Siddique Sir
Sun, Wed

CE - 341

5/5/19

Lec-01

→ Peck and Henson

→ B.M. Das – principles of Geotechnical Engineering [7th / 5th Edition]

Handout collect করবা sir এর। → 4টা

#

Soil type.

Index properties

Classification of soils

Engineering property of soil -

— Permeability and seepage

— Compressibility

— Shear-strain-strength properties

— Lateral Earth pressure.

Soil originates from rocks.

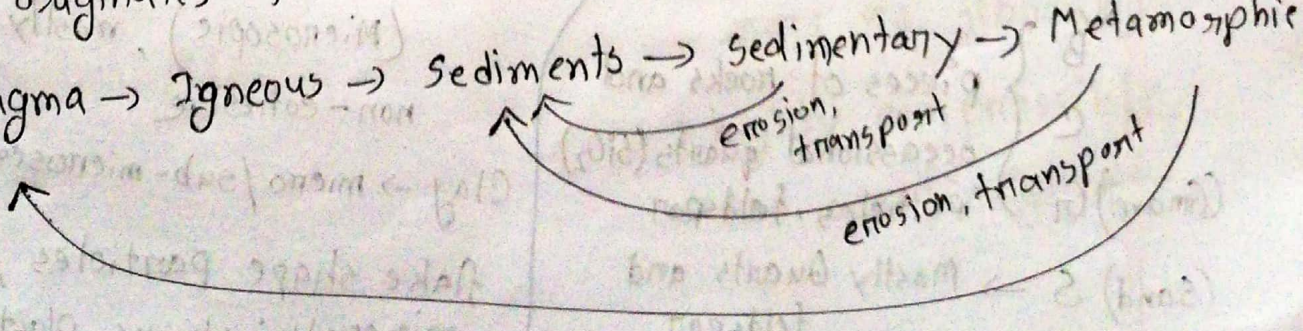
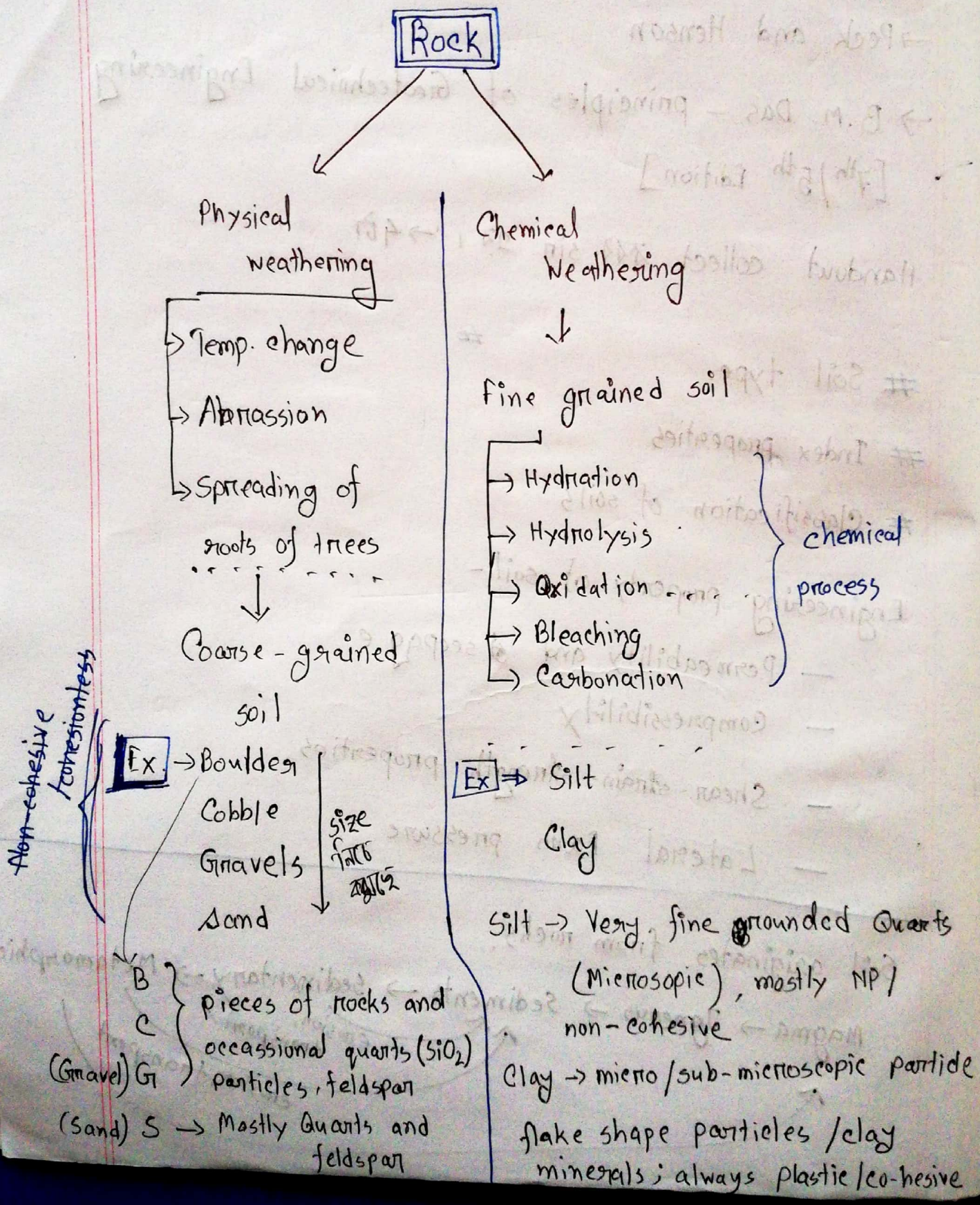


Fig. 2.1 → B.M. Das



Sand → coarse soil আর
fine aggregate

© ① no. handout ⇒ background of soil mechanics → reading দিবে।

Sand – Non-cohesive/ Cohesionless/Non-plastic(NP)	feldspar + ferromagnesiam + mica → এর chemical weathering এর জন্য clay create হয়। clay এর colloidal property থাকে।

Plastic soil → clay

Non plastic soil (NP soil) → coarse + silt (normally)

⌐ Rock flour (rarity of silty soil)

Flaky particles → fragments of micaceous minerals →

কিছু silty soil এ থাকে → তখন কিছু plasticity দেখায়।

যত বেশি clay, plasticity তত বেশি।

Clay mineral ৩ ধরনের →

→ Kaolinite

→ Illite

→ Montmorrilonite

silt আর clay →
organic হতে পারে #(burn করার পর fibrous)
highly compressible
low specific gravity

clay এর colloidal property:

Na^+, K^+, Mg^{++} ~~এর মধ্যে~~ (salt soln এ) clay particle গুলোর absorb করে (+)ve আয়ন; যারা clay এর উপর film তৈরি করে, then suppose অন্য কোন salt এর soln এ ডুবালে ক্যাটায়ন exchange হয় - Base exchange capacity / Catain exchange capacity

Table 1.6 / 1.7

Black cotton

Expansive clay ~~??~~ - Montmorrilonite → low s.g., black color, bad construction material, high water content - highly compressible (soft clay.)

28/5/19

Lec-02

Basic soil types:

1. Resedual soil

2. Transported → Agent দিয়ে transported

Resedual soil → যেখানে soil create হয় সেখানে থাকে।

Resedual

→ 1. Black cotton → Black in color, highly compressible..

2. Laterite → • igneous.
• Silica + aluminiam + iron oxide.

Transported:

- Water transported
- Glacier "
- Wind/Aolean "
- Gravity "

} inorganic soil

Organic soil:

Peat + Muck

Dark colour,
high water content,
high compressible,
poor foundation material

diff type of soil ask করলে যাবিনা নাম্বু বলবে।

Water transported:

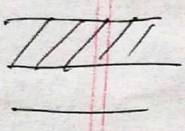
i) Alluvial soils → rivers and ~~streams~~ streams দিয়ে deposit হয়। very recent deposit. Silt/clay...

তবে ~~at~~ red soil → old deposit

but বেশিরভাগ recent deposits.

ii) Lacustrine soils → bed of lakes এ deposit.

