Lec-1 (Muqtadir Sir)

Dr. Abdul Muqtadir

Syllabus—

i) Weight-Volume relationship of soil
ii) ~~Relat~~ Density index/Relative density
iii) compaction characteristics of soil

} 1 (CT) after 4th or 5th week

iv) Fluid flow through porous media (7-8 Lectures)

CT-2

v) ~~consoc~~

Consolidation characteristics of soil (7-8 Lectures)

CT-3

vi) Stress distribution of soil (4 Lectures)

Textbook— (i) Foundation engineering by peck, hanson and thornburn

(ii) Soil Mechanics by BM Das

(iii) Advanced soil Mechanics by BM Das (MSc)

(iv) Soil Mechanics by craig

Body may be at rest or at motion

one of the oldest ~~science~~ branch of physical science which deals with force acting on bodies at motion or rest.

Rigid body , deformable body

Soil mechanics is one of the branches of civil engineering which deals with the application of soil science, the laws of statics & dynamics and the principles of mechanics and hydraulics to understand the behavior of and use of soil as an engineering material.

Foundation design করতে গেলে দু'টি criteria satisfy করতে হবে —

i) Bearing Capacity → The capacity of soil at which soil fails in shear. Adequate safety factor against bearing capacity

ii) The foundation must not experience excessive settlement and for conventional type of structure, the tolerance limit → 25 mm (1 in)

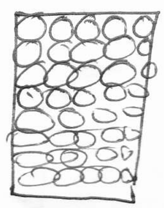
C.W.

5/5/19

Lec-2 (Muqtadir sir)

Principles of Soil Mechanics 1

Weight-Volume relationship:



Lump of soil

Soil contains 3 items—

1. Soil skeleton
2. Air
3. Water

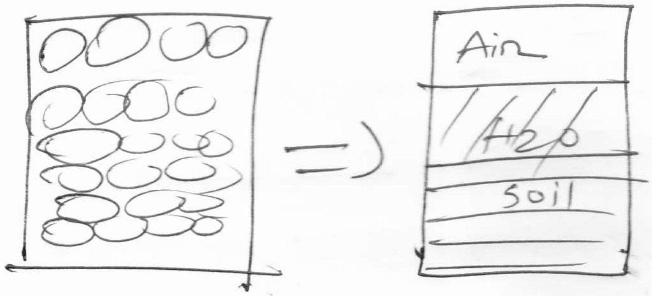
Dry soil contains — 2 components
Soil skeleton, air

Water দ্বারা Saturated হলে → 2 components
Water, skeleton

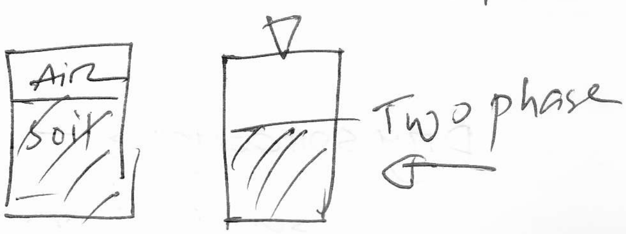
Block/phase diagram can be defined as the representation of the various constituents (soil skeleton, water, air);
(water, air) Represents voids

If ~~it contains~~ there exists three constituents. It is called three phase diagram.

If there exists two constituents. It is called two phase diagram.



3 phase



These phase diagram can be effectively used in establishing relationship between various terms like water content (→ Moisure content), void ratio, porosity, degrees of saturation and various unit weights or mass density of soil

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Extra:

Young's modulus of elasticity $= E$

$\nu \rightarrow$ poisson's Ratio

Bulk Modulus, $K = \dfrac{dp}{(dv/v)} = \dfrac{E}{3(1-2\nu)}$

Shear Modulus, $\mu = \dfrac{(F/A)}{(x/y)} = \dfrac{E}{2(1+\nu)}$

Basic Assumption:

Soil skeletons are incompressible and water is also incompressible. Weight of air is zero.

No change in volume of soil skeleton and water.

Infinite bulk Modulus Poisson ratio = 0.5	→ Incompressible characteristics

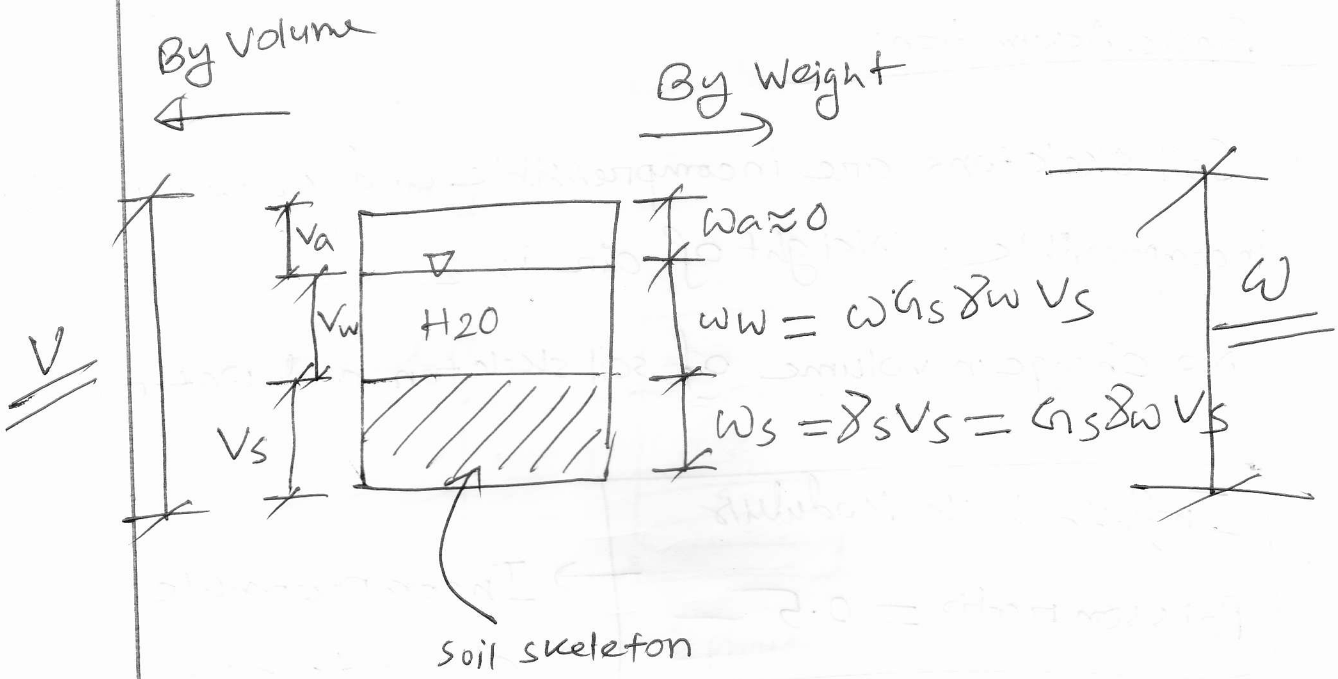
Water content/Moisture content is denoted by ω (omega) expressed in percentage.

