8.11.2015

Muqtadir Sir

Consolidation Characteristics of Soil

- Karl Tarzaghi ⇒

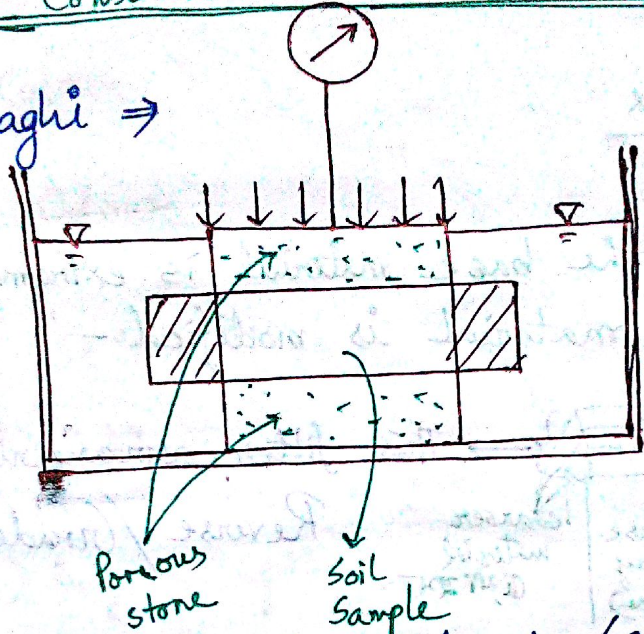
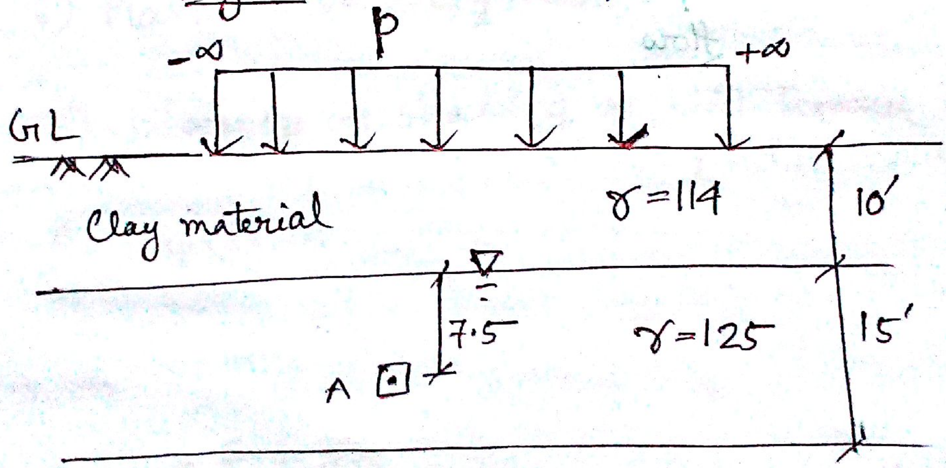


Fig: Consolidometer/Oedometer

* mainly settlement decrease করার হচ্ছে Engg. purpose



p load concentrated হলে slowly নিচে disperse করত। but এখানে infinity পর্যন্ত load আছে। So কমবে না।

before load giving —

effective stress

$$\bar{p}_A = 114 \times 10 + (125 - 62.5)\,7.5$$

soil skeleton এর

$$u_A = 7.5 \times 62.5$$

Scanned by CamScanner

* Clay ⇒ coefficient of permeability extremely low ⇒ So pore water বের হতে পারবে না।

⇓

So after giving load, ওই load এর পরিমাণ pressure excess develop করবে as excess pore water pressure

⇓

But অল্প কিছু permeability-র জন্য with time কিছু H_2O বের হবে So dissipation of H_2O হবে

⇓

এই পরিমাণ H_2O বের হওয়ার ফলে এই pressure তখন Soil skeleton নেবে।

⇓

So with time যে পরিমাণ H_2O dissipate করবে, ঐ পরিমাণ effective stress increase করবে, which will be carried out by $\boxed{\text{Soil skeleton}}$

Scanned by CamScanner

* Clay ⇒ coefficient of permeability extremely low ⇒ So pore water বের হতে পারবে না।

⇓

So after giving load, যে load এর পরিমাণ pressure excess develop করবে as excess pore water pressure

⇓

But অল্প কিছু permeability-র জন্য with time কিছু H_2O বের হবে So <u>dissipation of H_2O</u> হবে

⇓

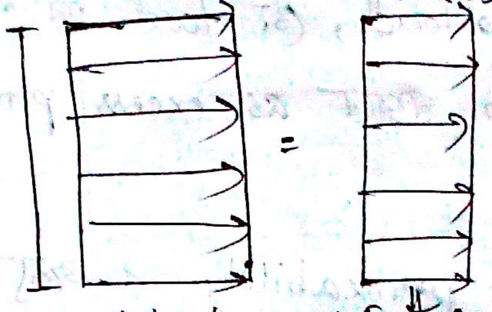
এই পরিমাণ H_2O বের হওয়ার ফলে এই pressure তখন Soil skeleton নেবে।

⇓

So with time যে পরিমাণ H_2O dissipate করবে, ঐ পরিমাণ <u>effective stress</u> increase করবে, which will be carried out by $\boxed{\text{Soil skeleton}}$

Let, $P = 2\,ksf$ $\therefore$ P = excess pore H_2O pressure

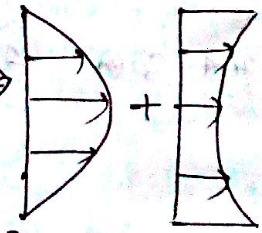
$= 2\,ksf$



at $t = t_0$ → Excess pore H_2O pressure & at that very instant of giving load

$\boxed{\text{effective stress} = 0}$

at $t = t_1 \Rightarrow$



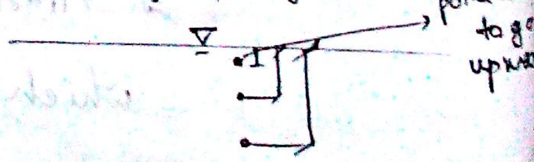
Pore H_2O Pressure

Effective stress

⇓

i.e. dissipated H_2O pressure.

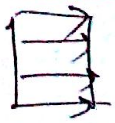
Sand / soil / clay



যত নিচের particle path তত বেশি So dissipation rate কমে যাচ্ছে

So the shape of the pressure dia is ⇒

At $t = \infty$  will be 0

and  will be exactly 

- Diff. bet^n Compaction & Consolidation —

Compaction ⇓ particially saturated so both air & water will dissipate

Consolidation ⇓ fully saturated so only H_2O dissipate হবে

- Def^n of Consolidation —

Consolidation is a time dependent phenomena associated with the dissipation of excess pore H_2O pressure.

The process of gradual load transfer from pore water to soil skeleton & the corresponding gradual compression is called Consolidation.

⇓

This compression results in the settlement of structure

Tarzagi Def^n — A decrease in H_2O content of a saturated soil mass without the replacement of H_2O by air is called process of Consolidation.

Scanned by CamScanner

• Consolidometer

Cylindrical shape cup opened at both end.

(6-10)m ⇒ dia

Height = 3/4" to 1".

- Porous stone acts like a filter material.
- Pressure given is = field pressure and 24 hrs রেখে দিব
- Incremental way তে load দিব & কতটুকু compression/settlement হল দেখব।

⇓

Consolidation এর time এ vol^m change হবে becz of ↓ voids which is related to void ratio (e).

load দেওয়ার সাথে সাথে it is transferred as excess pore water pressure.

Then with time it will be converted to effective stress.

At one time after giving load there is no settlement ⇒ This proves all the stress will be converted to effective stress.

Scanned by CamScanner

load Increment — Time

load Increment	Time
25 kPa.	15 sec, 30 sec, 1 min, 2, 4, 8, 15, 30, 1 hr, 2 hr, 4 hr, 8 hr, 24 hr. (for every loading)
50	
100	
200	
400	
800	
1600	
3200	

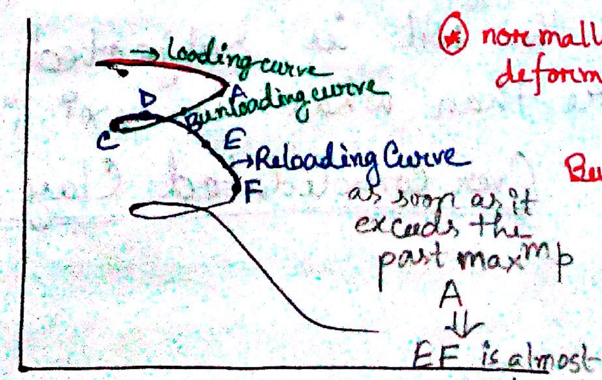
Monotonically load বাড়িয়ে then at a time 1/4 th load unload করি। Next step-এ approx. 50 kPa থেকে

* দুটি analysis (Imp.)

