) Unit weight $\gamma_{sat} = \frac{\gamma_w(G+e)}{1+e}$

$= \frac{9.81(2.7+0.66)}{1+0.66}$

$= 19.85\ kN/m^3$

Q:2 An ondistrube sample on soil has a valeme of 100 c.m³. & mass of 190 gm. on oven draying form 24 hour the mass is reduced to 160 gm. If the specific gravity of soil is 2.68 determind the water content, voids ratio & degree of saturation of the soil.

Given data

Solⁿ

$V = 100\ cm^3$

$M = 190\ gm$

$M_d = 160\ gm$

$M = M_d + M_w$

$M_w = M - M_d$

$\Rightarrow M_w = 190 - 160 = 30\ gm$

$G = 2.68$

$$w = \frac{M_w}{M_d}$$

$$= \frac{30}{160} = 0.187 = 18.7\%$$

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

$\Rightarrow \rho_w = 1 gm/cm^3$

$\rho_d = \frac{M_d}{V} = \frac{160}{100} = 1.6 \ gm/cm^3$

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

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

$\Rightarrow e = \frac{G\rho_w}{\rho_d} - 1$

$\Rightarrow e = \frac{2.68 \times 1}{1.6} - 1$

$\Rightarrow e = 0.675$

$Se = wG$

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

$\Rightarrow S = \frac{0.187 \times 2.68}{0.675}$

$\Rightarrow S = 0.742 = 74.2\%$

Q=3 A soil sample as a volume of 200 cm³ & mass of 380 gm on ovendrying the mass is redused 320 gm if the specifigravity of soil is 2.68 determind the water content voids ratio, degree of saturation.

Given data

Sol: $V = 200\ cm^3$ $G = 2.68$

$M = 380\ gm$

$M_d = 320\ gm$

$M = M_d + M_w$

$\Rightarrow M_w = M - M_d$

$\Rightarrow M_w = 380 - 320 = 60$

$G = 2.68$

$$w = \frac{M_w}{M_d}$$

$$= \frac{60}{320} = 0.18 = 18.7\%$$

$$e = \rho_d = \frac{G\rho_d}{1+e}$$

$\Rightarrow$ ~~$1+e = \frac{G\rho}{\rho_d}$~~ $\rho_w = 1\ gm/cm^3$

$$\rho_d = \frac{M_d}{V} = \frac{320}{200} = 1.6\ gm/cm^3$$

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

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

$$\Rightarrow e = \frac{2.68 \times 1}{1.6} - 1$$

$$\Rightarrow e = 0.675$$

$$Se = wG$$

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

$$\Rightarrow \cancel{S = \frac{9.81 \times 2.68}{0.675}}$$

$$\Rightarrow \cancel{S = 38.94}$$

$$\Rightarrow S = \frac{0.18 \times 2.68}{0.675}$$

$$\Rightarrow S = 0.71 = 71.4\%$$

Q-4 The total unit weight of the soil is 16 kN/m³ the specific gravity of soil is 2.67 the water content 17% calculate

(i) dry unit weight?

(ii) Porocity?

(iii) Voids ratio?

(iv) degree of saturation?

Given data

Sol^n

$\gamma = 16\ kN/m^3$

$G = 2.67$

$w = 17\%$

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

~~$= \frac{16}{1+17} = 0.88$~~

~~$\gamma_d = 0.88$~~

$\gamma_d = \frac{16}{1+0.17} = 13.67\ kN/m^3$

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

$\Rightarrow e = \frac{G\gamma_w}{\gamma_d} - 1$

$$\Rightarrow e = \frac{2.67 \times 9.81}{13.67}$$

$$\Rightarrow e = 0.91 = 91\%$$

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

$$\Rightarrow n = \frac{0.91}{1+0.91}$$

$$\Rightarrow n = 0.47 = 47\%$$

$$e \cdot S = wG$$

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

$$\Rightarrow S = \frac{0.17 \times 2.67}{0.91}$$

$$\Rightarrow 0.49$$

$$\Rightarrow 49\%$$

DETERMINATION OF INDEX PROPERTIES

The properties of soil such as water content, specific gravity, Particle size distribution, consistency limits, density, density-index.

Water content of a soil can be determine by some method:-

(i) Oven drying method
(ii) Pycnometer "
(iii) Sand bath "
(iv) Calcium carbide "
(v) Radiation "
(vi) Alcohol "

Determination of water content using oven drying method

(i) This is the most aqurate method of determining the water content & it's used in the laboretory.