Still/quiet. Ex → Varved clay



winter season এ clay deposit

summer এ running water এ silt deposit.

iii) Marine soil → bed of seas (deposited in salain water)

Ex- Marine clay

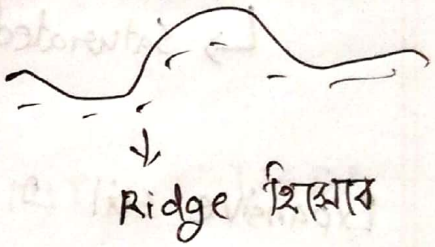
iv) Marl/Marl stone:

$CaCO_3$ (lime) + clay.

35-65% clay এবং 65-35% এ $CaCO_3$

Glaciers transported: ~~→ Basically they are boulders (বড় size)~~

- Glacial drift
- Glacial ~~diff~~ till (large boulders to very small size clay)
- Boulder clay (assorted boulders (different size))
- Eskers (surface এবং subsurface of glacial river এ deposit থাকে)



↓
Ridge হিসাবে

- Erratics large boulders which are picked up by glacier এবং and deposited at diff. places
- Drumlins (~~Aerodinaf~~ Aerodynamic profile থাকে; canoy shaped↓)

mainly till, Assymetric (হাঁস ডিমের)

Wind.

i) Aeoline soil

ii) Dunes / sand dunes → desert এ থাকে (fine medium to fine. sand)

iii) Loess → silty soil with little clay + highly compressible.

↳ Saturated হয়ে গেলে collapse করে (collapsible soil)

Expansive soil এ swelling pressure থাকবে (upward)

Shallow structure হলে Expansive soil এর উপর → severe cracking হবে floor এ। যদি বড় building হয় তাহলে enough downward pressure থাকে swelling P overcome করবে।

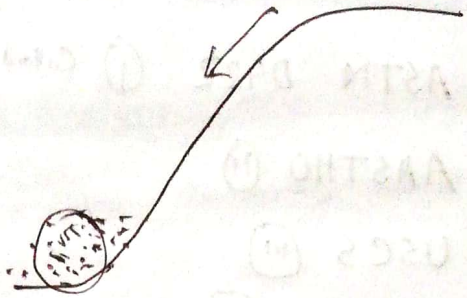
iv) Tuff → Volcanic ash

Gravity:

Colluvial soil

steep hill/

cliff এখানে



rainy season এ landslide হয়ে নিচে এসে জমা হয় —

colluvial soil.

Soil particle size:

ASTM AASHTO USCS ← MIT USDA

5টা organization recommend করেছে ~~types~~ of soil size.

12/5/19

Lec-03

* ASTM D422 (I) Colloid < 0.001 mm clay $< .005$ mm

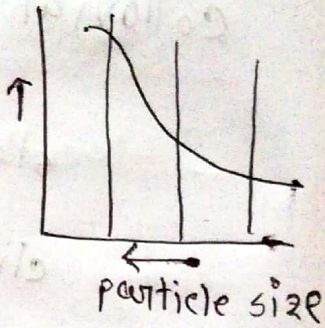
AASTHO (II)

USCS (III)

MIT/BS (IV)

USDA (5)

এগুলো এখান থেকে পাবো



Fine content / Fines | % Finer No. 200 sieve = 100 − Cumulative % retained (CPR)

0.075 mm = 75 μm	1 mm = 10^3 μm, 1 μm = 10^{-3} mm = 10^{-6} m

100 — CPR

Wet sieving

Dry "

colloid < .001 mm

clay < .005 mm

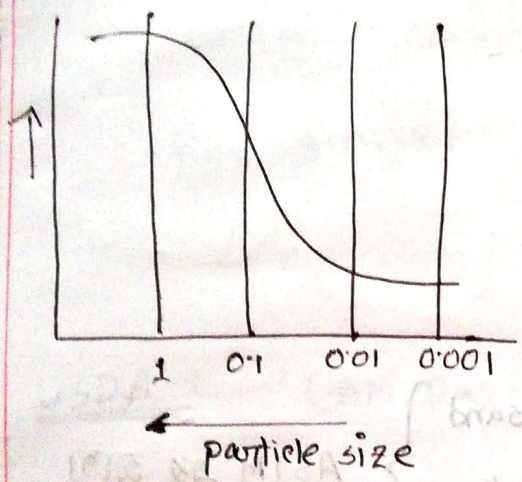
silt .005 mm – 0.075 mm (No. 200)

Sand 0.075 mm – 4.75 mm (No. 4)

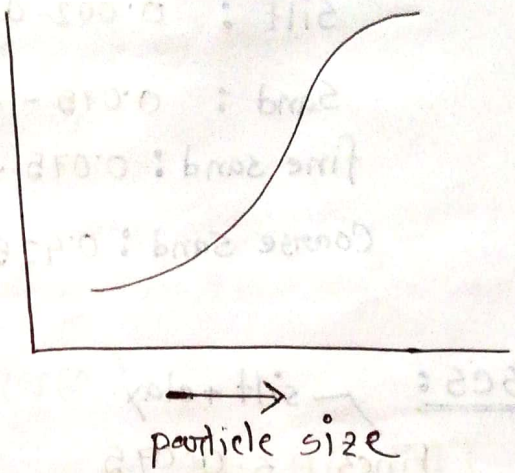
Fine sand →

Semi log paper

US system



UK System



ASTM : Silt : 0·005 – 0·075 mm 0·075 mm → No. 200 sieve

Sand : 0·075 – 4·75 mm 4·75 mm → No. 4 sieve

Sand কি? According to ASTM যা # 4 দিয়ে pass করে এবং # 200 তে retain করে।

Fine sand : 0·075 – 0·425 (No. 40)

Medium " : 0·425 – 2 (No. 10)

Coarse " : 2 – 4·75

~~Seive no~~. Sieve No. যত বাড়ে opening তত কমে।

Gravel : 4·75 – 75

Cobbol : 75 – 300

Boulder : > 300

AASTHO:

Colloid : < 0.001 mm

Clay : < 0.002 mm

Silt : 0.002 - 0.075 mm

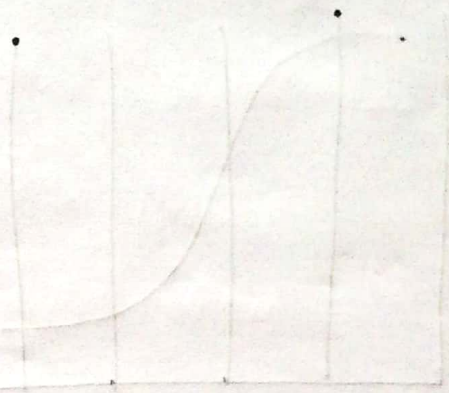
Sand : 0.075 - 2.0

fine sand : 0.075 - 0.425

Coarse sand : 0.425 - 2

Gravel : 2 - 75

Boulder : > 75



USCS:

Fines (silt + clay) < 0.075

Sand : 075 - 4.75

Fine sand
Middle "
Coarse "
} ASTM এর মতো

MIT:

Clay → < 0.002 mm same as AASTHO

Silt → 0.002 - 0.06

Sand → 0.06 - 2

Gravel → 2 - 60

Cobble → 60 - 200

Boulder → > 200

Fine silt : ~~0.06 - 0.2~~ 0.002 - 0.006

Medium " : ~~0.2 - 0.6~~ 0.006 - 0.02

Coarse " : ~~0.6 - 2~~ 0.02 - 0.06

Fine sand : 0·06 - 0·2

Medium " : 0·2 - 0·6

Coarse " : 0·6 - 2

fine gravel 2 - 6

6 - 20

20 - 6

USDA : (BM pas এর বই থেকে)

Clay : < 0·002 same as AASTHO, MIT

Silt : 0·002 - 0·05

Sand : 0·05 - 2

Gravel : > 2

15/5/19

Lec-04

ASTM D 2487 → Engineering classification of soil

D 2488 → Descriptive and identification of soil (visual)

Dark soil + smell → organic soil → fibrous particle থাকে

Dry strength ⟶ sandy/silty/clayi

Plasticity or Toughness

Dilatancy or Shaking

Dispersion

Silty sand

Sandy silt

Silty clay · Silty clay আর Clay এর Dry strength
Clayey silt বোঝা হবে।

Plasticity:

Sandy clay, silty clay → tough thread → mold করতে পারবো

not for clayey silt, silty sand

Water content → Imp. parameter.