1. consolidation rate
   i.e. total এর 80–90% হতে কত সময় লাগে
2. & Total magnitude of settlement
   ⇓
   This takes infinity time. (for foundation design)

At the end of each load increment, we have to calculate void ratio (e)

Initial void ratio, $e = \omega G_s$
↓
e at field, $S_r = 1$



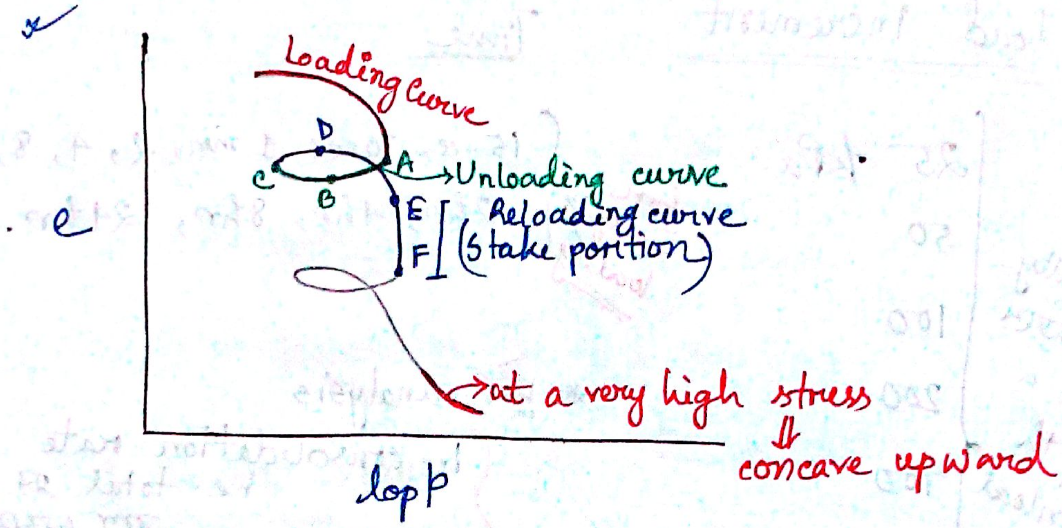
Void ratio

log (p)
↓
effective stress

* normally 24 hrs এর পর significant deformation হয় না। So we can stop.
⇓
But unfortunately for organic soil, 24 hrs এর পরও sig. deformation হয়।

* unload করলে expand করবে So ABC also Expansion Curve

9.11.15



- Types — actually represents the condition of the soil.

1) Normally Consolidated Soil —

— if the existing pressure (overburden effective pressure) on the soil is the max^m pressure that the soil has been subjected to in its lifetime/stress history, then the soil is called Normally Consolidated Soil (clay) ⇒ NC (mostly used.)

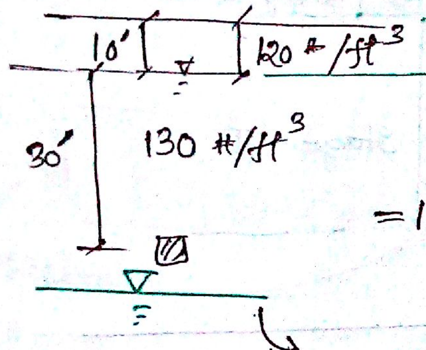
80% of our soil.

2) Over Consolidated Soil —

— If the soil is subjected to a pressure which is more than what is existing now, then the soil is called Over Consolidated Clay (OC).

Scanned by CamScanner

- Due to fluctuation of water table —



→ previous

- about 100 years before —

$= 120 \times 10 + (130 - 62.5) \times 30$

for this, $120 \times 40 \Rightarrow$ more

V. Imp. Water table ↓ (নিচে নামালে) ⇒ OC

" " ↑ (উপরে গেলে). ⇒ NC

1. Very stiff in nature

2. Magnitude of settlement is less.

- Over Consolidation Pressure (p_c) —

past max^m pressure to which the soil is subjected to is called Over Consolidation Pressure.

Current pressure = p_o

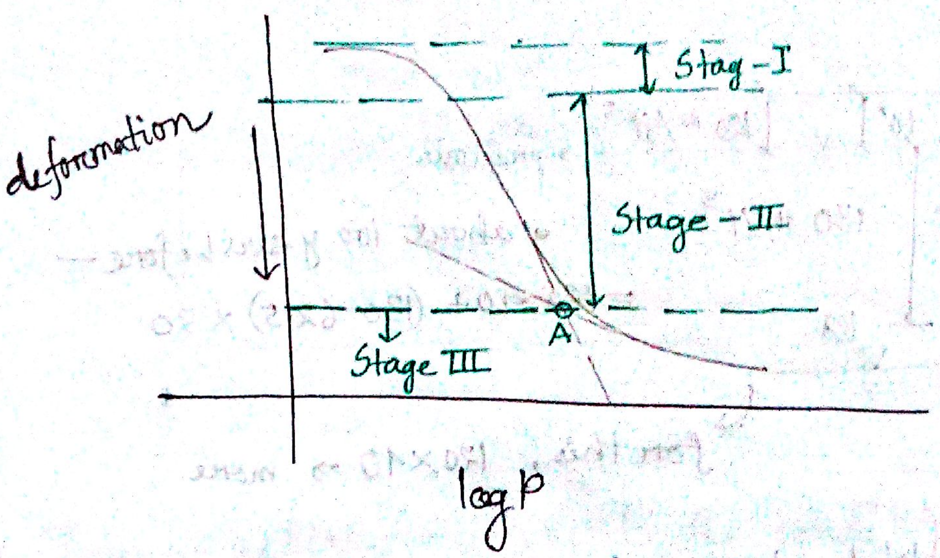
∴ Over Consolidation ration (OCR) $= \dfrac{p_c}{p_o}$

$< 1 \Rightarrow$ NC

$> 1 \Rightarrow$ OC

⊛ ∵ higher the degrees of consolidation, OCR ↑.

Scanned by CamScanner



- 3 Stages —

Stage-1 / Initial ~~stage~~ consolidation

Stage-2 / Primary Consolidation ⇒ deformation due to primary consolidation ⇓ w.r.t excess pore water pressure completely dissipates ⇓ ⩾95% magnitude of settlement carries

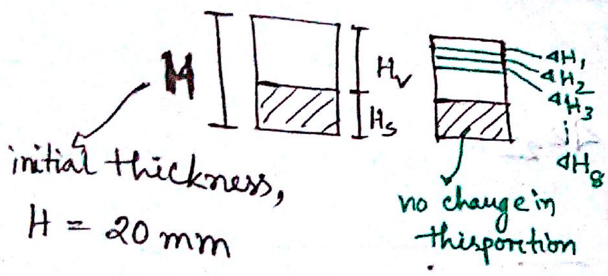
Stage-3 / Secondary Consolidation ⇓ We assume at A, all pore water pressure has dissipated & further settlement for particle reorientation / elastic deformation ⇓ i.e. for secondary consolidation.

the deformation for H_2O & soil skeleton (negligible)

V.V. imp. { Inorganic ⇒ Stage II & stage III is negligible
Organic ⇒ stage II is very important

• Steps in determining e vs logp curve —

1. Determining H_s —



$$H_s = \frac{W_s}{A\, G_s \gamma_w}$$

W_s → dry wt. of soil after test

G_s ↓ By Pycnometer

2. $H_v = H - H_s$

3. Initial void ratio — (before loading)

$e_0 = \frac{H_v}{H_s}$ or we can get by alternative way —

$e_0 = w G_s$ (for $S_r = 1$)

4. for the first incremental loading P_1 causing a deformation of ΔH_1 ⇒

∴ change in void ration, $\Delta e_1 = \Delta H_1 / H_s$

5. Calculation existing void ratio after the load transfers to effective stress — $e_1 = e_0 - \Delta e_1$

Scanned by CamScanner

6. for the next increment of loading P_2 and the corresponding deformation ΔH_2 and change in void ratio, $\Delta e_2 = \frac{\Delta H_2}{H_s}$

