Geotechnical: objective

Soil Mechanics → 4 marks

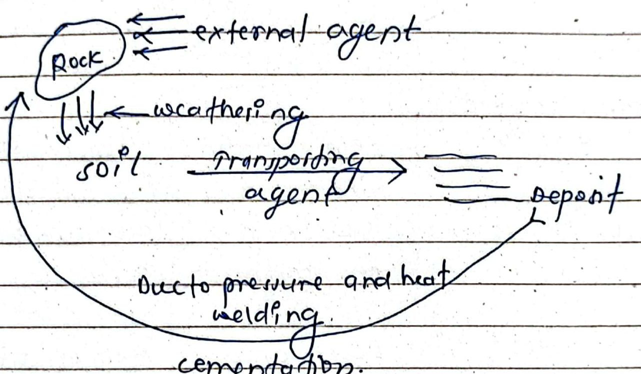
Geology + Tunnelling: → 2 marks

Chapter: 1

General classification of soil depending on formation, transporting agent and deposit media:

Soil: Accumulation of particles formed by disintegration of rocks.

- Uncemented or partially cemented: soil.
- Full cemented: rock.



Soil formation: weathering

Physical weathering | chemical weathering

→ Rock only converts into small particles but minerals remains same as parent rock.

Forms: gravel and sand.

→ Rock not only changed into smaller particles but minerals also changed.

Forms: silt and clay.

Physical weathering

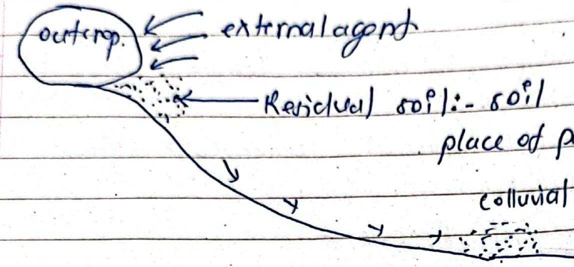
causes:

- → Abrasion
- → wedge action of ice
- → spreading of roots of tree
- → Heat: Regular expansion & contraction

chemical weathering:

causes:

- → Chemical reaction
- → Hydration, oxidation
- → carbonation, solution, hydrolysis.



Residual soil:- soil formed and placed at same place of parent rock.

colluvial deposit: pulled by gravity and placed at base of slope.

Transporting agent:-	Deposit media:	Name of soil:	Remarks
water:	River basin	Alluvial soil	Terai
	lake basin	lacustrine soil	Kathmandu
	sea basin	Marine clay	finest.
Air	Desert area	Aeolian soil	
Glacier	~~Glacier deposit~~ Base of mountain	glacier deposit	

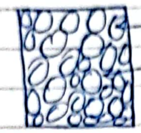
Sea soil: finest soil, sensitivity ↑, shear strength ↓.

Outcrop: Rock exposed to atmosphere.

more than 150 % water content. lacustrine : अवंति मिट्टी : highly compressible , more settlement
↳ pile or pier foundation suitable

Alluvial soil:- well foundation because of sandy soil.
Residual soil: Hilly area: shallow foundation.

Chapter 2 Three phases of soil:



soil particles : solid.
space between soil particles : void
void → water, air.

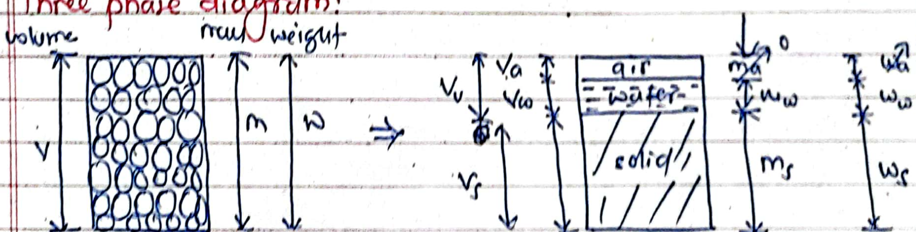
In general condition : soil mass consists of solid, water and air ∴ three phase material.

Two extreme condition:

Two phase { • Dry condition : Due to regular contact with heat (solid + air)
• saturated condition: Due to regular contact with water (solid + water)

Theoretically:
One phase:- fully compacted or fully consolidated or zero void.
But practically not possible.

Three phase diagram:



Basic terms:-

(i) Void ratio (e):

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

(ii) Porosity (n)

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

Relation

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

(iii) air content (ac)

$$a_c = \frac{V_a}{V_v} \times 100\%$$

(iv) % air voids (n_a)

$$n_a = \frac{V_a}{V} \times 100\%$$

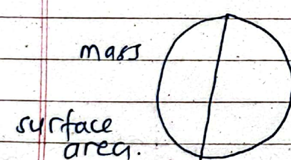
(v) Moisture content (w)

$$w = \frac{M_w}{M_s} \times 100\%$$

Note: The more the finer, more is the water content.