(ii) A speximen of soil sample is kept in a clean container & put in a oven maintaning the tempearture bet^n 105°c to 110°c the sample is kept for 24 hor in the oven so that complite drying each taken place

(iii) 1st take a clean non-corrodiable container & bound it's mass with it's lids on a balance take the mass = M_2

(iv) A specimen of the moist soil is placed in the container & the lid is replaced : take the mass = M_2.

(V) Keep the container is the oven with the lid ~~mam~~ removed bind the mainten the tempearture & the oven bet^n 105°C to 110°C about 24 hour,

Take out the container brom the oven, replaced the lid & add the sample in a decicocator the mass of the container with lid & dryied soil sample is M_3.

(vi) The water content is calculated brom the following expression.

$$W = \frac{M_2 - M_3}{M_3 - M_1} \times 100$$

M_1 = Mass of container with lid

M_2 = " " " " & moist soil

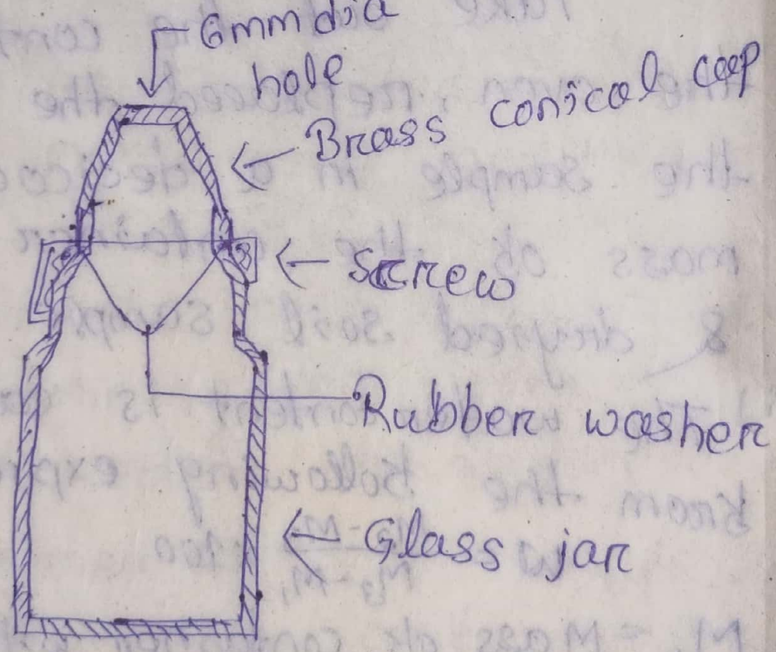
M_3 = " " " " " &

dry soil.

Pycnometer method for water content

(i) This is a weak method for determing the water content for those soil whose specific gravity known.

(ii) Pycnometer is a large size bottle a conical brass cap having 6 mm diameter hole at it's top is screwed to the open end of the Pycnometer, a rubber washer is placed bet^n the conical cap & the rim of bottle for no lekage of water.



(Pycnometer)

Procedure

Take a clean dry pycnometer & find it's mass with it's cap & washer i.e M_1.

(ii) Put about 200 gm to 400 gm of moist soil sample in the Pycnometer & find it's mass with it's cap & washer i.e M_2.

(iii) Field the pycnometer to have it's height & mix it with the glass rod add water & stir it replace the screw top & field the Pycnometer flush with the hole in the conical cap dry the Pycnometer from the out side & find it's mass M_3.

(iv) empty the Pyacnometer clean it thoroly & it with clean water to the hole of the conical cap & find it's mass M_4.

The water content is calculated by following expression.

$$w = \left[\left(\frac{M_2 - M_1}{M_3 - M_4}\right)\left(\frac{G-1}{G}\right) - 1\right] \times 100$$

Particle size distribution

(i) The percentage of various sizes of particle in a given soil sample is found by a particle size analysis or mechanical analysis.

(ii) Mechanical analysis is mean the separation of soil into it's different size fraction.

(iii) Mechanical analysis is performed in two stagess.

(a) ~~Seave~~ Sieve analysis

(b) Sedimaintation " or weat mechanical analysis

(iv) Sieve analysis is ment for coarse grained soil.

(v) Sedimentation analysis is mean for fine grained soil.

Sieve analysis

(i) The sieves designeted by the size of the number of openings in mm

(ii) There are a list of sieves & there openings with some specification

the sieve designation ...

40 mm, 20 mm, 10 mm, 4.75 mm, 4 mm, ~~3 mm~~
2.8 mm, 2.36 mm, 2 mm, 1.4 mm, 1.18 mm,
1 mm, 710 ~~mm~~ μ (Micron), 600 μ, 500 μ,
425 μ, 355 μ, 300 μ, 250 μ, 212 μ,
180 μ, 150 μ, 125 μ, 90 μ, 75 μ, 63 μ,
45 μ.