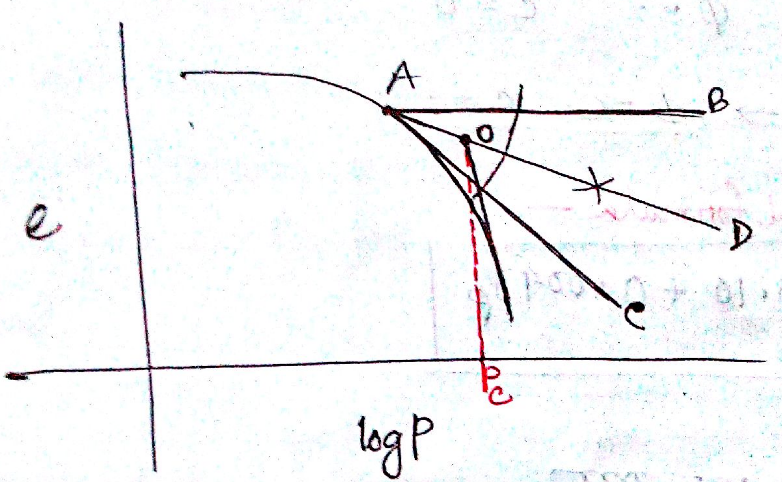
7. And, $e_2 = e_1 - \Delta e_2$

and so on ....

Scanned by CamScanner

15·11·15

⊛ Determination of Preconsolidation pressure p_c :



1. By visual inspection, select a point A which gives you min^m radius of curvature / max^m curvature

2. Draw a tangent to the curve from A ⇒ AC

3. Bisect the angle BAC by AD.

4. Draw a tangent to the straight portion of the curve which intersects AD at O.

5. The pressure corresponding to O ⇒ P_c

Liquidity index

OC = 0-0·6 ~~1·0~~

NC = 0·6-1·0

Scanned by CamScanner

- Shear strength parameter (c, ϕ)

Sandy $\rightarrow$ $\phi = ---$ $\quad c = 0$

Pure clay $\rightarrow$ $\phi = 0$ $\quad c = ---$

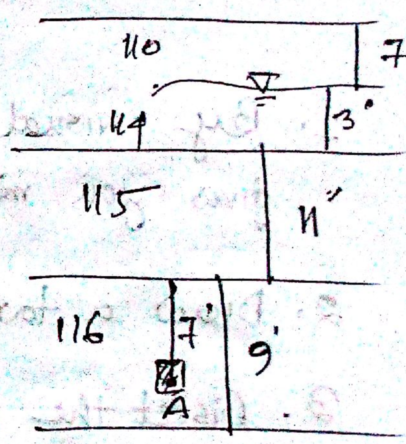
- Empirical formula —

$$\boxed{\frac{c}{p_c} = 0.10 + 0.004 I_p}$$

$\Downarrow$

(p_c value বের করব

$\Downarrow$ Then field-এর p_{o_A} বের করব।)



$p_{o_A} > p_c \Rightarrow NC$

$p_{o_A} < p_c \Rightarrow OV$

Existing overburden pressure. $p_{o_A} = 110\times7 + (114-62.5)\times3$

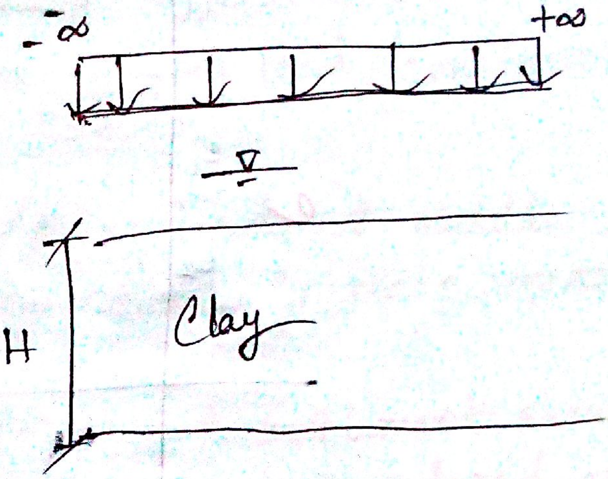
$+ (115-62.5)\times 11$

$+ (116-62.5)\times 7$

- Computation of the settlement –

Basic assumption

Clay layer subjected to uniform strain across its thickness for the load

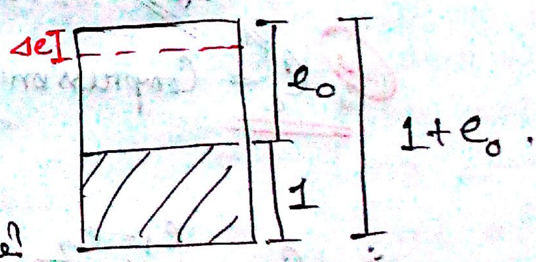


Settlement,

$S = H\varepsilon$

uniform strain

or, $\varepsilon = \dfrac{S}{H}$



$\therefore \dfrac{\Delta e}{1+e_0} = \dfrac{S}{H}$

how to determine?

$\because \varepsilon = \dfrac{\Delta e}{1+e_0}$

$\Rightarrow \boxed{S = H\dfrac{\Delta e}{1+e_0}}$

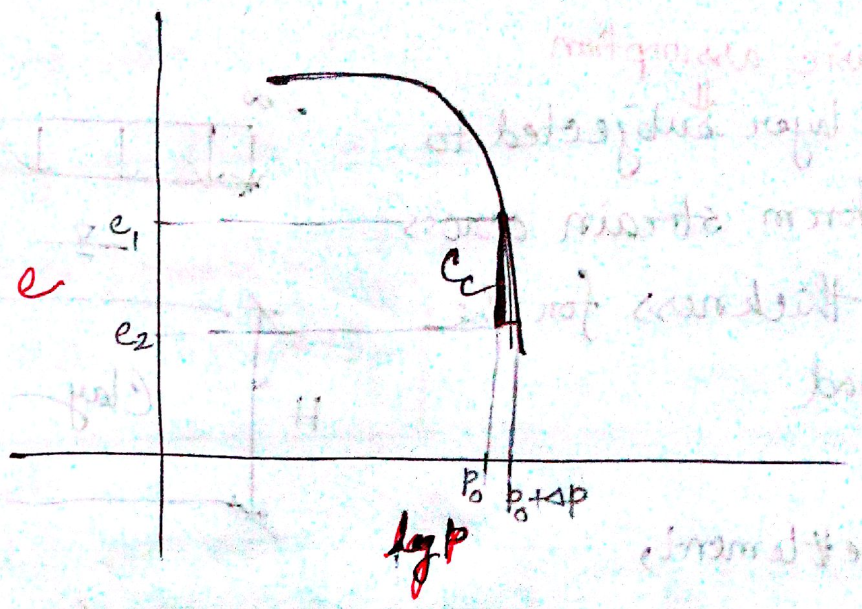
Δe → change in void ratio after giving load

e_0 → load দেওয়ার আগমুহূর্তের void ratio

S → settlement

H → thickness of the clay layer

Scanned by CamScanner



$\cdot 15 - \cdot 35 \Rightarrow$ এর plasticity ↑, C_c ↑.

C_c = Compression index = slope of the verticle portion of the curve.

$$\therefore C_c = \frac{e_1 - e_2}{\log(P_o + \Delta P) - \log P_o} = \frac{\Delta e}{\log \frac{P_o + \Delta P}{P_{o1}}}$$

$$\Rightarrow \Delta e = C_c \log \frac{P_o + \Delta P}{P_o}$$

$\therefore$ Settlement $\Rightarrow S = H \frac{C_c}{1+e_o} \log \frac{P_o + \Delta P}{P_o}$ $\Rightarrow$ valid for only NC Clay.

Suppose, for the above fig.