~~Dia~~ Dilatancy or Shaking:

Permeability test.

Sandy silt / silty sand → permeable (Highly)

Clayey soid → very low permeable soil

Slow reaction → clayey ~~sea~~ silt,

None → silty clay, clay

Dispersion test:

Clay suspension এ থাকে for several hours/days.

Sand অনেক তাড়াতাড়ি পড়ে যায়। 60 seconds for sand particle

15–60 minutes → for silt

several hours – days → clays

Table 2 → 8টা

short Ques.

Soil A B C D

Reaction in dry strength . . . . (4টা test)

Identify the soil?

3 no. sheet + peck এর মধ্যে দেওয়া

Structure & fabric

sheet এ
দেওয়া def. দেওয়া

Structure affects invisible property of soil → compressibi-lity, shear strength . . .

Structure → sand/silt/clay

Fabric → Clay oily

Geometric size of mineral of clays
particle spacing } থাকবে
pore size distn

- Primary (sedimentation এবং weathering এর time এ create)

- Secondary (After formation of soil, (sometimes after deposition)

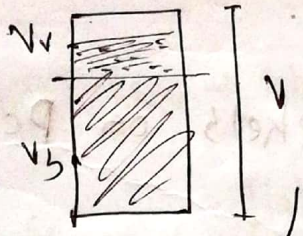
Primary
- single grain → Coarse sand
- Homey combed → Fine sand and silt.

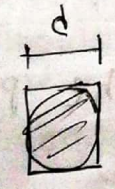
single grain → loose / dense হতে পারে

loose → 0.91 ← void ratio $e = \frac{V_v}{V_s}$

dense → 0.35 void ratio approx.

$V_v = V_w + V_a$





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

$$\Rightarrow \frac{d^3 - \frac{\pi d^3}{6}}{\frac{1}{6}\pi d^3}$$

$$e = \frac{(\sqrt{2}d)^3 - 4\frac{1}{6}\pi d^3}{4 \times \frac{1}{6}\pi d^3}$$

Honey comb

→ অনেক void

→ deposition এর time এর inter molecular force overcome করতে পারে না → chain আকারে create হয়, অনেক বেশি settle করে, dynamic / large static loading এ structure ভেঙে যায় (metastable; not stable)

Clays: Stable 3·5 – Days

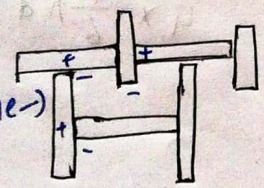
→ Foculable ?

→ Dispersed

→ Domains – clusters, Packets or Peds

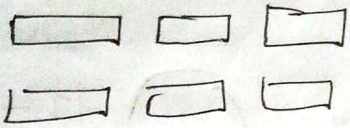
Clay – flake shaped / flaky → clay platilate.

Foculable structure →



→ the corners will attract the phase salt/sea water

Dispersed



→ Dispersed

same electrically charges ; dispersed from one another

Domains

কাঠামো

Domain

Group of domain → clusters | Group of clusters → Packets

~~light mic~~

electromicroscope দিয়ে → Domain আরো foculables দেখা যায়

Lec - 05

23/06/19

ASTM D-2488 অধ্যায় → table → criteria for describing angularity of coarse grained soil (gravel, sand..)

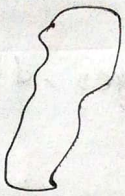
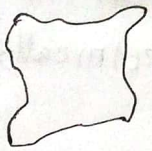
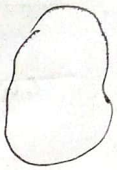
Bulky · flaky

→ Angular

→ Subangular

→ Subrounded

→ Rounded


Angular Sub Angular Sub rounded rounded

- Sharp edge
- Relatively plane sides
- Unpolished surfaces

} Angular particles

- rounded edges
- plane sli side
- Unpolished surface

} Subangular

- Nearly plane sides
- well rounded edges

} Sub rounded

- Smooth curved sides
- no edges / corners

} rounded

Table 1 এ দেখাও

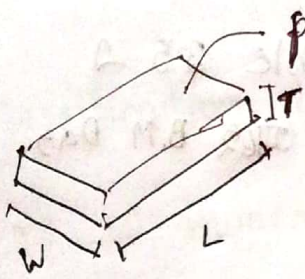
Short Question
এটাকে বলে (Angularity of coarse grained soils) → গঠন + description

Table 2 তে আছে

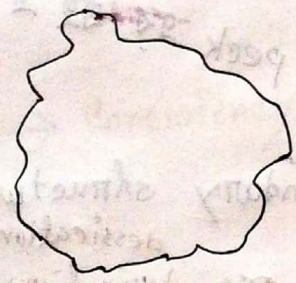
Criteria for describing shape of the particle

Shape:

- Elongated ⇒ $\frac{L}{W} > 3$
- Flat ⇒ ⇒ $\frac{W}{T} > 3$
- Flat & Elongated ⇒ আগের 2টা satisfy করলে।



Defitith of angularity:



$$\text{Angularity} = \frac{\text{Average of radius of the corners (sum করে avg)}}{\text{সবচেয়ে বড় যে sphere particle এর ভিতর draw করতে পারব তার radius}}$$

Roundness / Sphericity:

$\frac{De}{L}$ ← equivalent dia / Length of particle

$$V = \frac{1}{6}\pi D^3$$

$$\Rightarrow D = \sqrt[3]{\frac{6V}{\pi}}$$

Angularity, roundness এর def^n দেখবার।

(এটাই theory এর জন্য পড়ব)

Flaky:

·01 or less ~~sp gravity~~ roundness

very low roundness

Domains - Sub microsopic
Clusters — light microscopic
Peds — খালি চোখে দেখা যাবে

} Table 3·5 এ আছে B.M Das.

Group of clusters - peds , peck এর বই এ দেখব

What are the diff types of secondary structure:

Cracks / Joints → deposit এর পর ~~desication~~ dessication এর জন্য হয়; shallow depth এ; long time after deposition of soil

Slickenside → stiff clay তে polished surface এ differential movement এর জন্য দেখা যায়

Concretion → soil এ iron / ~~carbonade compo~~ carbo compound accumulate হয় তখন এই structure

Secondary str. is for fine grained soil (basically clay)

soil classification:

USCS
↓
Geo তে use করি (foundation)

Unified soil classification system

AASTHO
↳ subgrade design (basically transportation এ use করা হয়)
(Runway, taxiway, major highway design এ)

Classification test (to classify soil)

এর দ্বারা numerical value আসে — Index ~~প্রপার~~ property

→ Grain size analysis — wet / Dry ....

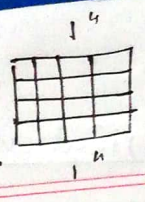
→ Consistency test — shrinkage limit, plasticity limit

.....