Void ratio is denoted by e, expressed in decimal.

Porosity is denoted by n, expressed in percentage

Degrees of saturation is denoted by S_r, expressed in percentage.

Generalised 3 phase diagram:



1. $\omega = \frac{W_w}{W_s} \times 100\%$ (moisture content)

It could have value more than 100%

$W_w = \omega W_s$ $\quad V_w = \omega G_s V_s$

$V = V_s + V_w + V_a$ → void

$= V_s + V_v \quad V_v = V_a + V_w$

Void ratio can be defined as the ratio of volume of void and the volume of solid

$$e = \frac{V_v}{V_s} \quad \text{(expressed in decimal)}$$

1 এর বেশি হতে পারে

Porosity is the volume of voids divided by total volume.

$$n = \frac{V_v}{V} \times 100\% \quad \text{(Expressed in percentage)}$$

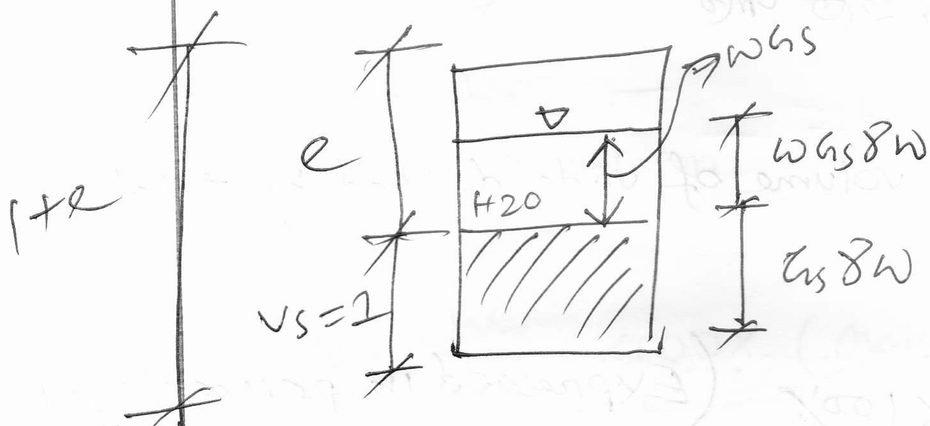
$$e = \frac{V_v}{V_s} = \frac{V_v}{V - V_v} = \frac{\frac{V_v}{V_v}}{\frac{V}{V_v} - 1}$$

$$= \frac{1}{\frac{V}{V_v} - 1}$$

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

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

$V_s = 1$ → Normalize



Degrees of saturation represents to what extent, void spaces are filled up with water.

$$S_r = \frac{V_w}{V_v} \times 100\%$$

$$S_r = \frac{wG_s}{e} \times 100\%$$

(*) $w = \frac{W_w}{W_s}$ থেকে $S_r = \frac{wG_s}{e}$ prove কর।

Total volume, $V = V_s + V_v$

$$= V_s\left(1 + \frac{V_v}{V_s}\right)$$

$$= V_s(1+e)$$

$$V \propto (1+e)$$

V_s is constant because soil is assumed incompressible.

$V_f = 10^6$ cft

$V_b \propto (1+e_b)$

$V_F \propto (1+e_F)$

$$\frac{V_b}{V_F} = \frac{1+e_b}{1+e_F}$$

$$\Rightarrow V_b = \left(\frac{1+e_b}{1+e_F}\right) \times V_F$$

$$= \left(\frac{1+0.75}{1+0.4}\right) \times 10^6$$

$= 1.25$ Millions eff

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

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

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

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

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

2.65 − 2.75 → G_s

Normal soil এর জন্য G_s খুব একটা vary করে না।

Sand এর জন্য,

typical value of G_s = 2.65 − 2.75

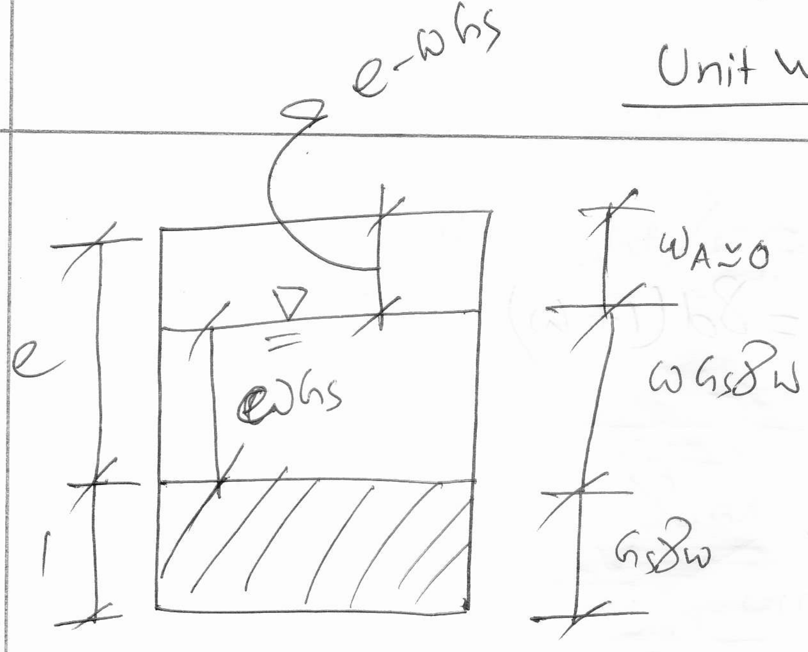
Silty sand, G_s = 2.67 − 2.7

Inorganic clay, G_s = 2.70 − 2.80

Organic material থাকলে G_s অনেক বেশি vary করে। Test করতে হবে। G_s can be as low as 2 if organic impurities are present.