$e_o = e_1$

cz P_o ধরা হয়েছে প্রথমে

P_0 = যে layer-এর settlement compute করব ঐ layer-র middle-এ existing effective overburden pressure before applying load/construction

ΔP = after construction/giving load ঐ middle-এর ঐ point-এ কতটুকু stress increase হবে।

Example

$p_0 = 115\times 9 + (122-62.5)\times 4 + 7.5(118-62.4)$

$= 1.69$ ksf

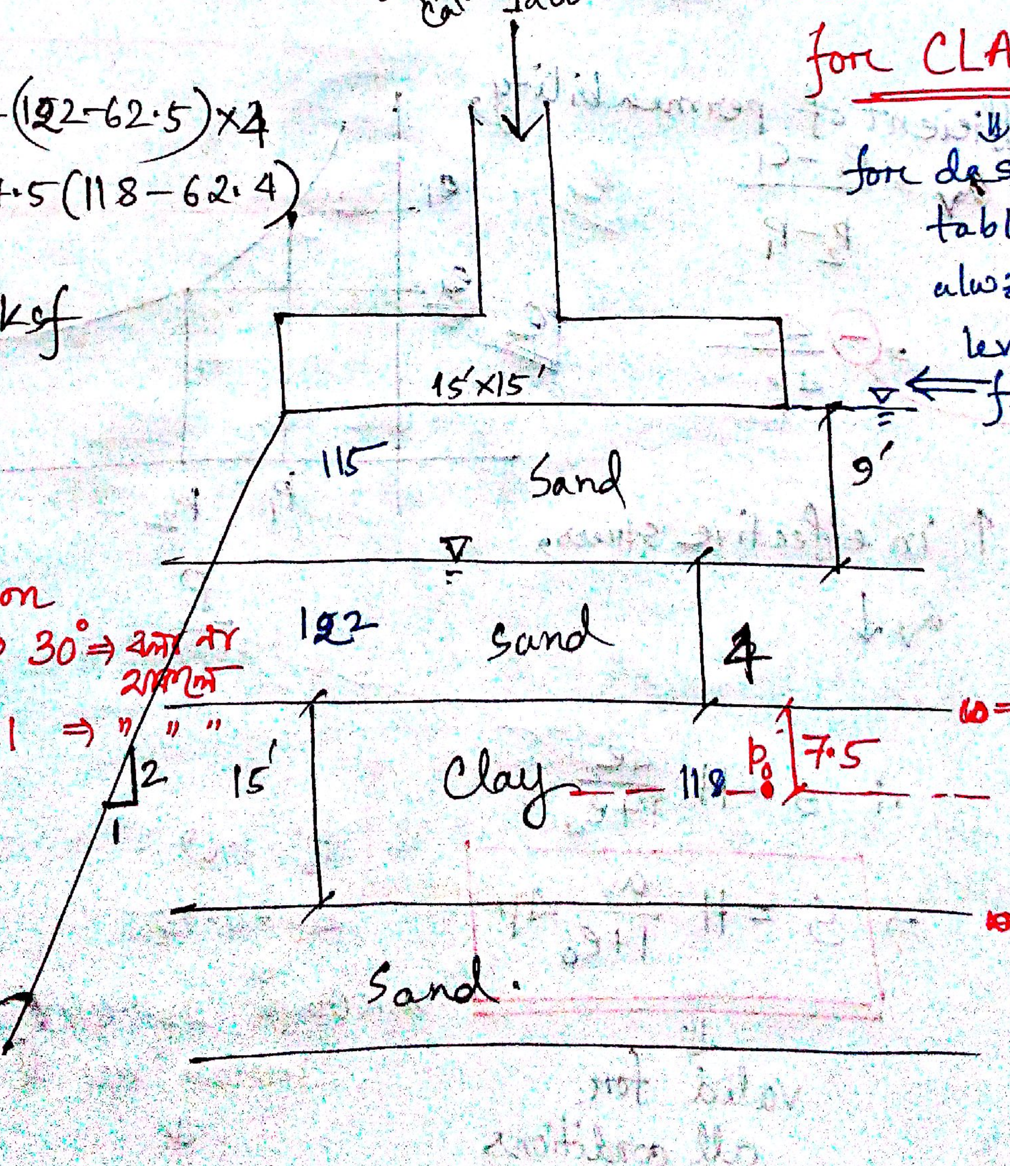
* Settlement should be considered only for CLAY

⇓

for design water table will be alwz at the level of foundation bottom.

⊛ dispersion angle ⇒ 30° ⇒ এটা ধরে নিলাম

& slope ⇒ 2:1 ⇒ " " "



Clay middle layer footing থেকে 20.5' নিচে আছে।
∴ 2:1 slope হলে hor. distance হবে 10.25.
⇓
So only the 15' layer-এর ver. distance হবে 35.5' এর প্রত্যেকে 2 side-এ 10.25 করে বেড়ে যাচ্ছে।

$$15 + 10.25 \times 2 = 35.5'$$

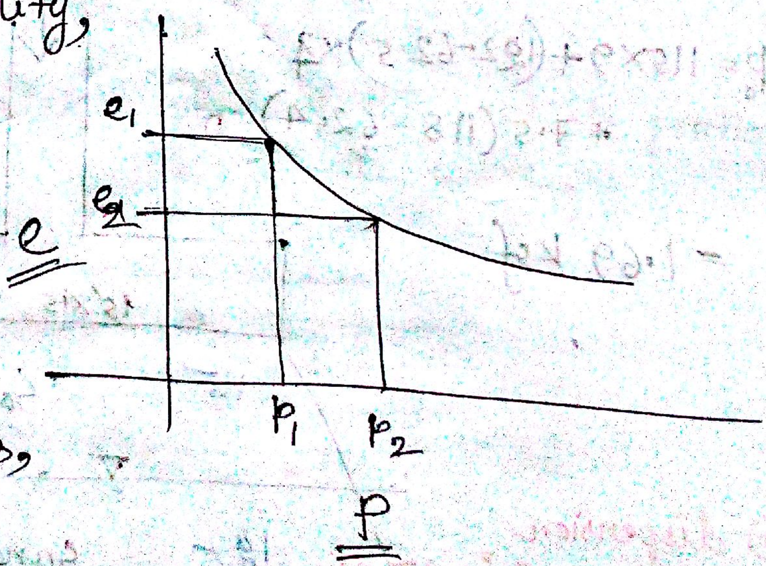
$$\Delta p = \frac{1200}{35.5 \times 35.5} =$$

$$\therefore e_0 = w G_s = .29 \times 2.7 =$$

⊛ Coefficient of permeability,

$$a_v = \frac{e_1 - e_1}{p_2 - p_1}$$

$$= - \frac{\Delta e}{\Delta p}$$



-ve becz একটা অন্যটার reverse with ↑ in effective stress, $a_v \downarrow$
⇓
তাই কারণেও আসছে - sign.

$$\therefore S = H \frac{\Delta e}{1+e_0}$$

$$\Rightarrow \boxed{S = H \frac{a_v}{1+e_0} \Delta p}$$

⇓
valid for all conditions

$p_0 = 1.69$
$\Delta p = 0.95$
⇓
curve Graph – $\Delta p_1 = 1.69$ ধরে then 0.95 increase করব & p_2 পাব।
⇓
e_0 হবে 1.69 এর corresponding

• Coefficient of vol^m compressibility — (m_v)

Volumetric strain per unit increase in effecting stress.

$$\varepsilon = \frac{\Delta L}{L_0}$$

$$m_v = \frac{\Delta V}{V_0} \cdot \frac{1}{\Delta p}$$

from block dia $\Rightarrow \dfrac{\Delta V}{V_0} = \dfrac{\Delta e}{1+e_0}$

$$\therefore \boxed{m_v = \frac{\Delta e}{1+e_0} \cdot \frac{1}{\Delta p}}$$

$$\Rightarrow m_v = \frac{\Delta H}{H} \cdot \frac{1}{\Delta p}$$

$$\therefore \Delta e = m_v (1+e_0) \Delta p$$

Settlement, $S = H m_v (1+e_0) \Delta p \,/\, \cancel{(1+e_0)}$

$\therefore \boxed{S = H m_v \Delta p}$ $\Rightarrow$ valid for all conditions.