(iii) Sieve analysis is divided into two Parts.

(i) Coarse analysis.

(ii) Fine "

The soil Particle is separated into two fraction by sieveing it through a 4.75 mm IS-Sieve.

(iv) The portion retained on 4.75 mm IS-sieve is termed as gravel fraction.

(v) The Portion Passing through 4.75 mm IS-Seieve is termed as fine fraction.

(vi) A set up sieves are used for coarse sieve analysis like IS-100, 63, 20, 10 & 4.75 mm.

vii) A set up sieves are used for fine analysis like 2 mm, 1 mm, 600 μ, 425 μ, 300 μ, 212 μ, 150 μ & 75 μ,

Sedimeintation analysis

In the sedimeintation analy or wead mechanical analysis the soil braction is taken biner 75 μ size.

(ii) The sedimentation analysis is don either with the help up a hydrometer or pipete

Sedimentation by Pipeate method

The object ob this method is to determine the distribution ob particle size bine or than 75 μ sieve & about 12 to 30 gm ob soil sample is accurately weighed & mixed with ~~distributed~~ w dis-steeled water in a dish or beaker to borm a smooth paste.

(iii) A dispersing agent such as sodium oxaide tetrasodiom. Pyrochasphate Sodiomhesameta phosphate is taken a mix ob 33gm sodiom hesameta hosphate 7gm sodiom carbonate is adden in distill water to make 1 cetre ob sollution

→ 25 ml ob these solution is added to the beaker & the mixture is warned about 10 minutes,

→ The containt are then transfer to the cup of mechanical mixture using a jet of distiled water to wash the soil out of the ~~evapor~~ evaporating beaker.

→ The soil suspension is then stirred well for 15 minutes the suspension is then washed through 75 µ sieve & the suspension which has past through the sieve is transfered to the 500ml capacity of ~~sed~~ sedimentation tube.

→ The tube is then filled with distilled water upto 500 ml.

→ The tube is put in a constant temperature water bath.

→ when the temperature in the tube has been stabilised to the temperature of bath the soil suspension is throughly shaked & the replaced in the bath.

→ The stopwatch is then stratted & the soil sample are collected at various interval of time with the help of pipeate.

→ The soil suspension which are

collected at various intervals of ti[me] are placed in to the oven & the samples are evaporated to dry-ness after cooling the mass of containe[rs] are found to the nearest 0.001 gm

Determination of specific gravity using Pycnometer method :-

Take the soil having soil fraction passing 4.75 mm I.S sieve

→ clean the pycnometer & dry it, find the mass of the pycnometer that is M_1

→ Take about 200 to 400 gm oven dryied soil & put it in the pycnometer, find the mass of the pycnometer & the soil M_2.

→ Fill the pycnometer to have it's height with distilled water & mix it throughly glass rod then add more water upto the pycnometer flush with the hole in the conical cap, find the mass M_3.

→ MT the pycnometer & clean it throughly fill the pycnometer with distilled water up to the hole of the conical cap. find the mass M_4.

→ The specific gravity is calculated form the following expression

$$G = \frac{M_2 - M_1}{(M_2 - M_1)(M_3 - M_4)}$$

Hydrometer Method

Hydrometer method is used to determine to distribution of particle size finer than 75 μ seive by sedimentation analysis using a densicity hydrometer & then to grain size distribution curve.

Procedure

Weight required 50 - 100 gm of ovendryied soil sample ($M_{sub\ d}$) passing the 2mm is sieve.

→ At 150 ml of hydrogen percoxite paste in to the soil sample in a wide mouth conical flash & stir for few mins. with a glass rod. Cover the flask with glass & level it to sand over night.