Atterbug limits - LL, PL, SL, PI

Fine aggregate
FA → Sand → concrete casting এ

Sand → Geo তে → fine grained



#4
#8
#16
#20
#30
#50
#100
#200
#pan

মানে 1inch এর মধ্যে 16 টা opening আছে

3"
1 1/2"
3/4"
3/8"
1/4"

clear opening

1/4", 3/8" .... এগুলা কারে,

25.4 দিয়ে multiply করে mm এ opening পাবো

#4 — 4.75 mm
#8 — 2.36 / 2.38 "
#10 — 2.00
#16 — 1.18
#20 — 0.85
#30 — 0.6
#40 — .425
#50 — 0.3
#100 — 0.15
#200 — 0.075

500 gm sand নিয়ে

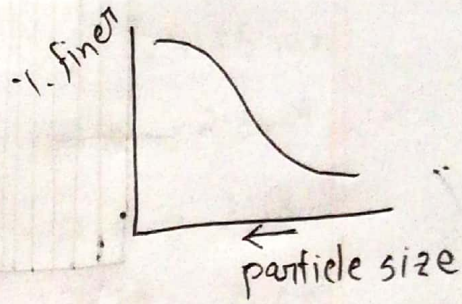
প্রতি sieve এ কত retain করে যের করলাম

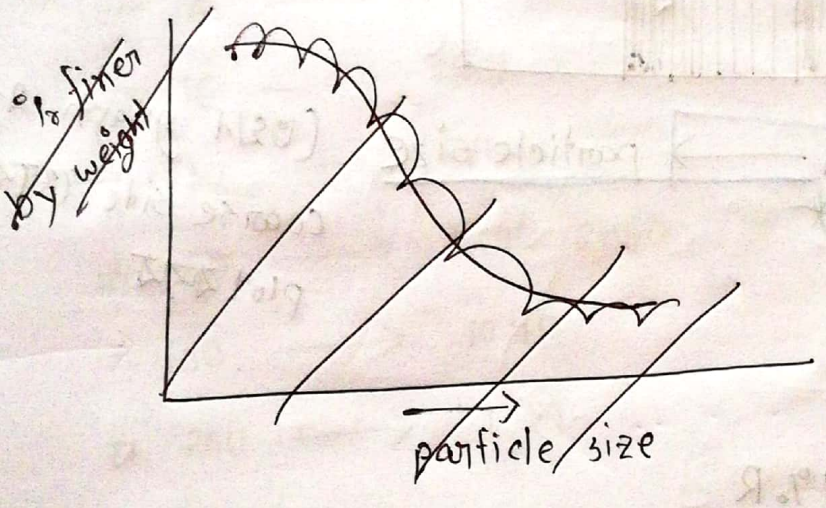
3/4"	———	0 gm
#4	———	12
#8	———	15
#10	———	60
16	———	82
20	———	31
30	———	57

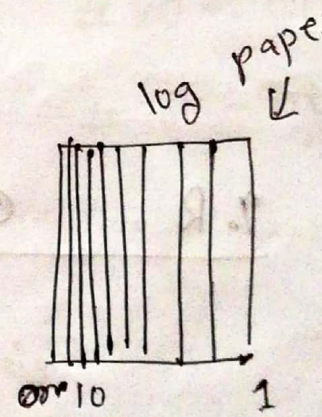
40	—	55 gm
50	—	63 "
100	—	65 "
200	—	237 "
Pan	—	23 "
		500 gm

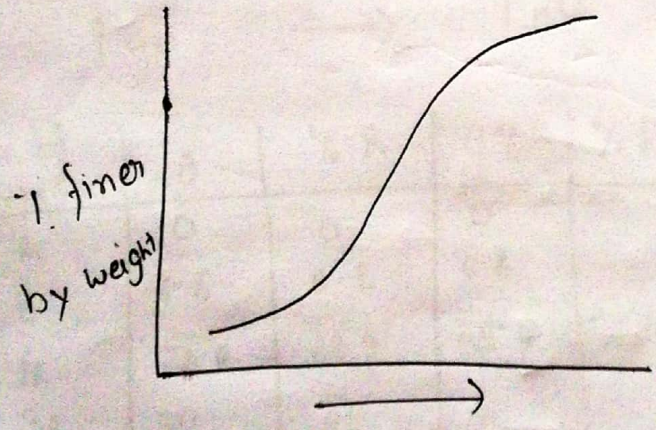
11টা sieve use করলাম;
11টা point পাবো

Grain size disth curve

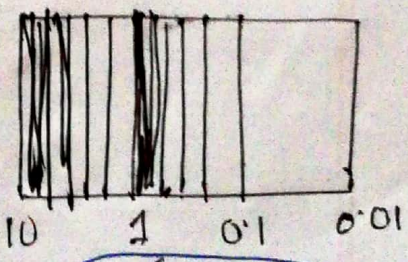








মান যেদিকে ছোট হচ্ছে space ওদিকে মান বাড়বে



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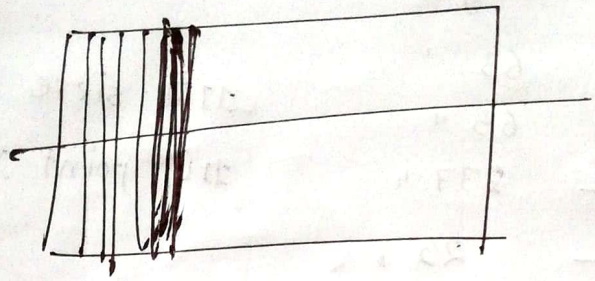
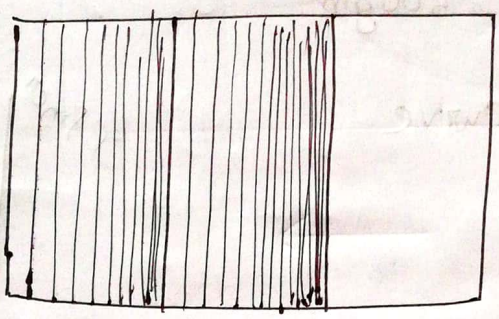


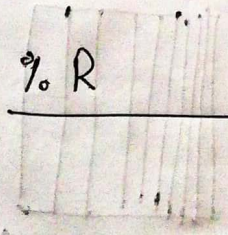


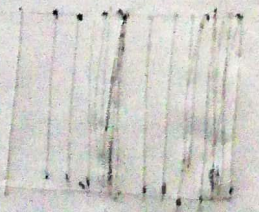
particle size

(তখন graph এর coarse side থেকে plot করব

% R

C % R





Lec-06

26/6/19

#200 sieve এর উপর sample retain করলে coarse fraction বলে তাদের।

Wet sieving করে first এ #200 দিয়ে যে fines pass করে যায় তাদের আলাদা করে করা হয়, wash করে then dry sieving করা হয়।

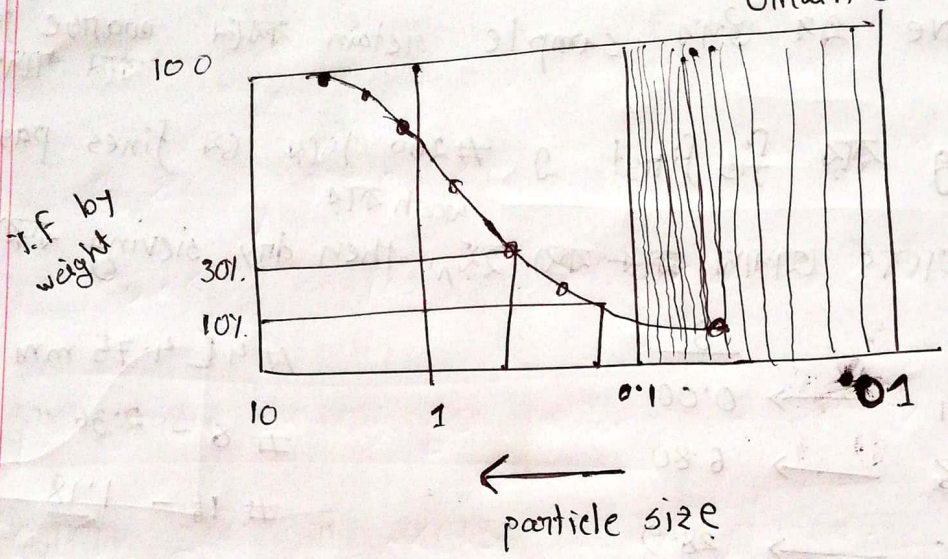
g

→ 0.00
#4 → 6.80
#8 → 28.9
#16 → 30.00
#30 → 21.50
#50 → 10.40
#100 → 1.20
#200 → 1.20
Pan → 1.20

#4 - 4.75 mm
#8 - 2.36 "
#16 - 1.18
#30 - 0.60
#50 - 0.30
#100 - 0.15
#200 - 0.075

no. of sieve	g	% R	C% R	% Finer by weight
4	0	0	0	(100 - C% R)
8	6.8	6.8	6.8	
16	28.9	28.9	35.7	
30	30	30		
50	21.5	21.5		
100	10.4	10.4		
200	1.2	1.2		
Pan	1.2	1.2		

Gradiation Curve / Grain size distribution



Sand, Gravel } Coarse grain

Silt, clay } fine grain

Uses अनुसारी

more than 50% retaining on #200 sieve

50% or more passing through #200 sieve

Coarse fraction → #200 ला retained

fines → #200 मिरो passing

#4 sieve এ যদি more than 50% of the coarse fraction retain করে → gravel. (suppose 100 gm soil এ 90 gm #200 এ retain. এখন এই gravel কে sieve এ দিলে 90 gm এর more than 50% হতে হবে).