Lec-3 (Muqtadir sir)

Unit Weight and Density



1. γ_{Bulk} = Bulk Unit weight $= \dfrac{W}{V}$

(field condition এ থাকলে)

$$= \frac{1+w}{1+e} G_s \gamma_w$$ ✓

2. Dry unit Weight

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

$$\gamma_{Bulk} = \frac{W_w + W_s}{V}$$

$$= \frac{W_s}{V}\left(1 + \frac{W_w}{W_s}\right)$$

$$\gamma_{bulk} = \frac{W}{V} = \gamma_d (1 + w)$$

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

Saturated Unit weight:

$$\gamma_{sat} = \frac{G_s \gamma_w + e \gamma_w}{1+e}$$

$$= \frac{G_s + e}{1+e} \gamma_w$$

$$S_r = \frac{w G_s}{e}$$

$$w = \frac{S_r e}{G_s}$$

Submerged unit weight / Effective Unit weight / Buon Unit weight:

$$\gamma_{sub} = \gamma' = \gamma_b = \underline{\underline{\gamma_{sat} - \gamma_w}}$$

$$= \frac{G_s - 1}{1+e}\gamma_w$$

$\gamma_{sat} - \gamma_w$

$$= \frac{G_s + e}{1+e}\gamma_w - \gamma_w$$

$$= \gamma_w\left(\frac{G_s+e}{1+e} - 1\right)$$

$$= \gamma_w\left(\frac{G_s+e-1-e}{1+e}\right)$$

$$= \gamma_w \times \left(\frac{G_s - 1}{1+e}\right)$$

Air content

Air void ratio:

$$A_v = \frac{V_a}{V} = \frac{V_v - V_w}{V_v + V_s}$$

$$= \frac{1 - \frac{V_w}{V_v}}{1 + \frac{V_s}{V_v}}$$

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

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

$$= \frac{1 - S_r}{1 + 1/e}$$

$$= \left(\frac{e}{1+e}\right) \times (1 - S_r)$$

$$= n \times (1 - S_r)$$

↓

Porosity

Relative density is used to indicate the insitu denseness or looseness of granular soil

Relative density / density index : $I_D = D_r$

Each value represents compactness of cohesionless material.

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

$$= \frac{V_{max} - V_f}{V_{max} - V_{min}}$$

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

$$\Rightarrow (1+e)_{max} = \frac{G_s \gamma_w}{\gamma_{d\,min}}$$

$$(1+e)_{min} = \frac{G_s \gamma_w}{\gamma_{d\,max}}$$

$$I_d = \frac{1/\gamma_{dmin} - 1/\gamma_{df}}{1/\gamma_{dmin} - \frac{1}{\gamma_{dmax}}} \times 100$$

<u>Id/Dr (%)</u>

0–15 — Very loose

15–35 — loose

35–65 — Medium Dense

65–85 — Dense

>85 — Very Dense

$$e_{max} = \frac{n_{max}}{1 - n_{max}}$$

$$I_d = D_r = \frac{\left(\frac{n_{max}}{1 - n_{max}} + 1\right) - (e + 1)}{\left(\right.}$$

C.W. Dr. Abdul Muqtadir Sir — Lec 4

Compaction

Dam, Highway, all structure ও compaction
লাগে।

Purpose of doing compaction —

1. It increases shear strength properties of soil. Therefore, it increases the bearing capacity of soil.

2. Reduces settlement.

3. It decreases permeability of soil.

4. It increases the stability of slope.

Compaction means the expulsion of air from the void

Consolidation means the expulsion of water from v

Compaction is a process of densification of soil by reducing/expelling air from the void.

It is done by applying mechanical energy to soil.

Factors affecting Compaction:

(1) Types of soil (clay, sandy type কোনটার)

(2) Moisture content (Most Important criteria)

(3) Amount of compactive effort (Mechanical energy)

plane এর Runway তে compaction করা হয়। Compaction test lab এ করব (field soil test করবো)

Energy:

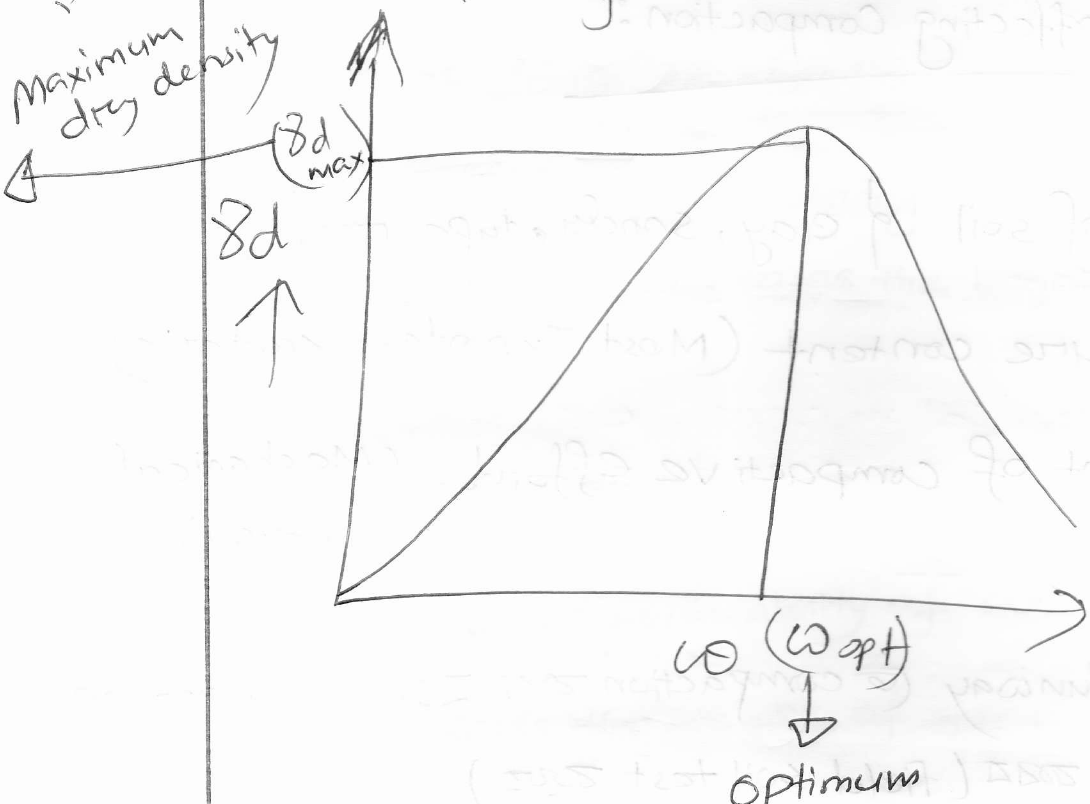
$$mgh$$

$$= 5.5 \times \frac{12}{12} \times 25 \times 30 \times 3$$

$$= 12375 \text{ lb-ft/cft}$$

"is also a function of compactive effort and type of soil"

$$\gamma_d = \frac{\gamma_{bulk}}{1+w_f}$$



for compactive effort, type of soil

ASTM D698 (Lab এ করতে) – Standard Proctor test

ASTM D1557 → Revised → 5 layers, 18" height of fall, 10 lb tamper

Energy = $10 \times 18/12 \times 5 \times 25 \times 30$ = 56250 lb ft/cft

γ_d বেড়ে যাবে 5-10%.