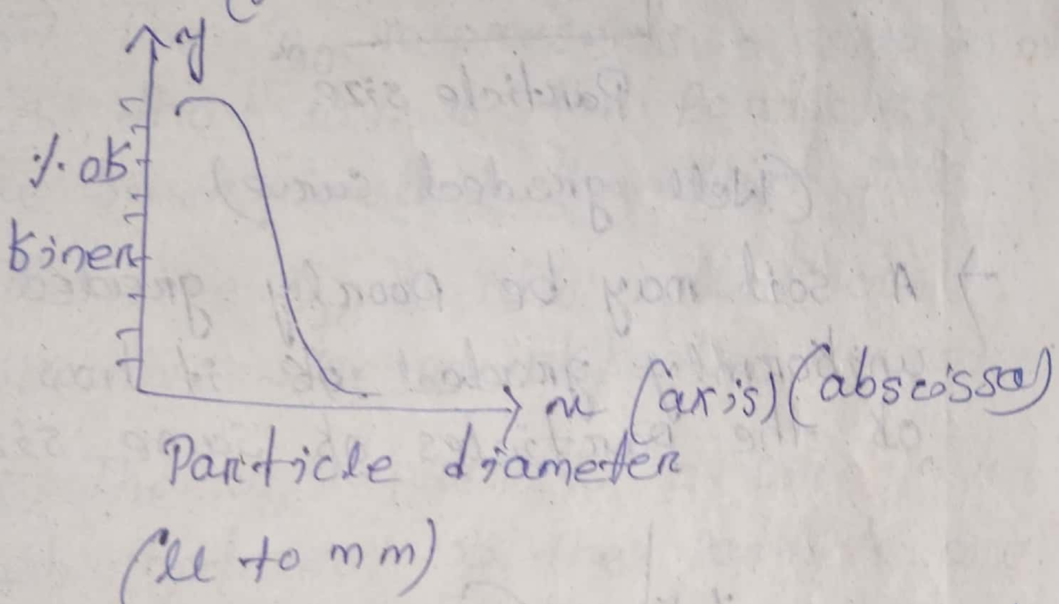
→ Next morning the mixture in the conical flash is heated in an evaporating disk.

→ Radious the valume to about 50 ml by bolying.

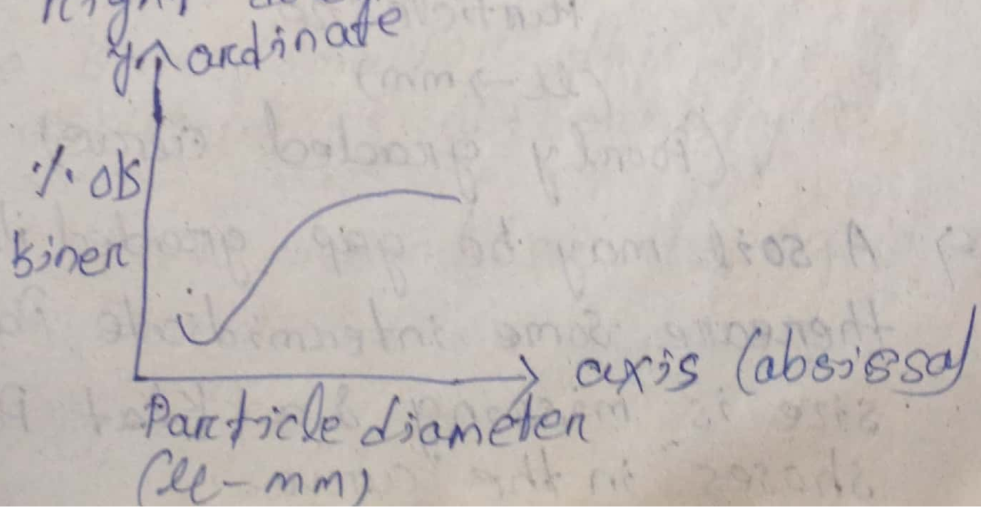
Particle size distribution curve

A particle size distribution curve gives a idea about the type & gredation of the soil.

→ To grade a particle size distribution curve a logarithimic scale is ploted where presentage of finear represent the odinate & the particle diameter represent obscissa. (ordinate)



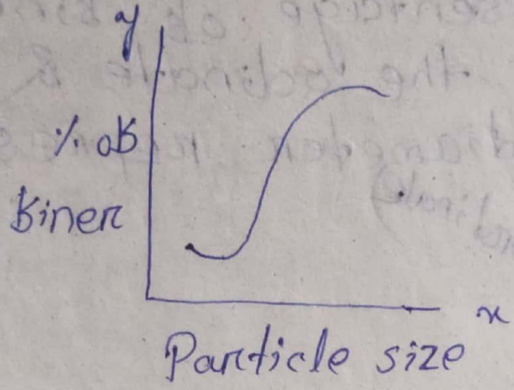
This curve represent fine grad soil because the curve has left & to right down



The curve represent course grain soil beacause the curve has left down & right up.