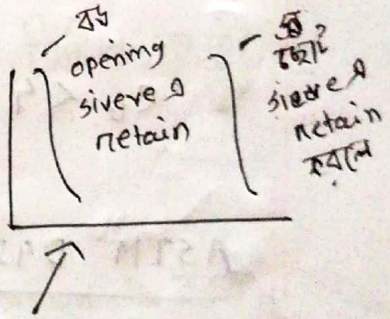
$D_{10} = 0.8$
$D_{30} = 0.3$
$D_{60} = 0.8$
} Physical meaning: যদি 0.8 mm opening এর sieve দিয়ে analysis করি 10% sample pass করে যাবে।

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

. Uniformity co-efficient

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

co-efficient of curvature

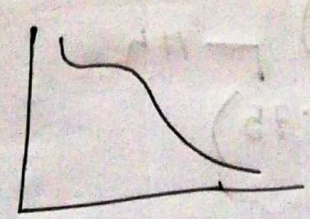


Engineering gradation:

#Well graded

Uniform or poorly graded

gap graded → কিছু sieve এ কোন soil retain করে নাই



Well graded / poor graded বোঝার জন্য C_u আর C_z জানা লাগবে।

$C_u \geq 6$; $1 \leq C_z \leq 3$ ⟶ well graded sand

$C_u < 6$; and/or $1 > C_z > 3$ ⟶ poor graded

well graded হয় জন্য দুটা condition ই satisfy করতে হবে। যেকোন একটা না করলেও poorly graded.

$C_u \geq 4$ $1 \leq C_z \leq 3$ ⟶ well graded gravel

$C_u < 4$ $1 > C_z > 3$ ⟶ poor " "

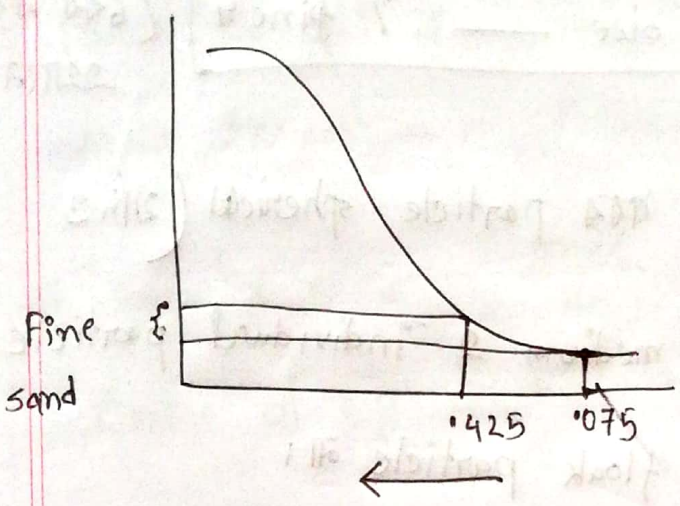
ASTM D422

USCS

Fine sand (0.075 – 0.425) mm → #40 to pass #200 & retain

medium sand (.425 – 2) #10 #40

~~fine~~ Coarse sand (2.0 – 4.75) #4



— এভাবে medium, coarse sand বের করা যাবে কত amount.

(%)

Hydrometer Analysis

Finer than #200 sieve এর analysis.

Sedimentation analysis.

দুই ভাগে করা যায় → পিপেট ও method — হাইড্রো মিটার method

Hydrometer Analysis

50-60 gm soil নিয়ে 1000ml এর suspension করব।

(4% $NaPO_3$ soln) তে,

আরেকটা cylinder এ clean পানি থাকবে।

Time — reading | particle size — % finer (বের করব এখানে)

certain velocity তে fall করে, ধরব particle spherical (যদিও actually flaky) এ infinite medium এ individual particle free fall করছে. যদি ~~not part~~ floak particle না।

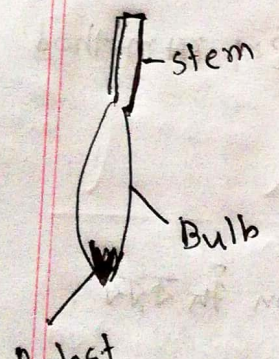
Calculation কিভাবে করব imp*

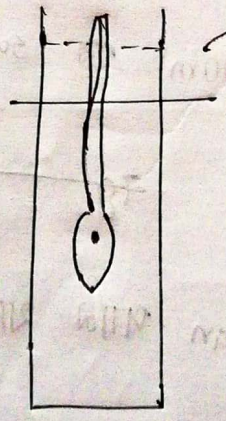
152 H

151 H — -5 - 60

Graduation উপরে থেকে নিচে যাচ্ছে।

প্রতি small devision হল 1, rounding করে 0.5 এ।





Hydrometer ডুবালে পানির level উপরে যাবে

~~Volm~~ $\frac{V_H}{A_j}$ =

152H এর vol^m ~~a~~ normally → 67 – 70 cc

A_j → 28 cm^2

~~Jar এর area~~ $\frac{100 cc}{Hei}$

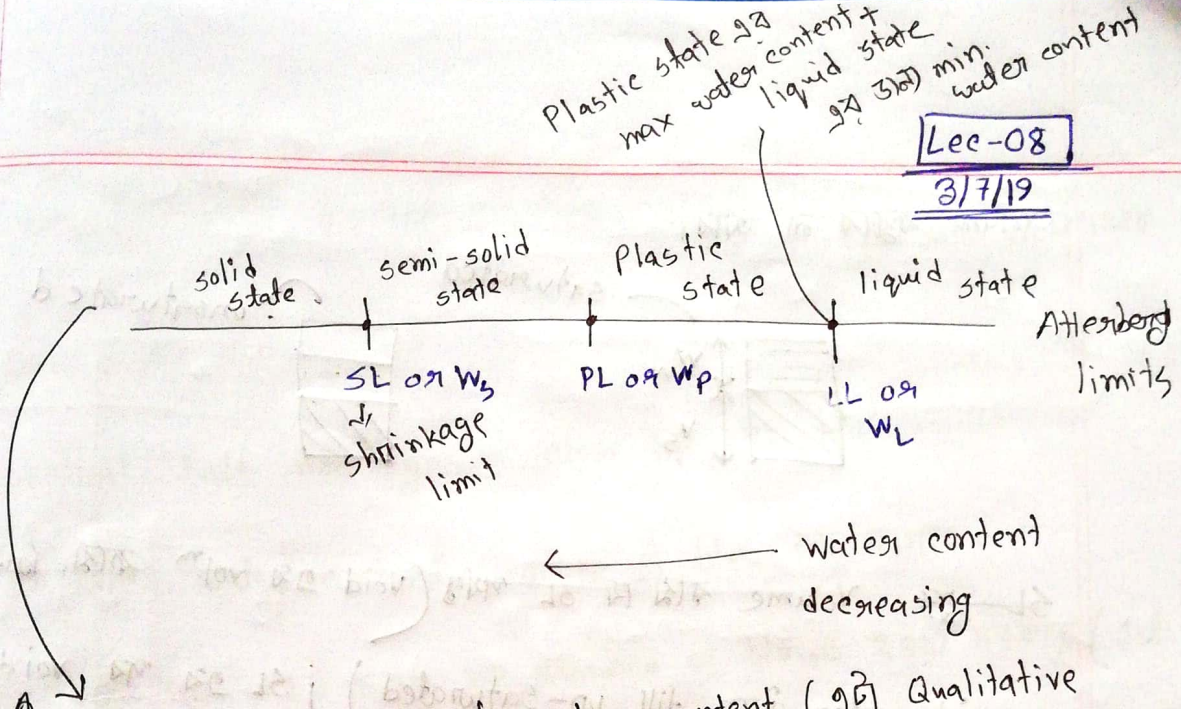
Centre of e.g. displaces by 50%.