Scanned by CamScanner

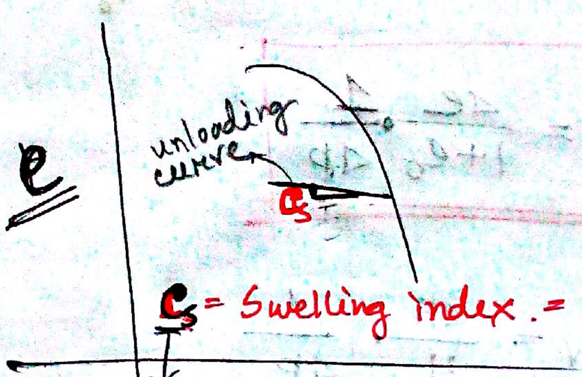
- Empirical formula —

$C_c = 0.009\,(LL-10) \Rightarrow$ undisturbed soil sample

$C_c = 0.007\,(LL-10) \Rightarrow$ ~~disturbed~~ " "
remolded

↓
বের হবে
e vs log p curve
থেকে ~~normally~~
এই ~~formula~~
থেকে ও করার
যায়

- Swelling Index



C_s = Swelling index = 10 – 20% of C_c
↓
for OC clay

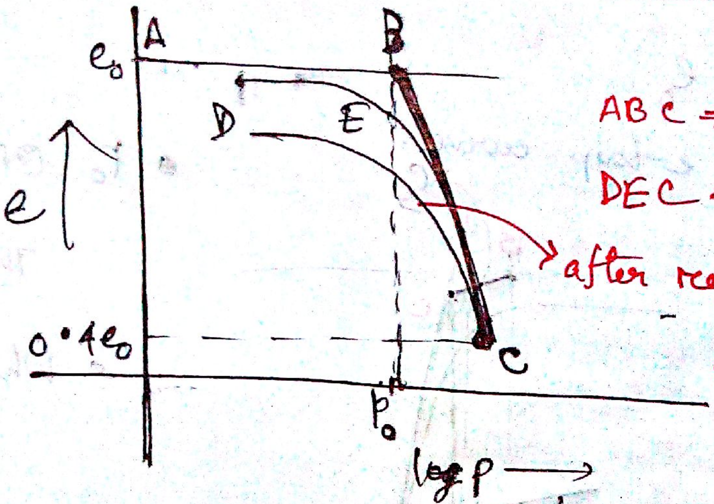
Scanned by CamScanner

Peck
V. Imp.

Max^m Settlement due to Primary Consolidation —

16·11·15

- Laboratory e-logp curve — (undisturbed) & NC Clay



ABC ⇒ field e-logp curve

DEC ⇒ laboratory e-logp "

after remolding ↓ degrees of disturbation ↑.

Impirical relat^n ship ⇒ SHartHan

⇓

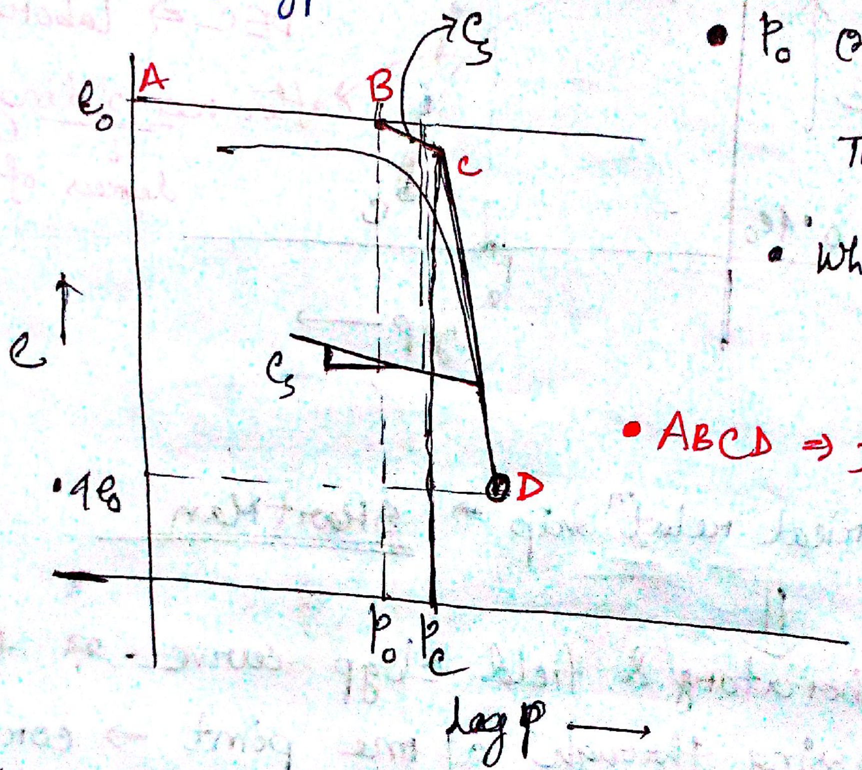
laboratory & field e-logp curve - ?? final straight portion passing through a one point ⇒ corresponds to 40% of e_0.

$$S = H \frac{C_c}{1+e_0} \log \frac{p_0 + \Delta p}{p_0}$$

⊛ for OC Clay

p_o, p_c, e_o.

Lab e-logp curve.



- p_o থেকে p_c যাবে ⇓ Then OC
- When crosses p_c ⇓ NC
- ABCD ⇒ field e-logp curve for OC clay

SMart Men ⇒

$\overrightarrow{BC}$, $S_1 = H \frac{C_s}{1+e_o} \log \frac{p_o + \Delta p}{p_o}$

where, $p_o + \Delta p < p_c$ p_o ↳ current/existing pressure

⇓

· এখানে BC portion-এর জন্য total S only 5% or <5% হয়। So ছোট project-এ হিসাব করা হয় না।

{ OC clay ⇒ যত load ↑ তত ভাল
{ NC " ⇒ যত " ↓ " "

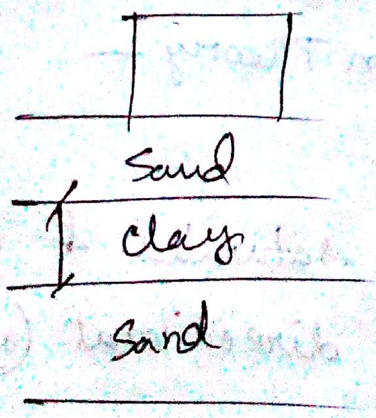
$\overrightarrow{CD}$, $S_2 = H \dfrac{C_c}{1+e_0} \log \dfrac{p_c + \Delta p}{p_c}$ or, $S_2 = H \dfrac{C_c}{1+e_0} \log \dfrac{p_0 + \Delta p}{p_c}$

where $p_0 + \Delta p > p_c$

cz its starts from c and so here initial pressure is p_c

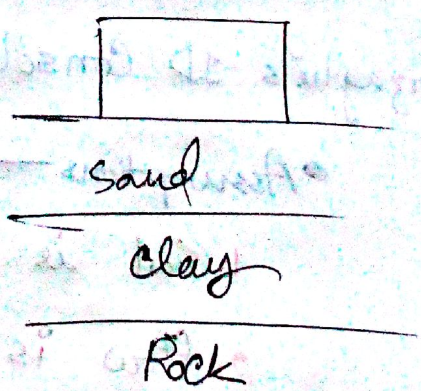
$$S = S_1 + S_2 = \frac{C_s H}{1+e_0} \log \frac{p_c}{p_0} + \frac{C_c H}{1+e_0} \log \frac{p_0 + \Delta p}{p_c}$$