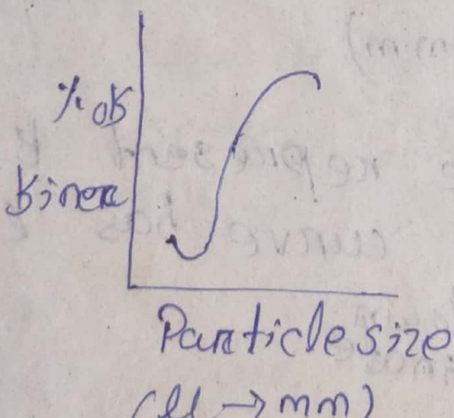
Gradation ob soil

A soil may be well graded if it has good represention ob Particles ob all sizes.



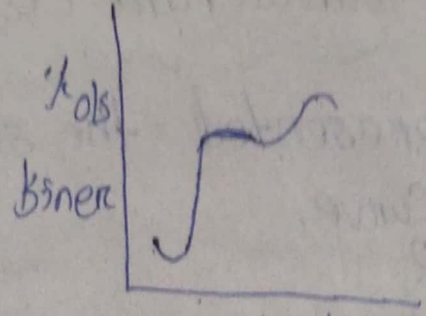
(Well graded curve)

→ A soil may be poorly graded or unibormly graded ib it has most ob the particles ob same sizes.



(Poorly graded curve)

→ A soil may be gap graded ib thereare some intermidiate Particle size is missing & a blat Portion shoses in the curve.



(gap greeded curve)

m.p

For course graded soil shorten Particle sizes are important such as. D_{10}, D_{30} & D_{60}

D_{10} → The D_{10} represents a size in mm such that 10% ob the Particles are biner / Smaller than that size.

→ The size D_{10} is also called as ebbective size or ebbective diameter.

D_{60} → The D_{60} represents a size in mm such that 60% ob the Particle are biner / smaller then this size.

D_{30} → The D_{30} represents a size in mm such that 30% ob the Particle are biner / smaller this size D_{30}.

Co-ebbicient ob uniformity (C_u)

It is debind as the ratio ob D_{60} & D_{10} sizes.

→ $C_u = \frac{D_{60}}{D_{10}}$

② Co-efficient of curvature (Cc)

It is represented the shape of Particle size Curve.

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

(iii) Consistency of soil

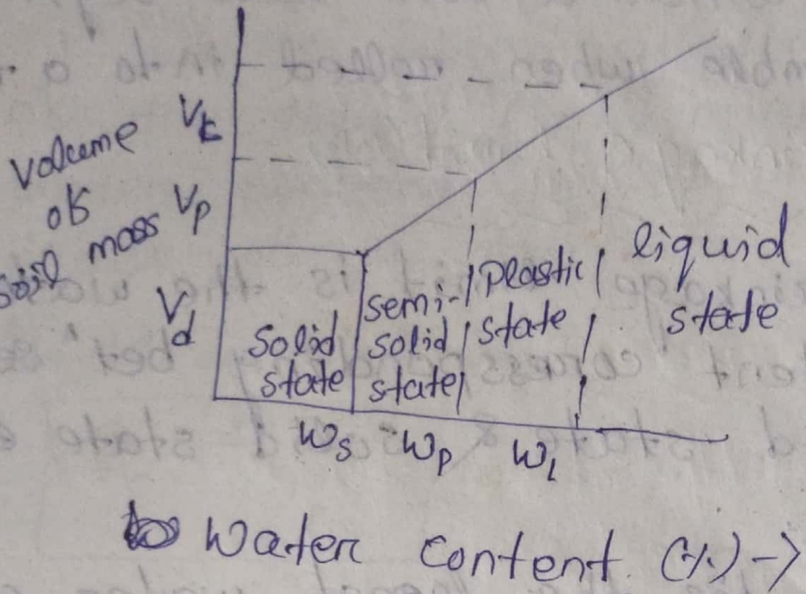
Consistency means the relative ease or working condition with which soil can be deformed.

(ii) Consistency denotes is "the degree of stiffness, softness of soil."

(iii) The soil passes through various state of consistency.

Consistency limits/Atterberg's limit

Atterberg devided the soil state into fore states. i.e liquid state, plastic state, semi solid state & soil state. He skets all the state into shorten limit known as atterberg limit. this limits show the water contents at which the soil mass passes from one state to next state the limits are expressed as persentage of water content.



(Consistency limits)

W_L = liquid limit

W_p = plastic limit

W_s = shrinkage limit

Liquid limit (W_L)

Liquid limit is the water content corresponding bet^ liquid state & plastic state of soil.

(ii) It is minimum water content at which the soil still in the liquid state.

plastic ~~state~~ limit (W_p)

(i) plastic state limit is the water content corresponding bet^ plastic state & semi-solid state of soil.

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(ii) It is the minimum water content at which a soil will begin to crumble when rolled into a thread.