Foundation design এর জন্য settlement criteria, bearing capacity এর চেয়ে বেশি গুরুত্বপূর্ণ।

The purpose of laboratory compaction test is to determine the proper amount of mixing water to use when compacting the soil in the field and the resulting degree of denseness / compactness which can be expected from the compaction at the determined optimum moisture content in the laboratory.

Laboratory result এর 95-98% field এ ensure করতে হবে।

| compactive effort | → Maximum dry density

(*) Standard Proctor, Modified proctor এর মধ্যে পার্থক্য?

C.W.

Muqtadir sir-lec-5

Compaction Requirement:

Compaction requirement 2টা specific way এ fullfil করা হয় —

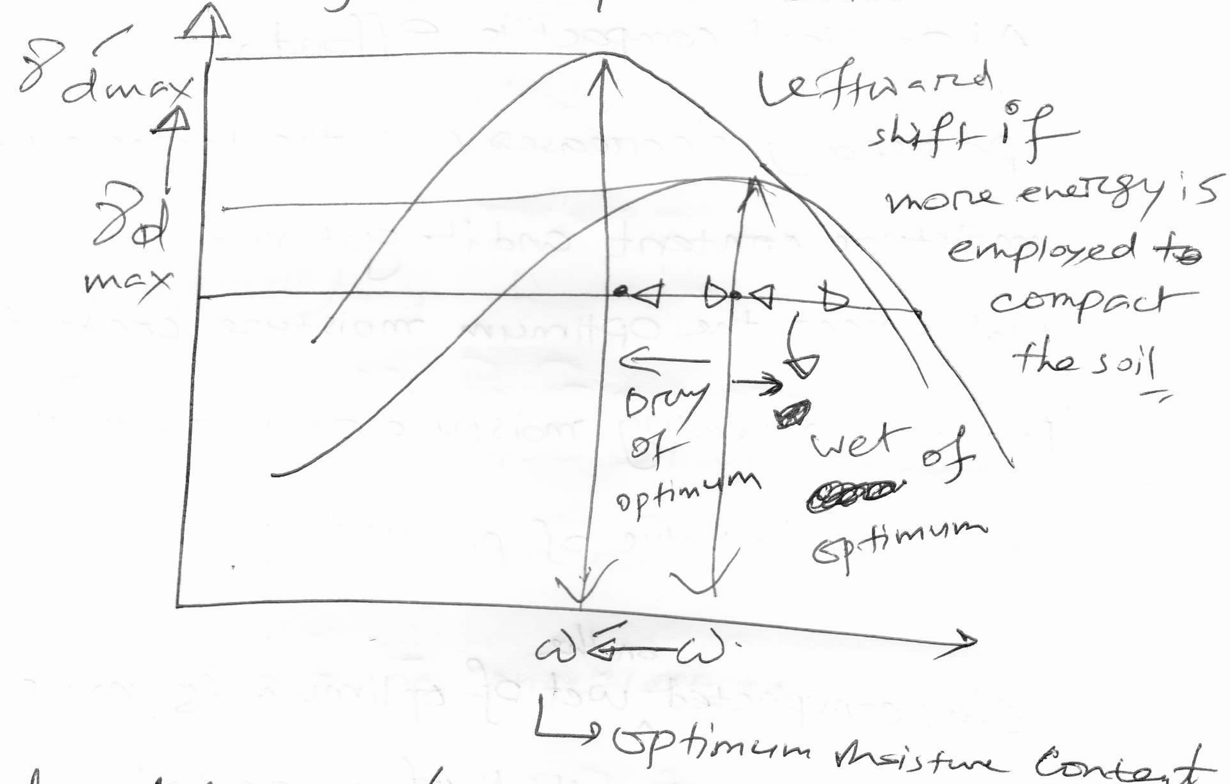
i) Method Specification (দায়িত্ব নিবে client/যারা specify করে দিবে)

ii) End ~~point~~ Product Specification

→ Method will be specified (Roller type, No. Number of pass specified, Layer thickness)

Standard proctor এর 95% compaction achieve করতে, কীভাবে করবে তা client, contractor কে বলবে না, Client কোন দায়িত্ব নিবে না, finished job এর quality achieve করা contractor এর দায়িত্ব।

Characteristic of the compaction curve:



Sand coal Method / Sand Replacement Method:

Relative compaction / Percent compaction:

$$\frac{\gamma_{df}}{\gamma_{d\,max\,(Std.)}} \geq 0.95$$

clay তে পানি ঢাললে ফুলে যায়।

At constant compactive effort, permeability decreases with the increase in moisture content and it got minimum value near the optimum moisture content. Further increasing moisture content ~~incre~~ increases the value of permeability.

Clay compacted on the wet of optimum is more compressible than that of compacted on the dry of optimum.

Swelling of the compacted clay is greater for those compacted at the dry of optimum.

Soil compacted on the wet of optimum shows more shrinkage than that of dry of optimum.

Dry of optimum → Microscopic লেভে দেখলে →

Soil skeleton structure is flocculated

wet of optimum → " " " is dispersive.

The shear strength of cohesive soil will have higher value in compared with the wet of optimum

Dry side will experience less strain in compared with the wet side.

Soil compacted on the wet of optimum can experience larger deformation without cracking.

Clay earth dams are usually compacted on the wet of optimum to tolerate large settlement without cracking.

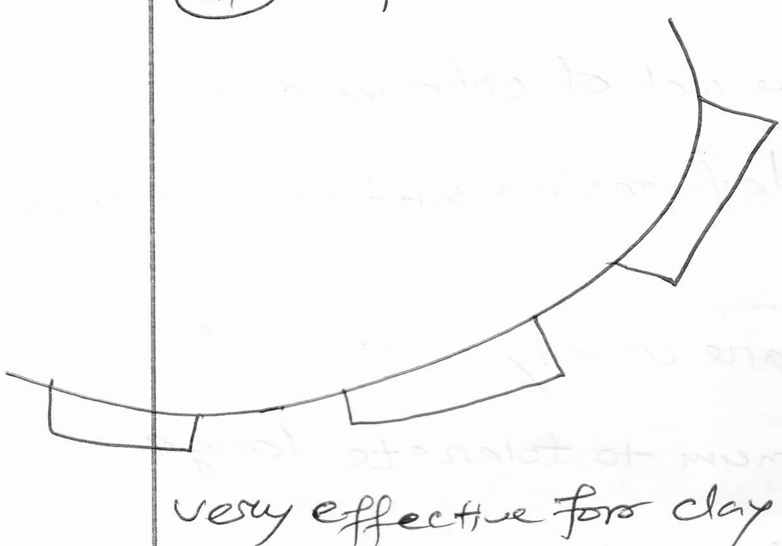
For highway structure, it is desirable to have low strain, higher shear strength and compacted on the dry side

(**) field compaction কী কী Machine দিয়ে করা যায়?