↳ When a particle is divided, surface area increases, mass remains constant

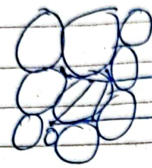
↳ more surface area, more water required to wet.



Specific surface area : $\frac{\text{area}}{\text{mass}}$

$= mm^2/gm$.

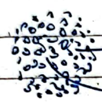
surface attraction (cohesion) is more in finer particles due to negligible gravity. and reverse in coarser particles.



void size (ठूलो)

No. of voids (less)

coarser particles



void size (सानो)

No. of voids (more)

finer particles

∴ Overall मा finer particles मा ~~...~~ voids ratio बढी हुन्छ in comparision to coarser particles.

(vi) Degree of saturation:

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

$S_r \propto w$ ∴ $\boxed{S_r \times e = w \times G}$

$S_r = 0$, dry soil.

$S_r = 1$, saturated soil.

$0 < S_r < 1$, general soil.

(vii) specific gravity of solid (G):

↳ Ratio of mass of solid to mass of ~~water~~ same volume of water at 4°c.

$$G = \frac{\rho_s}{\rho_w} = \frac{\gamma_s}{\gamma_w} \text{ at } 4°c.$$

generally for solid particles (2-2.7)

<u>Note:</u>

- M, V, W, w and G can be directly measured and other relations are found from the analysis of relationship between them.

for distilled water:

$\rho_w = 1$ gm/cc

$= 1$ gm/ml

$= 1000$ kg/m^3

$\gamma_w = 9.81$ kN/m^3

soil cond^n

(i) General cond^n.

(ii) Dry cond^n.

(iii) satura[...] cond^n.

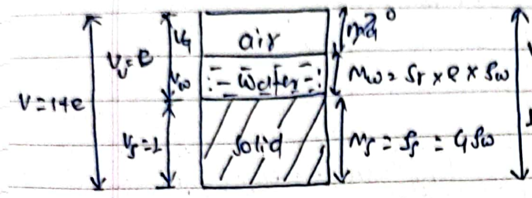
(iv) Subm[...] cond[...]

Volumetric Relationship

Soil cond^n	V-m Relationship	V-w Relationship
(i) General cond^n.	Bulk density $(\rho) = \frac{m}{V}$ $\rho = \frac{(S_r \times e + G)\rho_w}{1+e}$	Bulk unit weight $(\gamma) = \frac{W}{V}$ $\gamma = \frac{(S_r \times e + G)\gamma_w}{1+e}$
(ii) Dry cond^n.	Dry density $(\rho_{dry}) = \frac{M_{dry}}{V} = \frac{M_s}{V}$ $\therefore \rho_{dry} = \frac{G\rho_w}{1+e}$	Dry unit weight (γ_{dry}) $= \frac{W_{dry}}{V} = \frac{W_s}{V}$ $\therefore \gamma_{dry} = \frac{G\gamma_w}{1+e}$
(iii) saturated cond^n.	~~Saturated~~ saturated density $(\rho_{sat}) = \frac{M_{sat}}{V}$ $\therefore \rho_{sat} = \left(\frac{e+G}{1+e}\right)\rho_w$	saturated unit weight. $(\gamma_{sat}) = \frac{W_{sat}}{V}$ $\gamma_{sat} = \frac{(e+G)\gamma_w}{1+e}$
(iv) Submerged cond^n	submerged density (ρ_{sub}) or $\rho' = \frac{M_{sub}}{V}$ $\rho_{sub} = \rho_{sat} - \rho_w$ $\rho_{sub} = \left(\frac{G-1}{1+e}\right)\rho_w$.	submerged unit weight $(\gamma_{sub}$ or $\gamma')$ $\gamma_{sub} = \gamma_{sat} - \gamma_w = \frac{W_{sub}}{V}$ $\gamma_{sub} = \left(\frac{G-1}{1+e}\right)\gamma_w$

Q. $\rho_{sat} > \rho > \rho_{dry} > \rho_{sub}$ for same soil when its status changes.

Three phase diagram:-
↳ in terms of void ratio(e)



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

if $V_s = 1$

$\therefore V_v = e$

$V_w = S_r \times e$

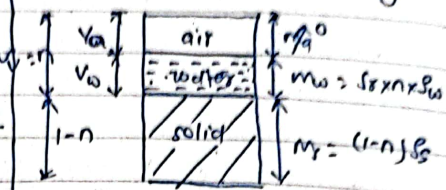
$V_a = (1-S_r) \times e$

$S_r = \frac{V_w}{V_v} \Rightarrow \boxed{V_w = S_r \times e}$

Q. Volumetric strain $= \frac{\Delta V}{V}$

Q. Relation of volumetric strain B: $= \frac{\Delta e}{1+e}$

Three phase diagram:
↳ In terms of porosity.