$\frac{V_H}{2A_j}$ → Immersion correction

time এর সাথে suspension নিচে settle করবে, density কমবে, Hydrometer flood করা করবে।

~~miniscus~~ upper miniscus এ reading নিলে তখন একটু করা reading আসবে। normally – 0·5 – ~~cc~~ meniscus correction এ 0·5 যোগ করতে হবে।

Lec-08
3/7/19



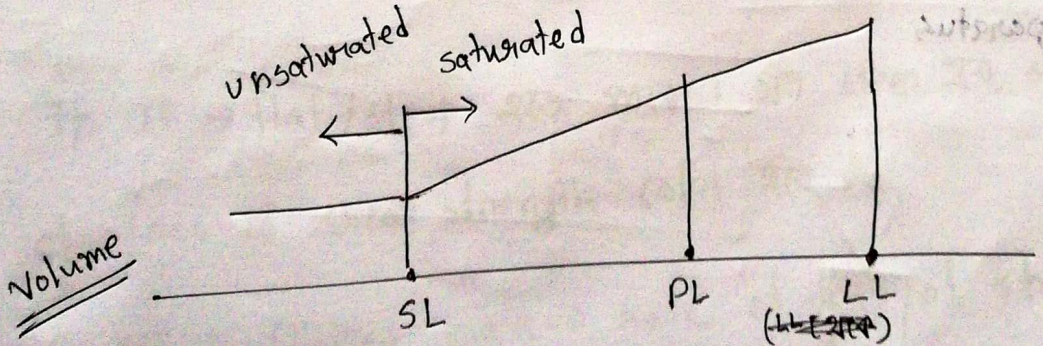
A limiting stage of water content (এটা Qualitative definition)

Liquid – flow করাতে পারবে

Plastic – Shape দিতে পারব crack form না করায়।

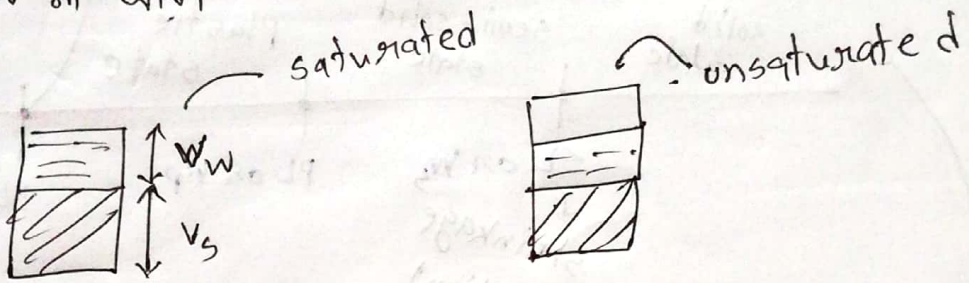
B Plasticity index = Liquid limit – plastic limit

Plasticity index = PI



LL থেকে SL এ যেখানে পর্যন্ত dry করলে volm কমবে, upto SL soil saturated. SL এর পর dry করলে

Volume কমবে না আর।



~~SL এর~~ Volume কমে যে SL পর্যন্ত (Void এর vol^m কমে, but void water দিয়ে fill up - saturated) ; SL এর পর void এর মধ্যে air ঢুকবে।

LL ~~Act~~

ASTM D4318

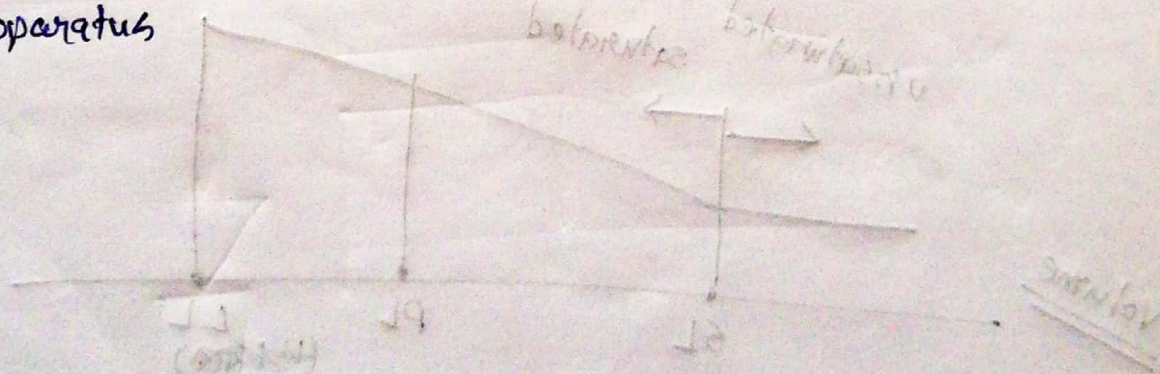
BS 1377

└ cone penetrometer or Fall cone

(

~~Casagrade~~

Casagrande apparatus



$w = \frac{W_w}{W_s} \times 100$ } water / moisture content. (Natural)
└ মাঠে field থেকে আনা

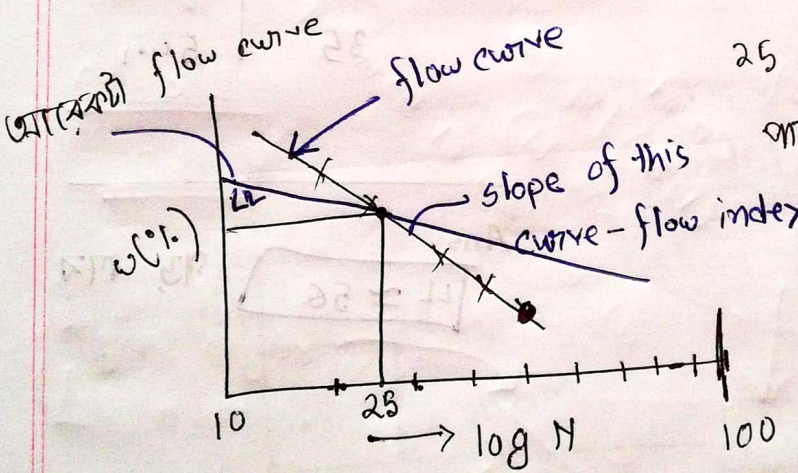
Groove এর dimension ?

central half inch groove close হতে কয়টা blow লাগবে

যত বেশি water content, number of blow কম লাগবে।

10 – 40 / 15 – 35 ⇒ number of blows হওয়া দরকার (1st

তিন বে 5টা sample তৈরি করব।



25 blow তে বে water content পাবো → তাকে LL or w_L

(negative করব না slope → বড় -ছোট করব)

If IF → flat / steep হতে পারে। যত steep হবে, shear rate of loss of shear strength বেশি হবে।

IF কম → flatter curve → rate of loss of shear strength কম।

One point method

1টা test করেই Liquid limit পাবো (flow curve আঁকতে হচ্ছে না)

US-Army Corps engineers → $W_L = w\left(\frac{N}{25}\right)^{0.121}$ → Impirical method

N → 20 & 30 } এর মধ্যে থাকতে হবে Blow

Japalen & M... $w_L = \frac{w(\%)}{1.3215 - 0.23 \log N}$

N = 15 & 35

N	w (%)
15	60.1
20	57.9
24	56.4
30	55.2
35	54.1

Ans.