$p_0 + \Delta p > p_c$



⇓

drainge in both way



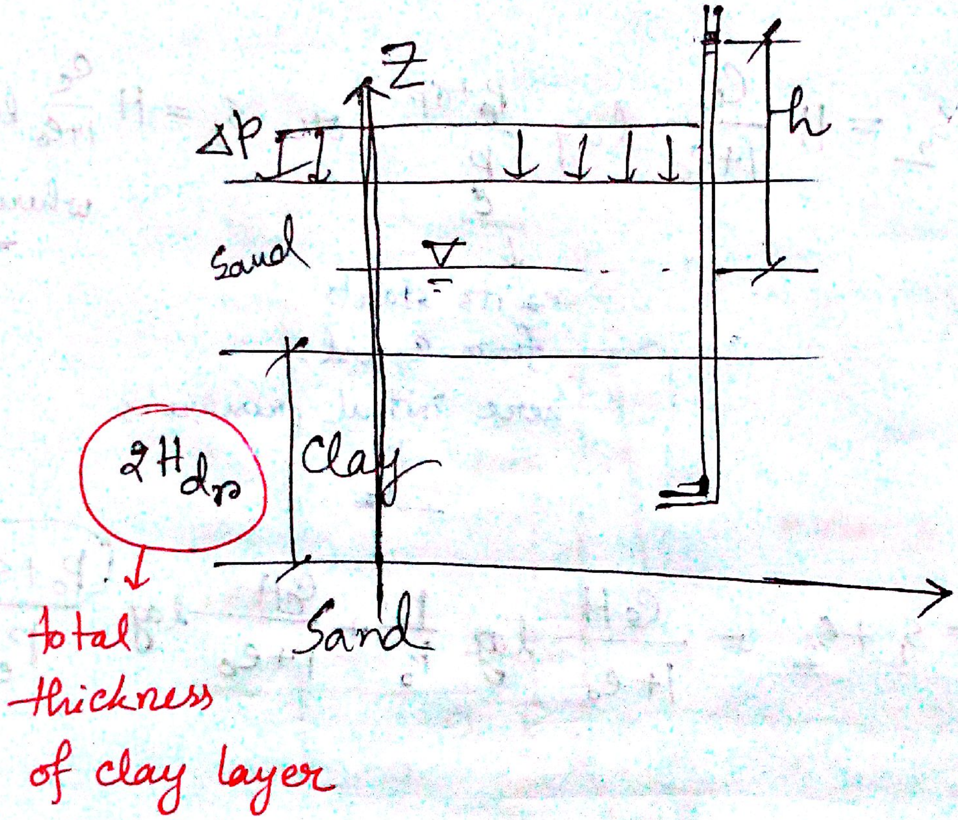
⇓

One way drainage ⇒ needs more time

* Magnitude of settlement will be same irrespective of drainage condition ⇒ only depends on $\boxed{\text{time}}$

- Settlement Rate —

extremely imp. for (embankment/road structure)



Terzaghi's 1D Consolidation Theory —

- Assumptions —

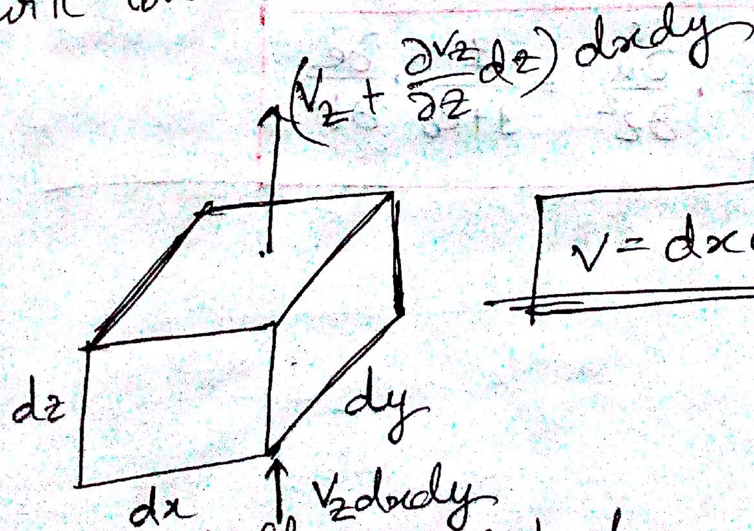
1. Soil is fully saturated & homogeneous, $S_r = 1$
2. Flow is one directional (only vertically)
3. Darcy's principle is applicable
4. Coefficient of permeability across the thickness remains constant ~~during~~ during the period of consolidation

5. Soil & H_2O particles are incompressible.

6. There is a unique rel^{n}ship exist bet^n void ration & the effective stress & this rel^{n}ship remains constant during the load increments which indicates m_v and a_v remains constants. for that particular load increment.

7. Secondary consideration is not applicable

8. Thickness of clay layer is small in compared will loaded area.



$$\boxed{V = dx\,dy\,dz}$$

Here, Outflow Rate − Inflow Rate = Rate of vol^m change.

$$\therefore \left(V_z + \frac{\partial V_z}{\partial z} dz\right) dx dy - V_z dx dy = \frac{\partial V}{\partial t}$$

$$\Rightarrow \frac{\partial V_z}{\partial z} dz dx dy = \frac{\partial V}{\partial t} \quad \text{——} \ 1$$

$$V_z = ki = -K \frac{\partial h}{\partial z}$$

for head loss

and $\underline{\underline{u}} = h\gamma_w \Rightarrow h = \dfrac{u}{\gamma_w}$

$\downarrow$

excess
pore water
pressure

From (i) $\Rightarrow$

$$-\frac{k}{\gamma_w}\cdot\frac{\partial^2 u}{\partial z^2}\,dxdydz = \frac{dxdydz}{1+e_0}\cdot\frac{\partial e}{\partial t}$$

Since $dxdydz \neq 0$.

$$\boxed{-\frac{k}{\gamma_w}\cdot\frac{\partial^2 u}{\partial z^2} = \frac{1}{1+e_0}\cdot\frac{\partial e}{\partial t}}$$

$$V = \underbrace{V_s}_{\text{const}} + V_s$$

$$\Rightarrow \frac{\partial}{\partial t}(V_s + W) = \frac{\partial V_s}{\partial t} + \frac{\partial e V_s}{\partial t}$$

$$\Rightarrow V_s \frac{\partial e}{\partial t}$$

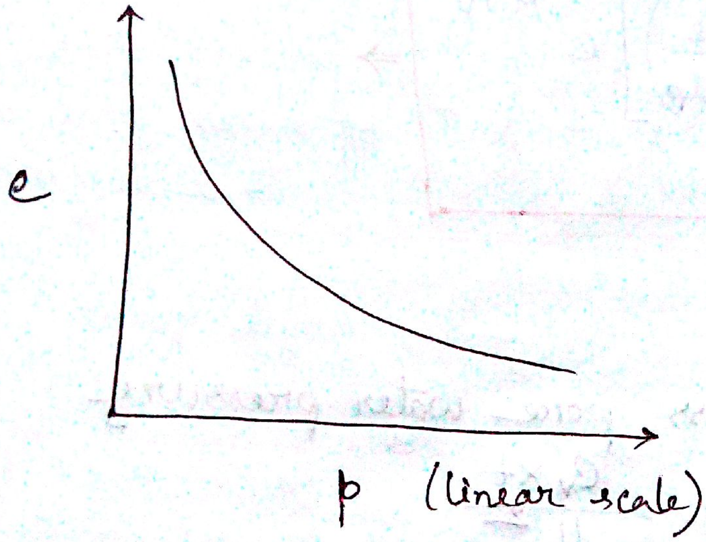
From block dia

$$\frac{V_s}{V} = \frac{1}{1+e_0} \Rightarrow V_s = \frac{V}{1+e_0}$$

$$\Rightarrow V_s = \frac{dxdydz}{1+e}$$

Scanned by CamScanner

22·11·15



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

$$\cancel{\partial p}^{\,0} = \partial \bar{p} + \partial u$$

$$\Rightarrow \underline{\partial \bar{p} = -\partial u}$$

$$a_v = \frac{\Delta e}{\Delta p} = \frac{\partial e}{\partial p}$$

$$\partial e = a_v \partial p = -a_v \partial u$$

$$\therefore\ -\frac{k}{\gamma_w} \cdot \frac{\partial^2 u}{\partial z^2} = \frac{1}{1+e_0} \cdot \frac{\partial e}{\partial t} = -\frac{a_v}{1+e_0} \cdot \frac{\partial u}{\partial t} = -m_v \frac{\partial u}{\partial t}$$

$$\frac{\partial u}{\partial t} = \frac{k}{\gamma_w m_v} \cdot \frac{\partial^2 u}{\partial z^2}$$

$$\Rightarrow \boxed{\frac{\partial u}{\partial t} = \underset{\text{Coefficient of Consolidation}}{\underline{C_v}} \frac{\partial^2 u}{\partial z^2}} \Rightarrow \text{1 D Consolidation eq}^n\text{—}$$

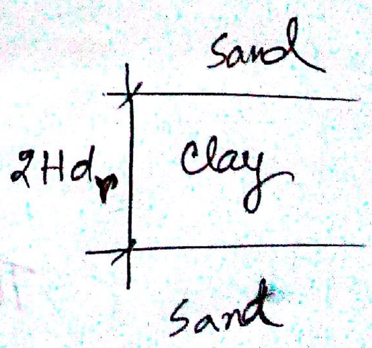
Boundary Conditions —

$z = 0$, $u = 0$.