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

$V_v = n \quad \therefore V = 1$

$V_w = S_r \times n$

$V_a = (1-S_r)n \qquad \frac{1}{1+e} = (1-n)$

$\rho = [S_r n + (1-n)G]\rho_w$

$\rho_{dry} = (1-n)G\rho_w = \frac{G\rho_w}{1+e}$

$\rho_{sat} = [n + (1-n)G]\rho_w$.

$\rho_{sub} = [(n-1) + (1-n)G]\rho_w$.

Analysis of soils-

$\rho, w, G \Rightarrow$ measured.

$\downarrow$

$\rho_{dry} = \frac{\rho}{1+w}$

$\downarrow$

$\rho_{dry} = \frac{(1-n_a)G\rho_w}{1+wG}$ $\quad \rho_{dry} = \frac{G\rho_w}{1+e}$ $\rightarrow S_r \times e = w \times G.$

$\downarrow$

$e \rightarrow \rho_{sat} = \frac{(e+G)\rho_w}{1+e}$

$n = \frac{e}{1+e}$ $\quad \downarrow$ $\rho_{sub} = \rho_{sat} - \rho_w$

n_a $\quad n$ $\quad \rho_{sub}$

$n_a = n \times a_c$

a_c

* Determination of field density of soils-(ρ):

(a) core cutter method] Majorly used.

(b) sand replacement method

(c) water displacement method.

(impt) Q. How will you measure field density of soil by using

(i) core cutter method [5 marks]

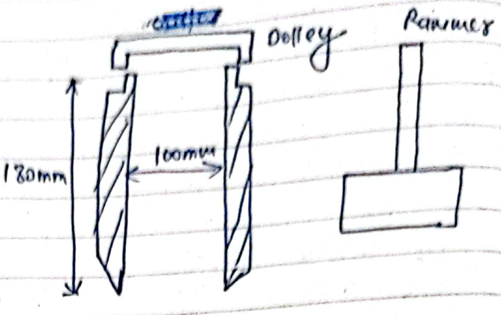
(ii) sand replacement method [5 marks]

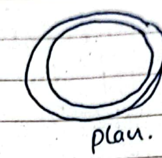
a. Core cutter method:

Apparatus:

(i) core cutter

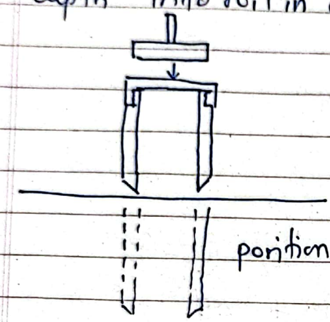
(ii) Rammer.





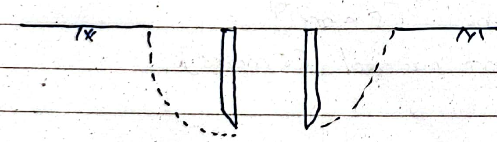
Procedure:

(i) Drive the corecutter full depth into soil in field.



position of core cutter after drived.

(ii) Take out the drived corecutter by excavation of surrounding soil.



Measure

(i) mass of empty corecutter $= m_1$

(ii) mass of core cutter with full soil $= m_2$

(iii) field density of soil (ρ) = $\frac{m}{V}$

$$= \frac{m_2 - m_1}{V}$$

$$; V = \frac{\pi d^2 h}{4}$$

limitation:

↳ not used for cohesionless soil.

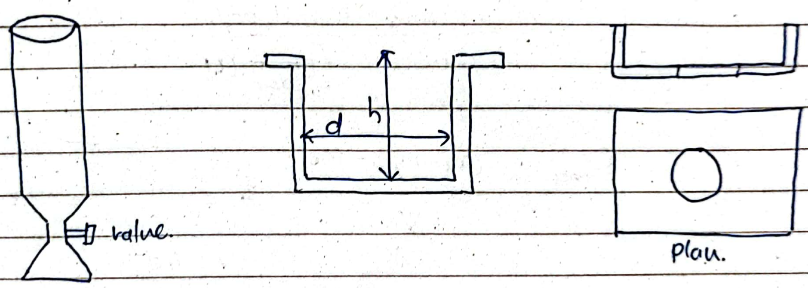
Use:

↳ for cohesive soil only.

(b) Sand Replacement Method:

Apparatus

(i) cone apparatus (ii) metallic pot (iii) Metallic pan.