LL ≃ 56

গড় করে

Fall cone Method:

80g (0.78 N)

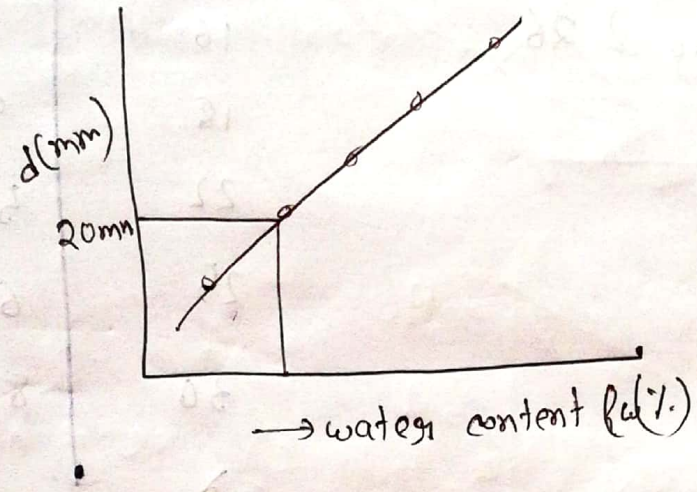
30° cone

যত dry soil হবে, penetration তত কম হবে।

release করব 5 second পর, lock করব ; depth of penetration

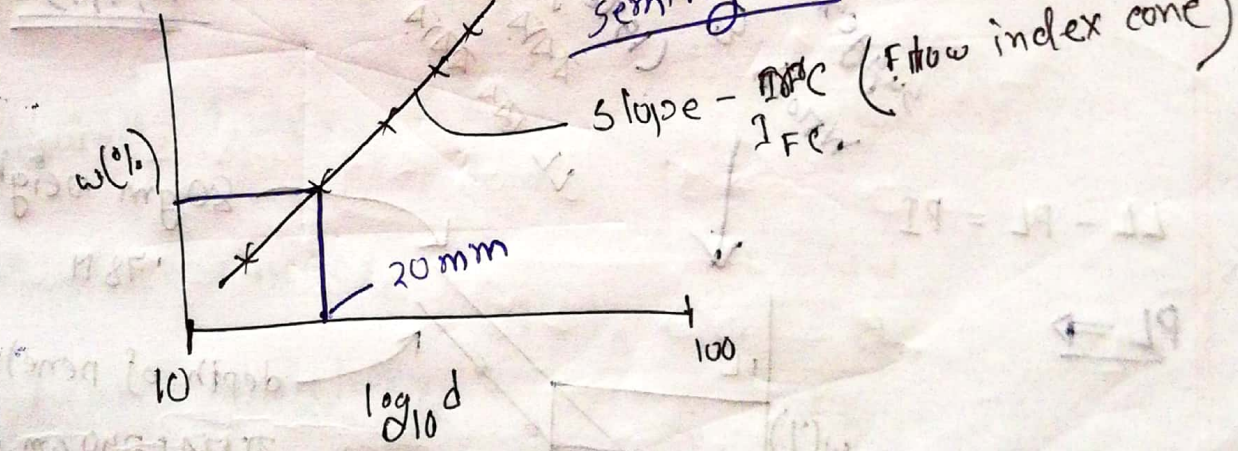
রেখ করব । → d (mm)

Plain graph →



20 mm এর corresponting water content → LL or W_L

বা



I_F → casacangne method এ slope } দুই different

I_{Fc} → BS

1 Point method for BS standard

$$W_L = \frac{\omega(\%)}{0.65 + 0.0175\,d}$$

$d \rightarrow$ d btn 16 & 26

d(mm)	ω(%)
16	33
18	40
22	54
25	63
30	83

Lec-09

10/7/19

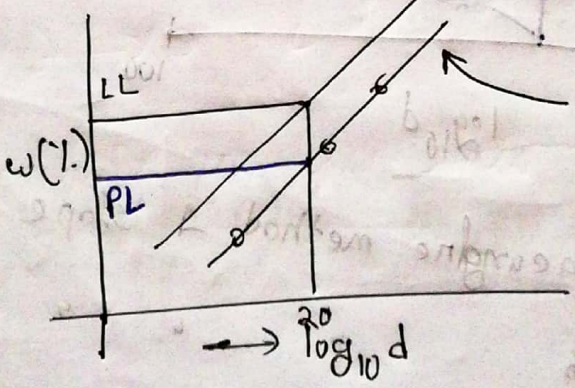
Suggested by Wroth & Crood (1972) [PL বের করার জন্য] LL বের করার জন্য BS method

$LL - PL = PI$

PL ⇒

80 gm weight } Cone
·78 N

depth of penetration বাড়বে (240 gm weight এর cone এ)



~~Atterberg & Wood~~ (1978)

~~Cone এর weight 240 gm হবে~~

PI ⇒ table 3.3 থেকে 3.4

~~LL বেশি হয় kaolinit~~

PI → বেশি মানে → বেশি clay content

PI → 0 → sand (non plastic)

LL, PL দুটোই বের করা যাচ্ছে → তাহলে plastic soil

PI → 16-35 — Plastic
> 35 — Highly plastic

0-3 → Non plastic
3-7 → low plastic
7-16 - medium "

~~Set~~ sandy silt → non plastic

Liquidity Index, $LI / I_L = \frac{w_n - PL}{LL - PL}$

Consistency index, $CI / I_c = \frac{LL - w}{\underbrace{LL - PL}_{PI}}$

Relative consistency,

Natural moisture content → field এ,
" " যত বেশি, soil তত নরম, } clay
" " কম firm/stiff/hard হবে

" "

Sand এর বেলায় use করি relative density.

Clay " " " " " consistency.

$w_n = PL$, $LI = 0$ w_n = natural moisture content

↓

~~very~~ hard

$LI = 1$ → The soil is very soft.

$w_n < PL$ ও (অনেক শুকনা soil গোছ, field এ) → very hard soil.

$I_L + I_C = 1$

LI ∘ 0 ⟶ 1 [hard থেকে soft এ যাচ্ছে]

CI 1 ⟶ 0 [" " " " "]

একটা জানলে আরেকটা বের করতে পারব

soil (A) soil (B)

PI same

45 - 20 = 25 55 - 30 = 25

Toughness index,

$$I_c = \frac{PI}{I_F}$$

এর উপর toughness depend

(A) (B)

flow index → বেশি, steep slope → rate of loss of shear strength বেশি হবে।

$$A_c = \frac{PI}{\%.\ clay\ (< 0.002\ mm)}$$

MIT classification

Inactive clay, Activity clay Normal clay

↓ ↓ ↓

Kalinite clay থাকে Montmorillite clay থাকে ~~Kalinite~~/Illite থাকে

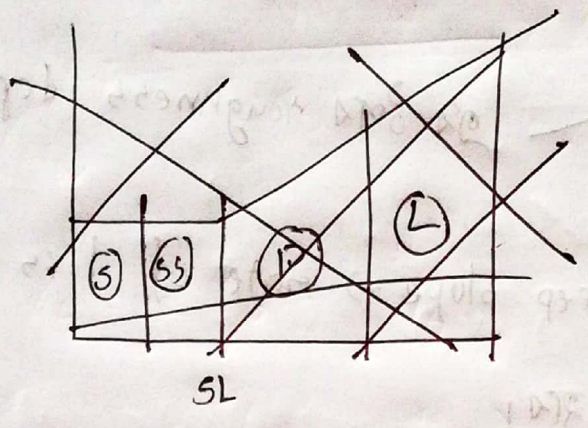
↓

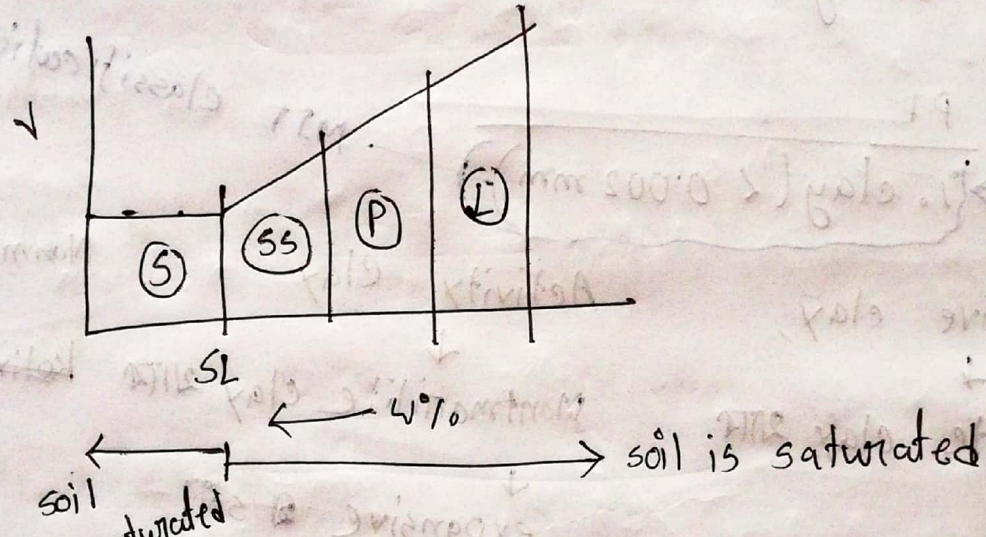
expansive soil

A_c যত বেশি, ততো বেশি active clay.