(i) Smooth wheel Roller (350 KN/m^2)

(ii) Pneumatic Rubber Tyre Roller (700 KN/m^2)

(iii) Sheep foot Roller



very effective for clay

(iv) Vibrator (for sandy types of soil)

Expelling water from void

Expelling air from void

(*) Moisture content:

Soil sample এ পানি add করে tamping করতেছি,

Soil layer is less compacted due to sliding.

Lubricating action of water.

In the process of sliding, due to the application of mechanical energy, there is a relative movement between layer. Void space is filled up with soil skeleton, if you keep on increasing moisture content. After certain (optimum) Moisture content, more water added will cause the void space to be filled up with water.

Muqtadir Sir - Lec (6)

1

(*) A nature soil deposit @ a bulk unit of 18.44 KN/m3 at a moistune content of 5%. Calculate the volume of water to raise the moisture content to 15%. Also calculate volume of water needed to make the soil sample fully saturated. Also calculated degrees of saturation at 15% moisture content. finished soil = 100m3

$G_s = 2.67$

1st process:

$$\gamma_d = \frac{\gamma_{bulk}}{1+\omega}$$

$$= \frac{18.44}{1+5/100} = 17.56 \text{ kN/m}^3$$

For 1m³ of soil sample,

$W_s = 17.56$ kN

W_w (5%) $= \omega W_s = \frac{5}{100} \times 17.56 = 0.878$ kN

W_w (15%) $= w W_s = \frac{15}{100} \times 17.56 = 2.634$ kN

$\Delta W_w = W_w(15\%) - W_w(5\%)$

$= 1.756$ kN

for 100 m³ of soil sample,

weight of water added $= 1.756$ kN

$= 175.6$ kN

Volume of water added $= \frac{175.6}{9.81}$ m³

$= 17.9$ m³ (Ans)

<u>2nd process:</u>

$\gamma_d = \frac{\gamma_{bulk}}{1+w} = 17.56$ kN/m³

γ_{bulk} (@ 5% MC) $= 18.44$ kN/m³

γ_{bulk} (@ 15% MC) $= 17.56(1 + 15/100) =$ ~~15.27~~ 20.19 kN/m³

Weight of water added (for 1 m³ soil sample) =

γ_{bulk} (@ 15% MC) $- \gamma_{bulk}$ (@ 5% MC)

$= 20.19 - 18.44 = 1.75$ kN

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

$$\Rightarrow 17.56 = \frac{2.67 \times 9.81}{1+e}$$

$$\Rightarrow e = 0.49$$

$$S_r = \frac{w G_s}{e} = \frac{15/100 \times 2.67}{0.49} \times 100$$

$$= 81.7\%$$

(*) Soil is to be excavated from a borrowpit area which has mass density of 1.75 gm/cc @ moisture content of 12%. The soil is compacted to dry density of 1.65 gm/cc @ a moisture content = 18%. $G_s = 2.7$. For 1000 m^3 of finished soil, what volume of soil you need to excavate from borrow area and how much you need to add to raise moisture content from 12% to 18%

1st process:

Borrow Side:

$\rho_{bulk} = 1.75\ gm/cc$

$\omega_b = 12/100 = 0.12$

$$\rho_d = \frac{\rho_{bulk}}{1+\omega_b} = \frac{1.75}{1+0.12} = 1.5625\ gm/cc$$

$$\rho_d = \frac{G_s \rho_w}{1+e_b}$$

$$\Rightarrow 1.5625 = \frac{2.7 \times 1}{1+e_b}$$

$$\Rightarrow e_b = 0.728$$

Finished Site:

$$\rho_d = \frac{G_s \rho_w}{1+e_f} \Rightarrow 1.65 = \frac{2.7 \times 1}{1+e_f}$$

$$\Rightarrow e_f = 0.636$$

$$\frac{V_b}{V_f} = \frac{1+e_b}{1+e_f} \Rightarrow \frac{V_b}{1000} = \frac{1+0.728}{1+0.636}$$

~~$\Rightarrow V_f$~~ $\Rightarrow V_b = 1056\ m^3$ ✓

2nd process

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

$$\gamma_d \propto \frac{1}{1+e}$$

$$\frac{V_b}{V_f} = \frac{1+e_b}{1+e_f} = \frac{\gamma_{df}}{\gamma_{db}}$$

$$\Rightarrow \frac{V_b}{1000} = \frac{\rho_{df}}{\rho_{db}}$$

$$\Rightarrow V_b = 1000 \times \frac{1.65}{1.5625}$$

$\Rightarrow V_b = 1056\ m^3$ ✓

ρ_{bulk} (@ 12% MC) $= 1.65 \times \left(1 + \frac{12}{100}\right)$

ρ_{bulk} (@ 18% MC) $= 1.65 \left(1 + \frac{18}{100}\right)$

Mass ~~Weight~~ of water added to raise MC from 12% to 18%

$= 1.65 \times \left(1 + \frac{18}{100}\right) - 1.65 \left(1 + \frac{12}{100}\right)$

$= 0.099$ gm (for 1cc of soil sample)

For 1000 m^3 of soil sample,

mass of water added = 99 000 kg

~~99 kg~~

Volume of water added = ~~$\frac{99\ kg}{9.81 \times 1000}$~~ $\frac{99000\ kg}{1000\ kg/m^3}$

$= 99\ m^3$ of water

Fluid flow through porous media :

পানির Flow continuous,
Soil contains with continuous voids } continuity eqn. valid.

Flow of water through the continuous voids of the soil sample is called seepage.