$z = 2H_{dr}$, $u = 0$

Initial Condition —

$t = 0$, $u = u_0$



⇓

excess pore water pressure 2 way এ যেতে পারবে

$$\boxed{u = \sum_{m=0}^{\infty} \left[\frac{2u_0}{M} \sin\left(\frac{Mz}{H_{dp}}\right) \right] e^{-M^2 T_v}}$$

$\Rightarrow$ at any time, magnitude of excess pore water pressure is determined.

when, $M = \frac{\pi}{2}(2m+1)$

u_0 = Initial excess pore water pressure

T_v = time factor $= \frac{C_v \times t}{H_{dp}^2}$

⊛ **Degrees of consolidation** (associated with particular point) means that excess pore water pressure dissipated divided by initial excess pore water pressure.

$$\therefore \boxed{U = \frac{u_0 - u_z}{u_0} = 1 - \frac{u_z}{u_0}} \; ;$$

u_z = at any time pore water pressure

U = degrees of consolidation.

$\Downarrow$

across the thickness u_z এর avg. value পেতে চাই

But ∞ no of u_z আছে, So intergrate করতে হবে।

Then 2H দিয়ে ভাগ করব।

$\Downarrow$

This is Average degree of consolidation

Scanned by CamScanner

$$\boxed{\underline{U} = 1 - \left(\frac{1}{2H_{dr}} \int_0^{2H_{dr}} u_z \, dz \right) / u_0}$$

average degrees of consolidation

$$\Rightarrow \boxed{U = 1 - \sum_{m=0}^{\infty} \frac{2}{M^2} e^{-M T_v^2}}$$

$\Rightarrow$ Very very converget. So একটা term নিয়ে কাজ করলেই approximately 99.99% accuracy পাওয়া যাবে।

and $T_v = \dfrac{C_v t}{H_{dr}^2}$ $\Rightarrow$ $C_v \Rightarrow$ laboratory determination

So we will test for $m = 0$.

$$\left.\begin{aligned} &\text{Then, } U = 1 - \frac{2}{M^2} e^{-M T_v^2} \\ &\text{and } M = \frac{\pi}{2}(2n\pi + 1) \end{aligned}\right\} \Rightarrow \boxed{U = 1 - 0.811\, e^{-2.467 T_v}}$$

$T_v \Rightarrow$ 50% consolidation $\Rightarrow$ 0.197

and $T_v \Rightarrow$ 90% " $\Rightarrow$ 0.848

$$T_v = \frac{\pi}{4}\left(\frac{U}{100}\right)^2 \quad ; \quad U \leq 60$$

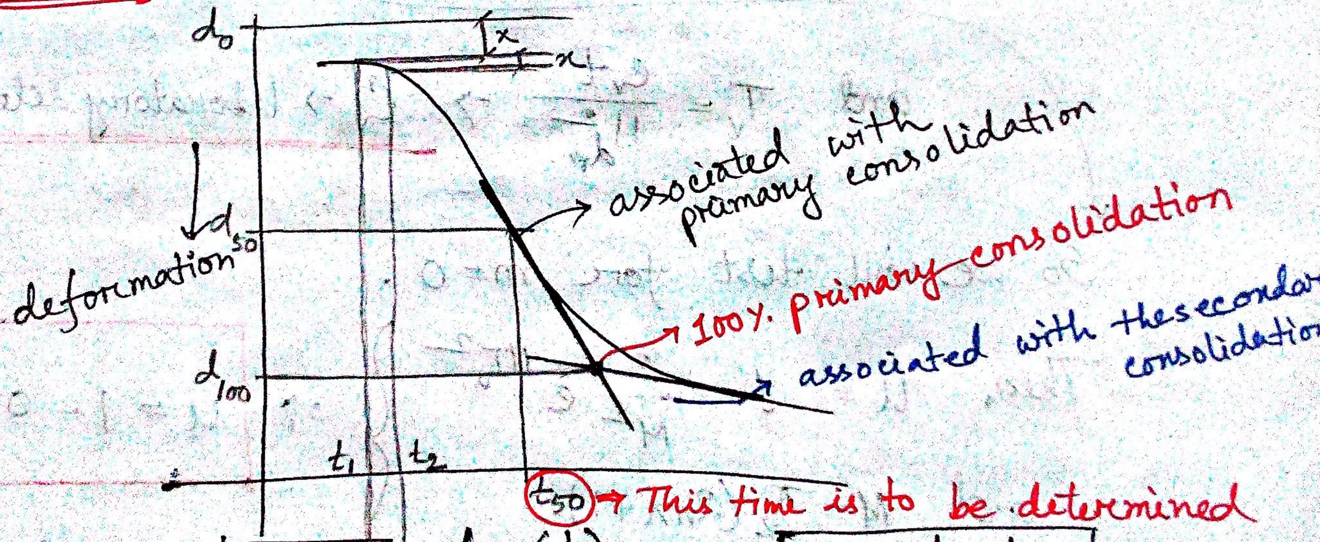
$$T_v = 1.781 - 0.933 \log_{10}(100 - U) \quad ; \quad U > 60$$

- Determination of C_v –

⇒ 1. Cassagrande & Fadum – 1940 ⇒ logarithm of time method

⇒ 2. Taylor's Method – 1942 ⇒ square root of time

Cassagrande :



$\boxed{t_2 = 4t_1}$ $\log(t)$ and $\boxed{d_{50} = \frac{d_0 + d_{100}}{2}}$

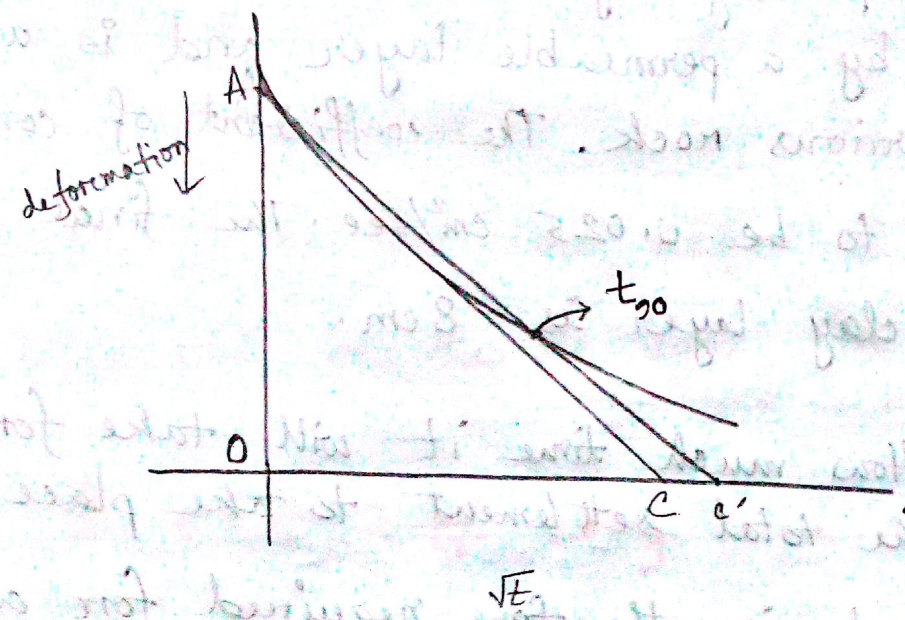
→ from graph

$$\underset{\substack{\downarrow \\ .197}}{T_v} = \frac{C_v \times t_{50}}{\underset{\substack{\Downarrow \\ \text{known}}}{H_{dr}^2}} \Rightarrow \text{from this } \underline{C_v \text{ is known}}$$

$$\text{Now, } C_v = \frac{K}{m_v \gamma_w} \Rightarrow \underline{K = C_v m_v \gamma_w}$$

(from this K determined)

Taylor's Method :



$$0.848 = \frac{C_v t_{90}}{H_{dr}^2}$$

$OC' = 1.15\, OC$

$\Downarrow$

15% বেশি নেওয়া হয়েছে।

$$T_{\frac{U}{I}} = \frac{\pi}{40}\left(\frac{U}{100}\right)^2$$

Initial value = 0.636

$\Downarrow$

but হওয়া উচিত 0.848

∴ ভুল হল 4

∴ ভুল $= \sqrt{\frac{.848}{.636}} = 1.15$

$\Downarrow$

That's why

$OC' = 1.15\, OC$

29·11·15

Problem-1

A 3m ~~deep~~ thick clay layer beneath a building is ~~under~~ over laid by a permeable layer and is underlaid by a impervious rock. The coefficient of consolidation is found to be 0.025 cm^2/sec. The final settlement for the clay layer is 8 cm.

a) How much time it will take for 80% of the total settlement to take place? 3.883 yrs

b) Determine the time required for a settlement of 2.5 cm. 198 days

c) Compute the settlement that would occur at the end of 1 year, 3.43 cm

Scanned by CamScanner

Problem-3

A building constructed on a compressible layer with double drainage settle by 8 mm in 4 years. a) What will be the settlement in 9 years if the final settlement is expected to be 300 mm. 120 mm

b) What will be the time required to settle by 210 mm? 28.8 yrs.

c) What will be the settlement in 25 years? 198 mm

5 - 2.3 3 $eq^n s$ using C_c, a_v, m_v → final settlement for 100% primary consolidation.

and |final settlement| is indepent of drainage condition.