Shrinkage limit (W_s)

(i) Shrinkage limit is the water content corresponding bet^n semi-solid state & solid state of soil.

(ii) It is the lowest water content at which a soil can be completely saturated.

Plasticity index

It is defind as the numerical difference bet^n the liquid limit & the plastic limit of the soil.

→ It is denoted as 'I_p'

$$I_p = W_L - W_p$$

Plasticity

plasticity is defind as the property of soil which allows is to be deformed without rupture, without elastic rebound & without volume change.

Classification of soil

Soil may be classified by the following system.

(1) Particle size classification

(2) Textural " "

(3) Highway Research Board (HRB)

(4) Unified soil / I.S classification.

(1) Particle size classification

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

(ii) According to particle size soil's are classified as :-

(a) Gravel

(b) Sand

(c) Silt

(d) clay

(2) Textural classification

(i) Soil classification of composied soil based on the particle size distribution is known as textural classification.

(ii) The classification based on the (%) of sand, silt & clay sizes.

The symbol is 'H'

Highly organic soil

The soil content large(%) of organic matter such as peat, particles of decomposed vegitation ~~sh~~ Cearten shells etc.

Q:) A specimen of soil has the following data :- % of passing in 75 μ I.S. seive = 50 %, liquid limit = 30 % plastic limit = 12 %. calculate the group index for the specimen.

Given data

a = ~~80%~~. The portion of % passing 75 μ < 35 & > 75 :

a = 50 - 35 = 15

b = Portion of % passing 75 μ < 15 > 55.

b = 50 - 15 = 35

c = Portion of liquid limit ~~>40 to 60~~ greater than 40 & less than 60.

c = 30 - 40 = -10 = (0)

d = ~~12~~ - ~~10~~ = ~~2~~ 18

$I_p = W_L - W_p$

Permeability & Seepage

$I_p = 30 - 12 = 18$

$d = 18 - 10 = 8$

group index $= (0.2 \times 15) + (0.005 \times 15 \times 0) + (0.0135 \times 8)$

$= 5.8$

Q2

A specimen of soil has the following data - % of passing in 75 μ I.S seive = 40% liquid limit = 30% plastic limit 12% calculate the group index for the specimen

Given data

~~$a = 50 - 40 = 10$~~

~~$b = 50 - 35 = 15$~~

~~$c = 30 - 30 = 0$~~

~~$d = 0$~~

~~$I_p = W_L - W_p$~~

~~$= 35 - 15 = 0$~~

~~$d = 0 - 10 = -10$ (0)~~

~~group index $= (0.2 \times 10) + (0.005 \times 10 \times 15) + (0.01 \times 15 \times 0)$~~

~~$= 4.5$~~

$a = 40 - 35 = 15$

$b = 40 - 15 = 25$

$c = 30 - 40 = -10$
$= 0$

$I_p = 30 - 12 = 18$

$d = 18 - 10 = 8$

group index $= (0.2a) + (0.005ac) + (0.01bd)$

$= (0.2 \times 15) + (0.005 \times 15 \times 0) + (0.01 \times 25 \times 8)$

$= 5$

Permeability & Seepage

Permeability is defind as the property of porous material which permites the passage of water through it's inter connecting voids.

(i) gravel & sand are highly permeable. & ~~silt~~ & clay are low permeable.

(ii) Co-efficient of Permeabity

It is defind as the average velocity of flow that will occure through the total cross-sectional area of soil. is known as co-efficient of Permeability

(ii) Area of under hydraulic gradident

(iii) $K = \frac{V}{i}$

where
k = co-efficient of Permeability

V = velocity of flow

i = Hydraulic gradident

It is expressed as = cm/s or m/day

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Darcey 's low

This low state's that the rate ob blow or discharge ob blow per unit time is proposind the to the hydrouldic gradidant.

$$q = kiA$$

Where,

q = discharge ob blow

k = co-ebbicient ob permeability

i = hydroaulaic gradiadnt

A = cross-seational area ob soil mass.

$$\Rightarrow \frac{q}{A} = ki$$

$$\Rightarrow V = ki$$

V = velocity ob blow

Factor abbecting permeability

The dibbeeente bactor's are

(i) grain size or particle size

(ii) Propertigs ob pore bloied

(iii) Voids ratio ob the soil

Falling head permebility test

$$K = \frac{al}{At} \log_e \frac{h_1}{h_2} = 2.3 \frac{al}{At} \log_{10} \frac{h_1}{h_2}$$

K = Co-efficient of permeability
a = cross-sectional area of a stand pipe
A = cross-sectional area of sample
l = length of the sample
h_1 = head at time interval t_1
h_2 = " " " " t_2
t = time interval $t = t_2 - t_1$

Q-3) A soil sample of 8 c.m hight & 100 c.m^2 cross-sectional area was subjected to the falling head permeabitity test of a time inverl 10 minite the head dropped from 75 c.m to 25 c.m. If the cross-sectional area of stand pipe is 2 c.m^2 compute the co-efficient of permeability of soil sample.