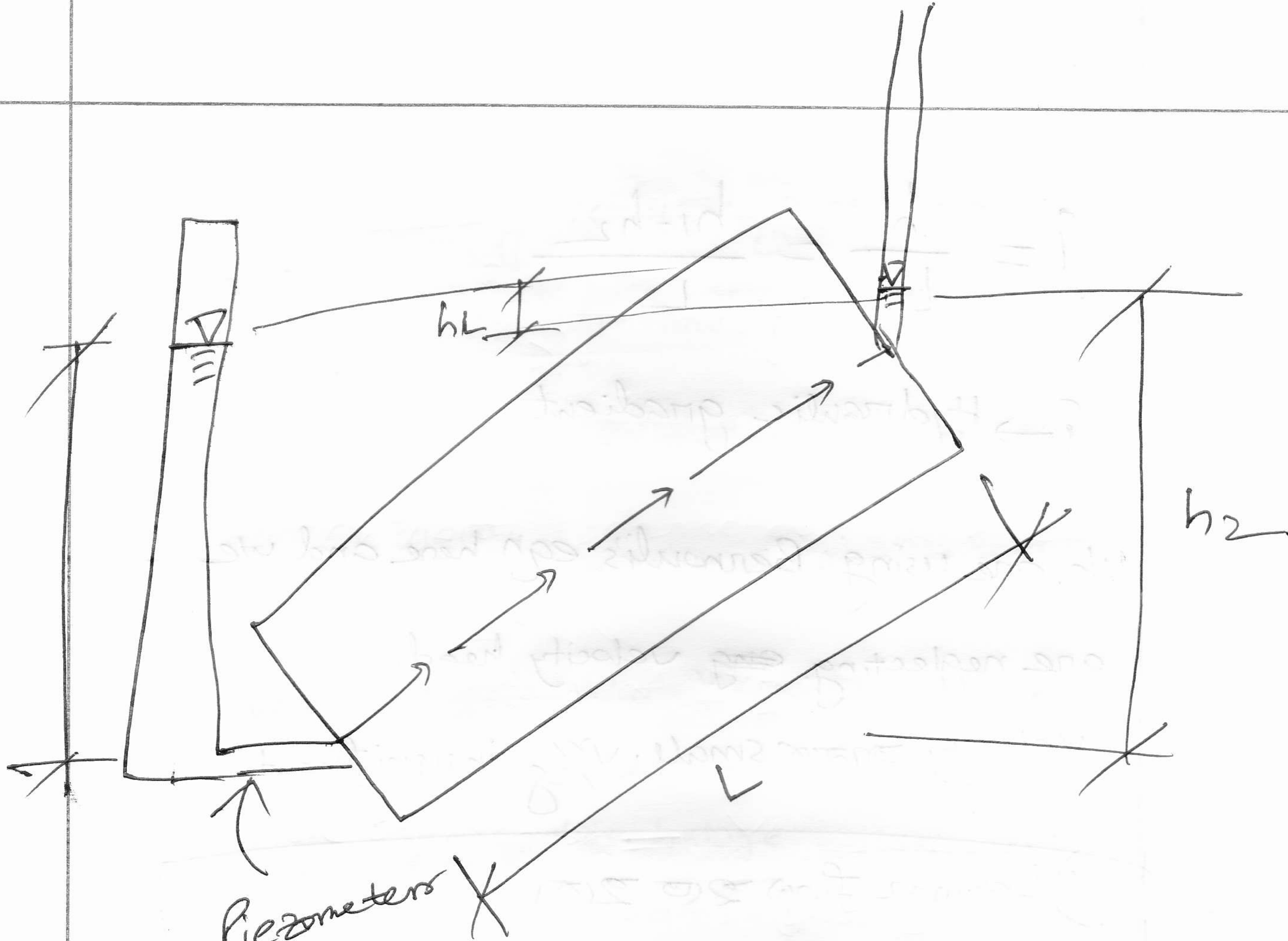
Soil is also permeable

How easily the water can flow through the soil.

Clay → Almost Impermeable

Darcy's principle (French Physicist)

Discharge velocity (velocity of flow) through the continuous voids of the ~~sample~~ soil sample is directly proportional to the discharge gradient.



h_L → head loss → frictional loss provided by soil sample.

$$h_L = h_1 - h_2$$

$h_1 - h_2$ → Driving head, Head loss

(Head loss per unit length of the soil sample is called Hydraulic gradient)

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

$i \rightarrow$ Hydraulic gradient

We are using Bernouli's eqn here and we are neglecting ~~eng~~ velocity head.

velocity অনেক small. $v^2/2g$ insignificant

i) Laminar flow হতে হবে।

ii) Soil sample is fully saturated with water

→ Assumptions for darcy's law এর applicability.

$$v = ki$$

$$q = AV$$

$$= kiA$$

Discharge velocity is the quantity of water that percolates in unit time through a cross sectional area of unity oriented at right angle to the direction of flow.

$q = VA$

$= V_d A_g$

$= V_s A_v$

Seepage velocity হল Quantity of water void দিয়ে flow করে।
Discharge velocity যে void + soil এর total area তে flow করে।

Only Velocity বলা হলে Discharge Velocity.

factors affecting the value of co-efficient of permeability:

i) Size of the soil grain

ii) Arrangement of the soil grain
(Flocculated হলে flow বেশি
Dispersive হলে flow কম)

(iii) Properties of void

Unitweight & ~~[illegible]~~ viscosity → Temperature

(iv) Degrees of saturation

Determination of K value:

i) Using empirical formula:

ii) Lab determination of K value →

2 methods →

a) Constant Head Method

b) Falling Head Method

~~[illegible]~~

iii) Field determination of K value

(i), (ii), (iii) procedure → cohesionless soil (এর জন্য applicable (Sandy type, clay নয়)

There is no direct procedure for determining K value of clay.

But from the consolidation test date, it can be determined.

Co-efficient of permeability, $K = 10^2$ cm/s (for coarse sand)

$K = (10^{-7} - 10^{-11})$ cm/s (for clayey soil)

~~Coarse, clean & typically~~

Darcy's formula:

Coarse, Loose & clean sand এর জন্য K এর

Estimated value বের করা যাবে।

$$K = C D_{10}^2$$

$C = 100$ $cm^{-1} sec^{-1}$

D_{10} = expressed in cm

Seepage Velocity → True Velocity

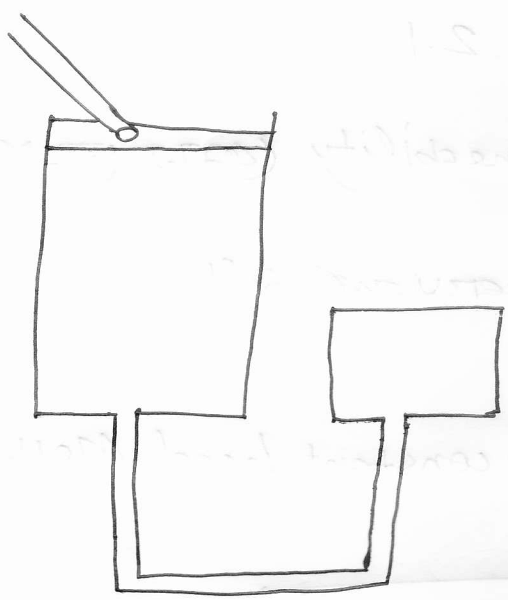
Discharge Velocity → Apparent Velocity → fictitious Velocity

$$\frac{V_D}{V_S} = \frac{A_V}{A_g}$$

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

$$V_D = n \times V_S$$

~~$V_S < V_D$~~ $V_S > V_D$



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

$$= k \times h/L \times A$$

$$k = \frac{Q}{t} \times \frac{L}{h} \times \frac{1}{A}$$

This test holds good if k is greater than 10^{-2} mm/sec (Coarse, clean sand)

Page-43, Table 2.1

Soil এর permeability কেমন দেখার আছে।

Practically impervious soil

Improvement of constant head Method.