Scanned by CamScanner

Problem-3

An undisturbed soil sample of a clay layer of 2m thick was tested in the lab and C_v was found to be 2×10^{-4} cm^2/sec. If a structure is built on the clay layer stratum, how long it will take to attain half of its settlement under the load of the structure.

(Assume double drainage)

$$T_v = \frac{C_v t}{H_{dr}^2}$$

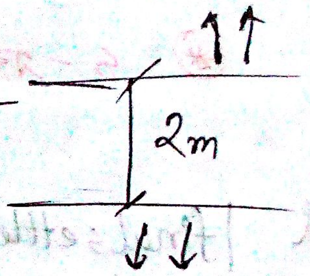
$$\Rightarrow t = \frac{.197 \times 100^2}{2\times10^{-4}}$$

$$\Rightarrow t = 9850000 \text{ sec}$$

$$\Rightarrow t = \underline{\underline{114 \text{ days}}}$$

Ans.

$C_v = 2\times10^{-4}\ cm^2/sec$



$H_{dr} = \frac{200}{2}$ cm

becz 2 way drainage

$T_v = 0.197$ cz 50% consolidation

(*) for the same soil under similar loading condition –

Wen know –

$$T_v = \frac{C_v t}{H_{dp}^2}$$

Suppose two types of consolidation – C_v remains constant –

$$T_{v_1} = \frac{C_v t_1}{H_{dp}^2}, \quad T_{v_2} = \frac{C_v t_2}{H_{dp}^2}$$

$$\Rightarrow \boxed{\frac{T_{v_1}}{T_{v_2}} = \frac{t_1}{t_2}}$$

$\Rightarrow$ no restriction of %..

Scanned by CamScanner

Now, $T_v = \frac{\pi}{4}\left(\frac{U}{100}\right)^2 \quad u \leq 60\%$

$\therefore U \propto \sqrt{T_v}$

as long as $U < 60\%$

$$\boxed{\frac{U_1}{U_2} = \sqrt{\frac{T_{v_1}}{T_{v_2}}}} = \sqrt{\frac{t_1}{t_2}}$$

⇓

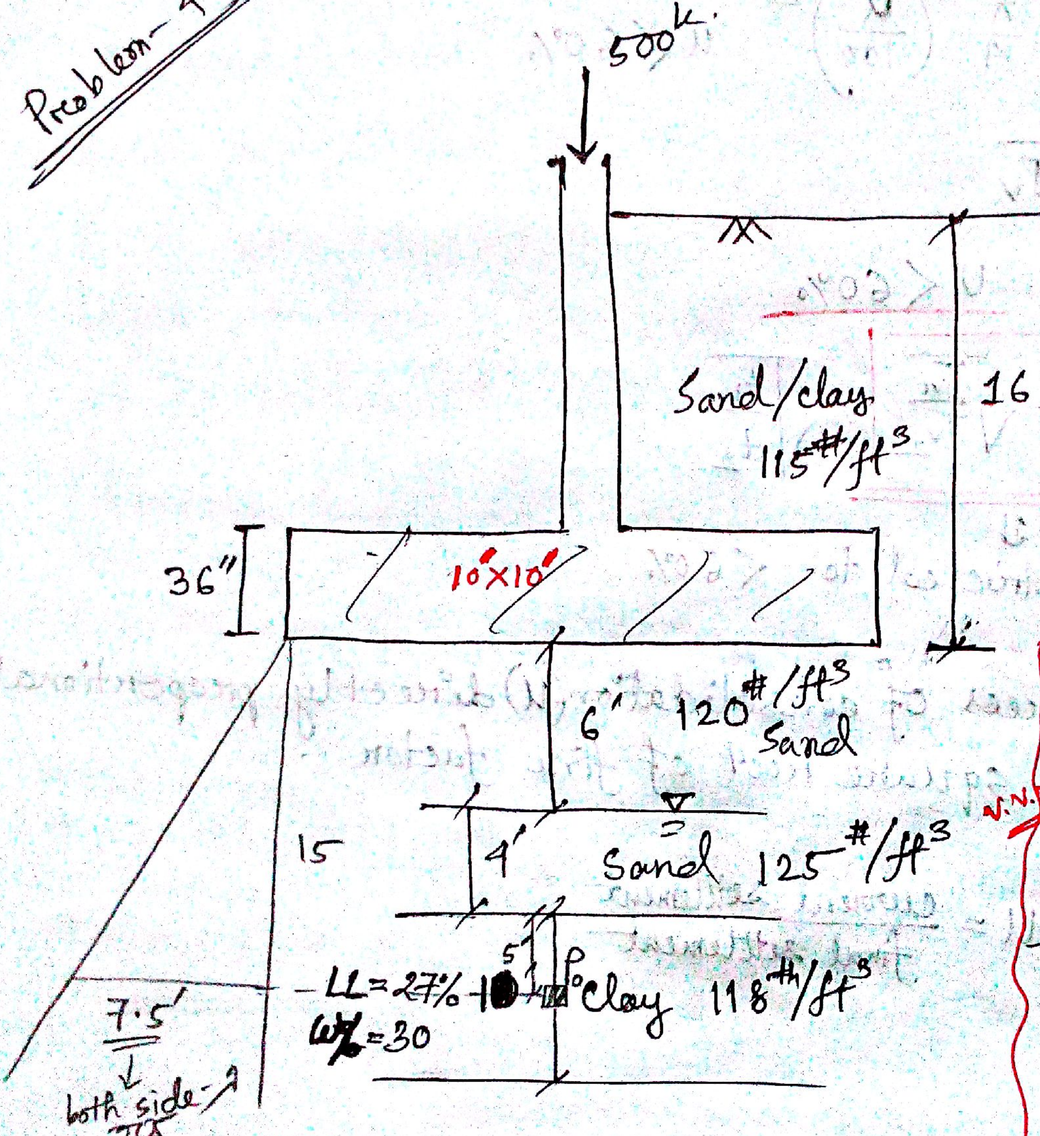
restricted to $< 60\%$

Avg. degrees of consolidation(U) directly proportional to square root of time factor.

where, $U = \frac{\text{current settlement}}{\text{final settlement}}$

Scanned by CamScanner

Problem-1



মাটি কাটার পর footing এর নিচের সব soil will OC.

⇓

Thereafter construction, যদি OC-এর load / আগের soil-এর জন্য যে load ছিল তা exceed করলে then lower soil NC হবে

$$\bar{p}_c / \bar{p}_o = 16\times115 + 120\times6 + (125-62.5)\times4 + (118-62.5)\times5$$

before doing any excavation

$$= 3.08$$

$$\bar{p} = \frac{\overset{\text{load}}{500}}{\underbrace{(10+15)^2}_{\text{area of the base}}} = 0.8 \text{ ksf.}$$

$\bar{p}$ → pressure for footing

$\overline{p}_0 = 6\times120 + 4(125-62.5) + 5(118-62.4)\,7.5$

after excavation $\swarrow$ $\overline{J}$ $= 1.52$ ksf.

Settlement expression —

$\underbrace{1.52 \text{ to } 3.08}_{\underline{OC}}$ এ আছে

Initial void ratio, $e_0 = \omega G_s$

$= 0.3\times2.7$

$= 0.81$

$C_c = .009(27-10)$

$= 0.15$

$C_s = 15\%\ C_c = 0.0225$

stress for footing

$\Uparrow$

$\overline{p}$

$\uparrow$

$$\therefore S = \frac{.0225\times120}{1+.8}\log\frac{3.08}{1.52} + \frac{.15\times120}{1+.8}\log\frac{3.08+.8}{3.08}$$