Given data

L = 8 c.m (hieght of soil sample)
A = 100 cm^2

$t = 10$ min $= 600$ sec

$h_1 = 75$ c.m

$h_2 = 25$ cm

$a = 2\,cm^2$

$$k = 2.3\frac{al}{At}\log_{10}\frac{h_1}{h_2}$$

$$= 2.3\frac{2\times 8}{100\times 600}\log_{10}\frac{75}{25}$$

$$= 2.92\times 10^{-4} \text{ c.m/sec}$$

Q.9 Calculate the co-efficient of Permeability of a soil sample 6 c.m in height & 50 c.m² in cross-sectional area if quantity of water = 430 ml passed down in 10 min under an constant head 40 c.m.

Given data

$l = 6$ c.m

$A = 50\,cm^2$

$Q = 430$ ml

$h = 40$ cm

$t = 10$ min $= 600$ sec

$$K = \frac{Q}{t}\times\frac{l}{h}\times\frac{1}{A}$$

$$k = \frac{430}{600} \times \frac{6}{40} \times \frac{1}{50}$$

$= 2.15 \times 10^{-3}$ c.m/s

Q:- A falling head permeability test has a soil sample of 12 cm height & 60 cm² cross section. The co-efficient permeability is expected to be 2×10^{-4} cm/sec. If it desired that head in the stand pipe to fall from 30 cm & 12 c.m in 30 min determine the size of the stand pipe.

Given data

$L = 12$ c.m

$A = 60\ cm^2$

$t = 30 = 1800$

$h_1 = 30$ cm

$h_2 = 12$ cm

$k = 2 \times 10^{-4}$ cm/sec

$$k = 2.3 \frac{al}{At} \log_{10} \frac{h_1}{h_2}$$

$$\Rightarrow 2 \times 10^{-4} = 2.3 \times \frac{a \times 12}{60 \times 1800} \log_{10} \frac{30}{12}$$

$$\Rightarrow 2 \times 10^{-4} = 1.017 \times 10^{-4} a$$

$$\Rightarrow a = \frac{2 \times 10^{-4}}{1.017 \times 10^{-4}} = 1.96\ cm^2$$

$a = cm^2$

Q=1

Co-ebbiciant ob permeability

It is defind as the avarge velocity ob blow that will occoun through out the total cross-sectional area ob soil. is known as co-ebbicent ob permeability.

Factor abbecting permeability

(i) grain size or particle size
(ii) Property ob pore blued
(iii) voids ratio. ob soil.
(iv) structural arrangement ob particles
(v) entraped air & bangen matter
(vi) adosbred water in clay soil.

Darcy's low

This low states that the rate ob bolco per blow ob or discharge ob per unit time is proposional to the hydrolic gradiadnt.

$q = kiA$

Shrinakge ratio

It is defind as the ratio ob given volume change & is expresed as % dry volume to the change in water content.

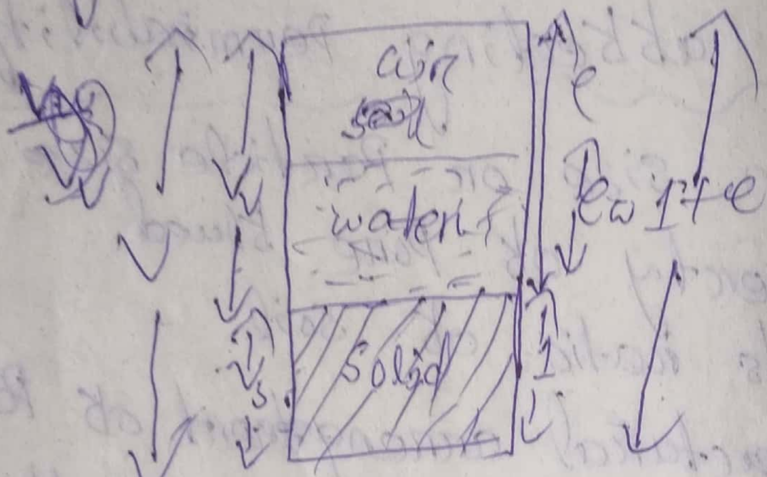
Relation bet^n e, w, G & S

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

w = water content = $\frac{W_w}{W_d}$

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

S = degree of saturation = $\frac{V_w}{V_v}$



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

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

$e_w = Se$ —(i)