(10^-5 – 10^-2) mm/sec এটার জন্য constant head method উপযুক্ত হয়।

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The K value of lab determination is often misnomer →

a) field condition achieve করা সম্ভব নয়।

b) ~~Air of voi~~ Void এ entrapped আর্দ্র থাকে।

c)

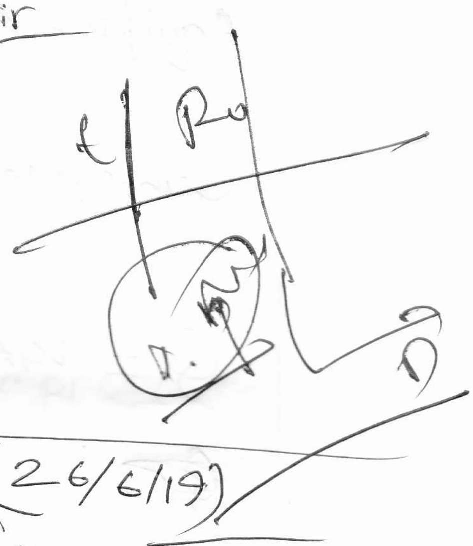
শনিবার => ২:৩০ → Soil ct - Muqtadir sir

রবিবার => ১১-১২ tr → extra class

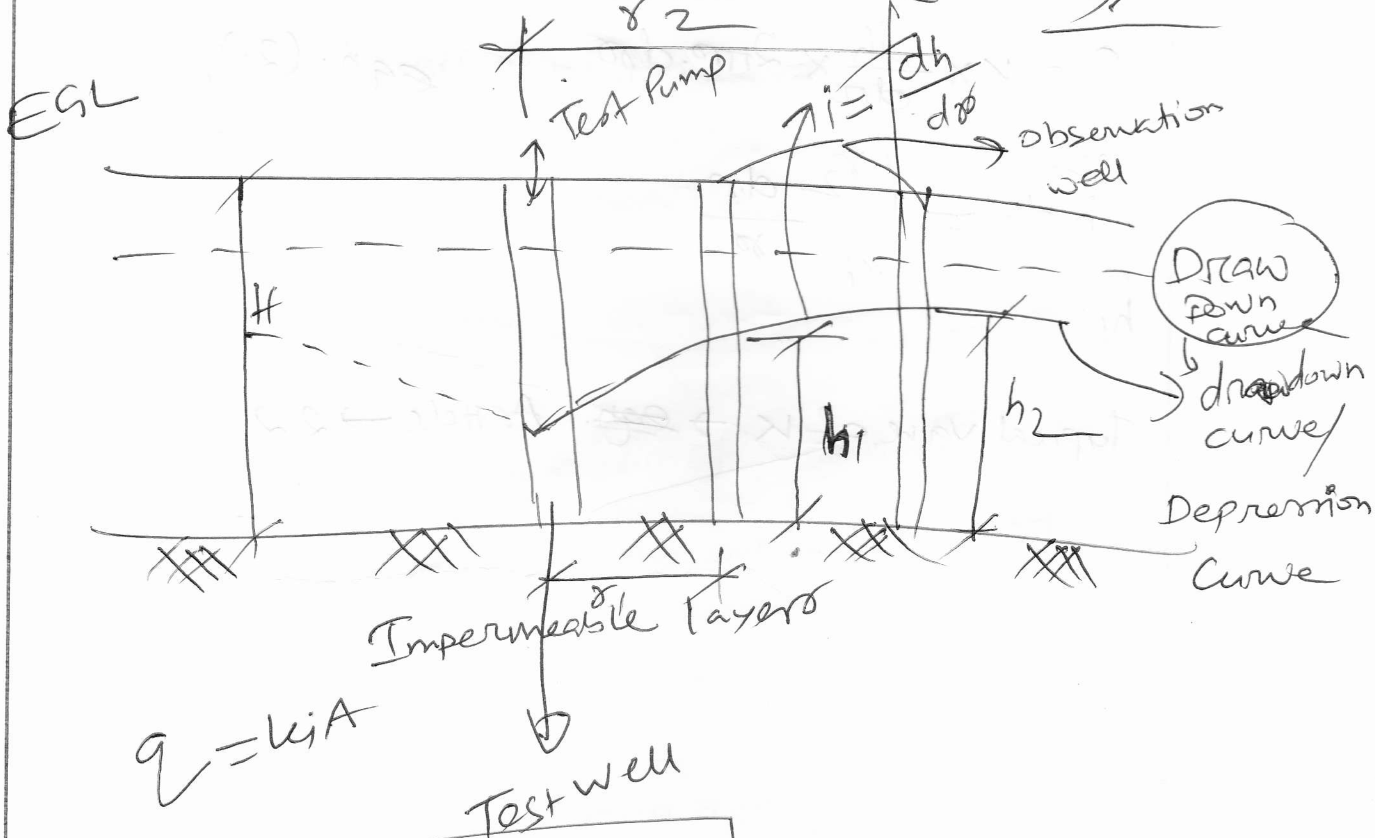
রবিবার => Delwan sir ct

সোমবার => Tahsin sir ct

মঙ্গলবার => PPC ct



Muqtadir sir → Lec 8 (26/6/19)



$q = kiA$

Field determination of k value

↳ Very expensive test

বড় Project এ করা হয়।

Aquifer : A porous formation

Sub-soil investigation report থেকে H আসে।

$$Q = KiA$$

$$Q = K \times \frac{dh}{dr} \times 2\pi r . dr \qquad eq^n . (2.7)$$

$$\int_{h_1}^{h_2} h . dh = \int_{r_1}^{r_2} \frac{dr}{r}$$

Typical value of K → Article → 2.2

Stress at a point on a plane.

The total Stress at a point through a section of a saturated soil on a plane composed of two parts; one part is called neutral stress or pore water pressure or hydrostatic stress which acts in water and on soil skeleton with equal magnitude in all direction.

$$p = u_w + \bar{p}$$

$$\bar{p} = p - u_w$$

Neutral stress

Effective stress in excess of pore water pressure ~~with~~ which exclusively acts on the contact point of soil skeleton.