→ ASTM এ বলি < .005 mm

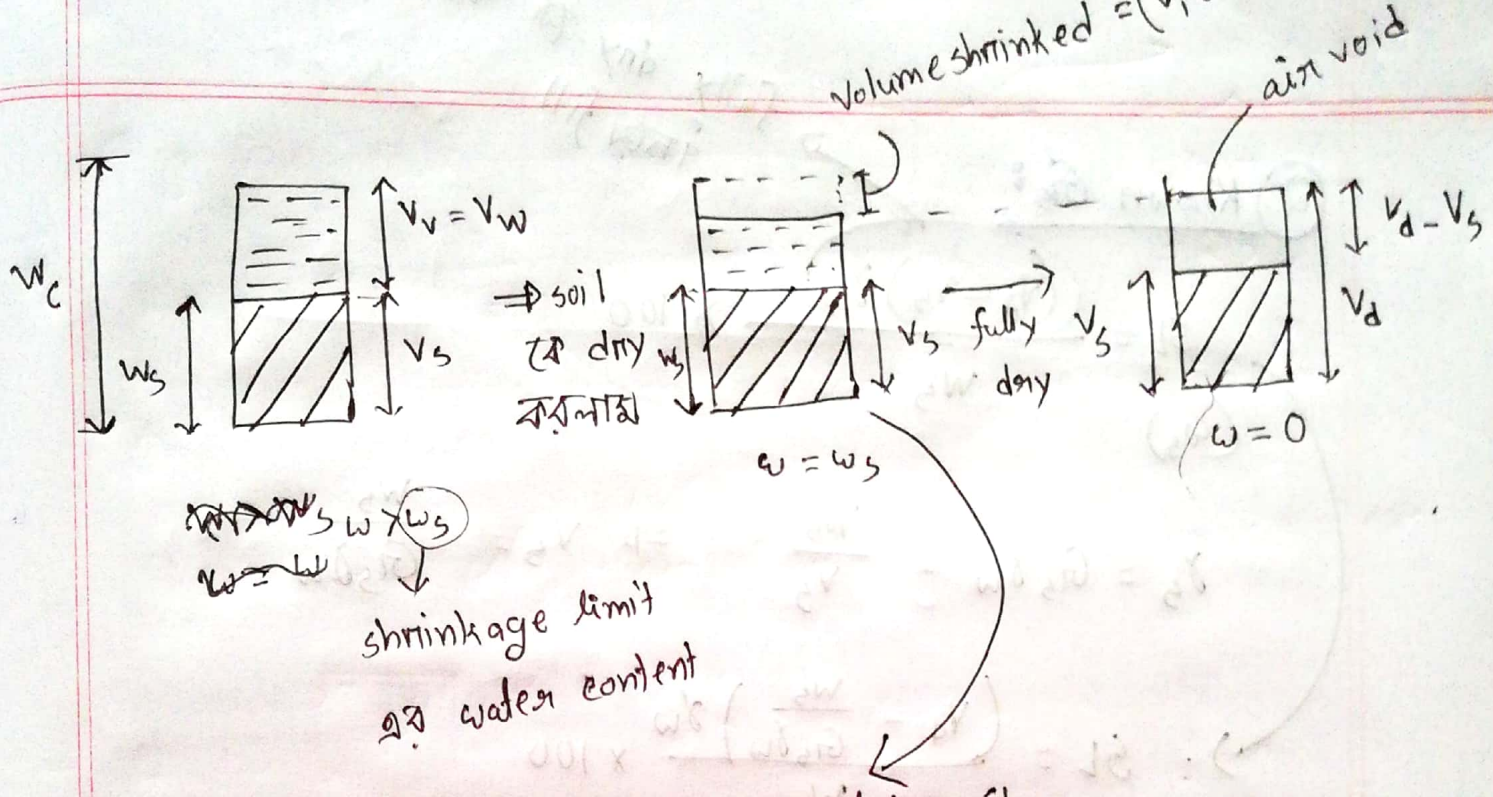
Shrinkage Limit (SL)





SL

Dish এর মধ্যে very soft soil (water content LL বা তার বেশি) যাতে fully saturated থাকে soil।



min. water content এ soil saturated → SL.

এর চেয়ে dry করলে air void আসবে তখন unsaturated soil

(1) unknown G_s

$$S.L. = \frac{W_w}{W_s} = \left[\frac{(W_i - W_s) - (V_i - V_d)\gamma_w}{W_s} \times 100 \right]$$ (W_i = initial)

$$SL(\%) = w_i(\%) - \frac{V_i - V_d}{W_s} \times 100$$

w_i → initial water content (%)

initial vol^m of dish নাগবে

vol^m of dry soil pat পাবো mercury ~~mercury~~ displacement

method এ.

(2) Known G_s:

fully dry হলে সমস্ত ফাঁকা fill

$$SL = \frac{(V_d - V_s)\gamma_w}{W_s} \times 100$$

(ω_s)

$$\gamma_s = G_s \gamma_w = \frac{W_s}{V_s} \Rightarrow V_s = \frac{W_s}{G_s \gamma_w}$$

$$\therefore SL = \frac{\left(V_d - \frac{W_s}{G_s \gamma_w}\right)\gamma_w}{W_s} \times 100$$

$$= \frac{V_d \gamma_w - \frac{W_s}{G_s}}{W_s} \times 100$$

$$= \frac{V_d \gamma_w}{W_s} \times 100 - \frac{1}{G_s} \times 100$$

$$= \left(\frac{V_d \gamma_w}{W_s} - \frac{1}{G_s}\right) \times 100$$

Shrinkage ratio, $R = \frac{W_s}{V_d \gamma_w}$

$$R \Rightarrow \frac{\Delta V/V}{\Delta \omega / W_s} = \frac{V_i - V_d / V_d}{\frac{(V_i - V_d)\gamma_w}{W_s}} = \frac{W_s}{V_d \gamma_w}$$

$$\frac{\text{change in vol}^m / \text{dry vol}^m}{\text{change in water} / \text{original soil এর weight}}$$

$$\therefore SL = \left[\frac{1}{R} - \frac{1}{G_S}\right] \times 100\%$$

$$\therefore \frac{SL\ (\%)}{100} = \frac{1}{R} - \frac{1}{G_S}$$

$$\Rightarrow G_S = \frac{1}{\frac{1}{R} - \frac{(SL)\%}{100}}$$

Volumatric Shrinkage:

$$V_S = \frac{V_i - V_d}{V_d} \times 100$$

$$V_S = R\left[w_i(\%) - w_S(\%)\right]$$

$$\gamma_S = G_S \gamma_w = \frac{W_S}{V_S}$$

Degree of shrinkage:

$$S_d = \frac{V_i - V_d}{V_i} \times 100$$

Linear shrinkage:

$$L_S = 100\left[1 - \sqrt[3]{100/(V_S + 100)}\right]$$

V_S in % বসাবো ←

ASTM D427

BS method এ linear shrinkage

$$\frac{\text{Original length (143 mm)} - \text{reduced length}}{\text{Original length}}$$

mold এর length

এখানে volm shrinkage হবে না, linear shrinkage হবে।