Let the soil fully saturated

$V_v = V_w$

$\Rightarrow e = e_w$

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

$$\gamma_w = \frac{W_w}{V_w}$$

$$\gamma_w = \frac{W_w}{e_w}$$

$$\boxed{W_w = \gamma_w e_w}$$

$$\gamma_s = \frac{W_d}{V_s}$$

$$\boxed{W_d = \gamma_s V_s}$$

$$W_w = \gamma_s 1$$

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

$$\boxed{\Rightarrow \gamma_s = G\gamma_w}$$

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

$$\Rightarrow w = \frac{\gamma_w e_w}{\gamma_s 1}$$

$$\Rightarrow w = \frac{\gamma_w e_w}{G\gamma_w}$$

$$w = \frac{e_w}{G}$$

$$e_w = Gw \quad \text{— (2)}$$

Combain equ (1) & (2)

$$Se = wG$$

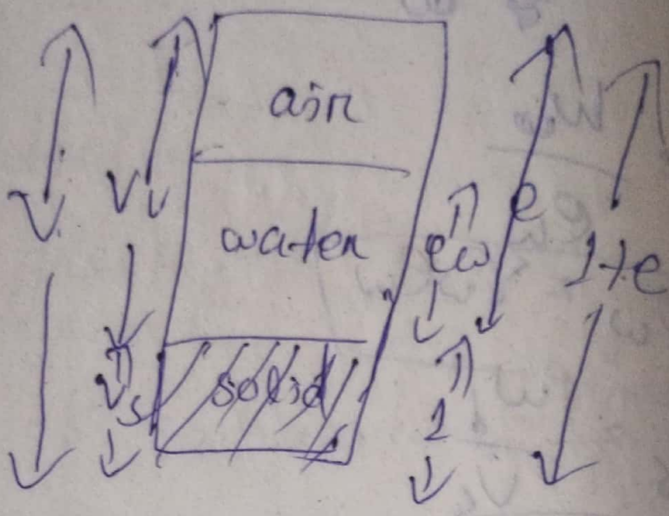
$$e = \frac{wG}{S}$$

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

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

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

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



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

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

$e_w = Se$

Let soil is fully saturated

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

$= e = e_w$

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

$\gamma_w = \frac{W_w}{V_w}$

$\gamma_w = \frac{W_w}{e_w}$

$= W_w = \gamma_w e_w$

$\gamma_s = \frac{W_d}{V_s}$

$\gamma_s = \frac{W_d}{V_s}$

$\Rightarrow \boxed{W_d = \gamma_s V_s}$

$\therefore W_d = \gamma_s 1$

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

$\therefore \gamma_s = G\gamma_w$

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

$w = \frac{\gamma_w e_w}{\gamma_s \cdot 1}$

$w = \frac{\gamma_w e_w}{G\gamma_w}$

$w = \frac{e_w}{G}$

$\Rightarrow e_w = wG$

comparin equatio (I) & (II)

$e_w = Se$

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

Relation γ_d, G, e, or n

$\gamma_d = \frac{W_d}{V}$, $G = \frac{\gamma_s}{\gamma_s}$, $e = \frac{V_v}{V_s}$, $n = \frac{V_v}{V}$

$\gamma_d = \frac{W_d}{V}$ $(W_d = \gamma_s V_s)$

$$\gamma_d = \frac{\gamma_s V_s}{V}$$

$$\gamma_d = \frac{\gamma_s \cdot 1}{1+e}$$

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

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

$$\Rightarrow e = \frac{G\gamma_w}{\gamma_w} \quad — 1$$

$$\gamma_d = \frac{\gamma_s V_s}{V}$$

$$\gamma_d = G\gamma_s \times (1-n)$$

$$1-n = \frac{G\gamma_s}{\gamma_d}$$

Relation γ_d, γ & w

$|w| = \frac{W_w}{W_d}$

∴ add 1 in both side

$1+w = \frac{W_w}{W_d} + 1$

$\Rightarrow 1+w = \frac{W_w + W_d}{W_d}$

$\Rightarrow 1+w = \frac{W}{W_d}$

$|w|_d = \frac{|W|}{1+w}$

$\gamma_d = \frac{|w|_d}{V}$

$\Rightarrow \gamma_d = \frac{\frac{W}{1+w}}{V}$

$\gamma_d = \frac{|W|}{V} \times \frac{1}{1+w}$

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

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

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