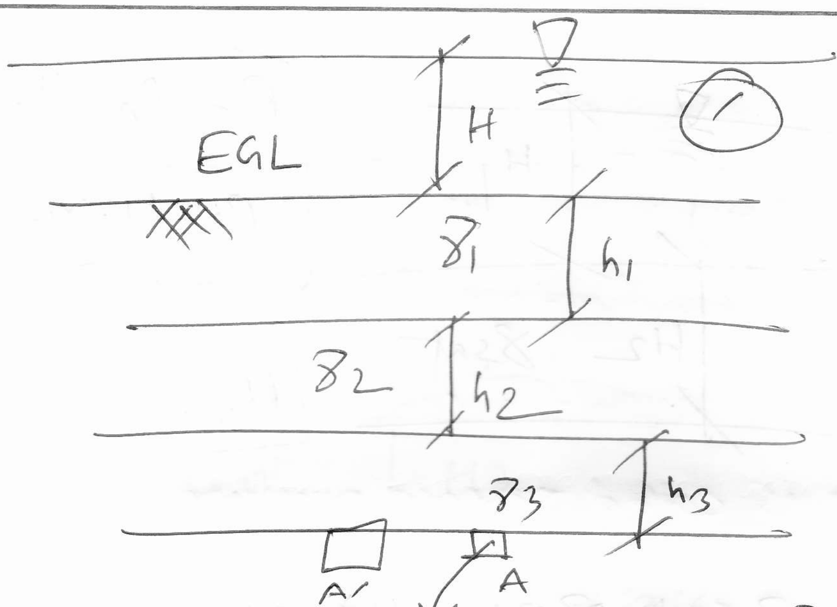
Geotechnical engineer এ stress বলতে generally effective stress কে mean করে।

The effective stress is responsible for inducing volume change behavior in soil and it also provides the frictional resistance.

On the other hand, pore water pressure has no role in causing volume change behavior nor does it provide any frictional resistance.

1925 – Carl → (Father of soil mechanics)
Developed this theory.

Total stress is the stress contributed by the overlying material.



stress here = $\gamma_1 h_1 + \gamma_2 h_2 + \gamma_3 h_3 = P_A$
(without saturation)

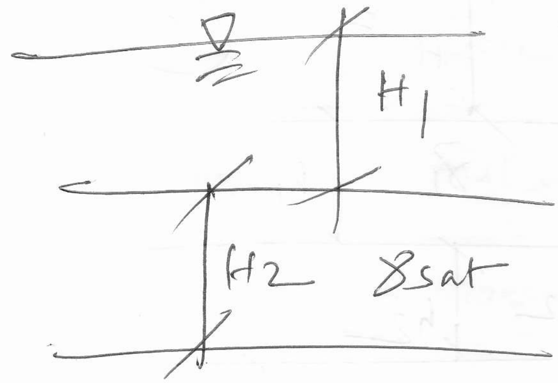
If there is a water layer of H above EGL,

$$P_A = \gamma_w H + \gamma_{1\,sat} h_1 + \gamma_{2\,sat} h_2 + \gamma_{3\,sat} h_3$$

Pore water pressure is derived by using principle of hydraulics.

$$\text{Pore water pressure} = \gamma_w (H + h_1 + h_2 + h_3)$$

$$\text{Effective stress} = P_A - \text{Pore water pressure}$$



$\bar{P} = P_A - u_{wA}$

$P_A = H_1 \gamma_w + H_2 \gamma_{sat}$

$u_{wA} = (H_1 + H_2) \cdot \gamma_w$

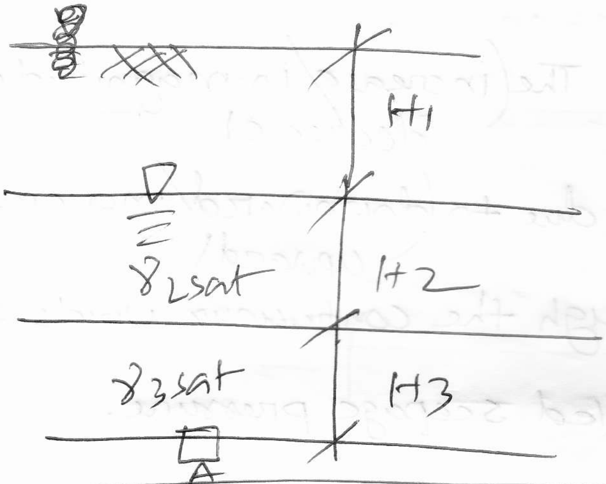
$\bar{P} = H_1 \gamma_w + H_2 \gamma_{sat} - H_1 \gamma_w - H_2 \gamma_w$

$= H_2 (\gamma_{sat} - \gamma_w)$

$= H_2 \gamma'$ $\gamma' \rightarrow$ submerged Unit weight

$H_2 \rightarrow$ Submerged soil layer এর Height

Effective stress is independent of the height of water above soil
↓
H_1



(at No flow condition)

$$\bar{P}_A = H_1\gamma_1 + H_2\gamma_2' + H_3\gamma_3'$$

Reservoir, containers

$$\text{Pore water pressure} = (H + H_1 - h)\gamma_w$$

$$H\gamma' + h\gamma_w$$

$$\frac{h}{H} z\gamma_w$$

$$= iz\gamma_w$$

seepage Pressure

$$\bar{P}_{a-b} = \gamma' z + iz\gamma_w$$

Seepage Pressure : The (increase / decrease) in magnitude of effective stress due to (downward / upward) movement of water ~~is~~ through the continuous voids of soil sample is called seepage pressure.

Expression of seepage pressure $= i z \gamma_w$

It is the result of frictional drag of the flowing water onto the soil skeleton.

$$\bar{P}_{a-b} = \gamma z' \pm i z \gamma_w$$

$$\bar{P}_{a-b} = \gamma z' - iz\gamma_w$$

$$\boxed{\bar{P}_{a-b} = 0}$$

$$\boxed{i = \frac{\gamma z'}{\gamma_w z}}$$

→ critical Hydraulic gradient (at which effective stress = 0)

Completely losses it's strength

co-efficient of permeability will be very high.

Agitation or boiling condition will appear (bubbles of water)

Quick Sand condition

Quick sand is not any type of sand and it refers to a condition when effective stress = 0

Generally it occurs in fine silty sand. clay হবে না,
Coarse sand or gravel এও হবে না।

In water to exist quick condition, we will have to satisfy two criteria —

(a) The strength of the soil must be proportional to the effective stress ~~and~~ (b) the effective stress must reduce to zero.

(১) বিশেষ velocity দরকার quick condition achieve করতে হবে যেটা gravel, coarse sand এ possible না।

Critical Hydraulic gradient