(iv) uniform sand:

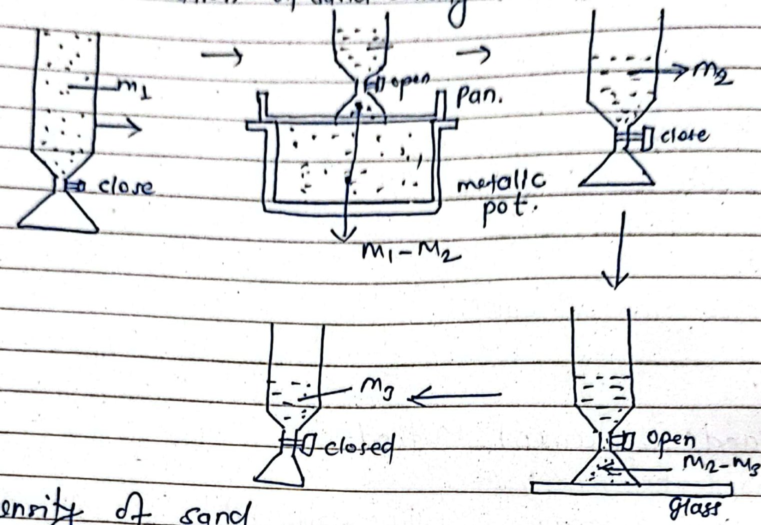
0.425 mm - 0.6 mm

↑ passing ↑ retained.

Procedure:

a. Calibration of sand:

(i) ↳ determination of sand density (ρ_{sand}).



density of sand

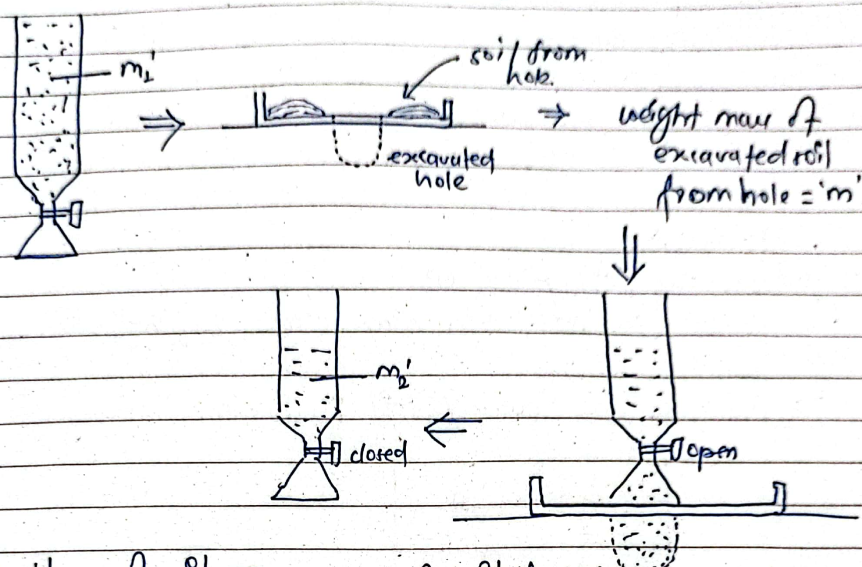
ρ_{sand} = $\frac{\text{mass of sand to fill pot}}{\text{volume of pot (V)}}$

$$\rho_{sand} = \frac{(m_1 - m_2) - m_c}{V} \quad ; m_c = m_2 - m_3$$

$V = \frac{\pi d^2}{h}$; h = height of

m_c = mass of sand to fill cone section.

(ख) Measurement of field density (ρ):



$$\text{density of soil } (\rho) = \frac{\text{mass of soil from hole } (m)}{\text{volume of hole } (V_h)}$$

$$; \; V_h = \frac{\text{mass of sand to fill hole}}{\text{density of sand}}$$

$$= \frac{(m_1' - m_2') - m_c}{\text{density of sand } (\rho_{sand})}$$

Use: for all types of soil.

(c) water displacement method:

Use:

↳ for clay:

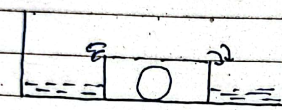
Undisturbed soil piece from field

Procedure:

↳ wt. the soil piece (m)

↳ coat the soil with wax. and weight the coated soil (m').

↳ Immerse the coated soil in water.



↳ Measure the displaced water during imersion of coated soil piece into water (V_t).

V_t = vol. of (soil + wax)

Vol. of soil (V) = V_t - vol. of wax

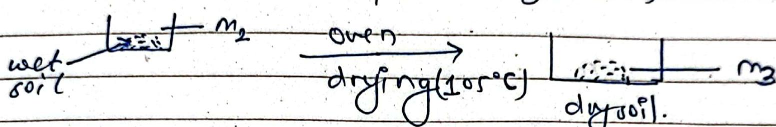
$$= V_t - \frac{(m' - m)}{\rho_{wax}} \quad ; \rho_{wax} = 0.89 \text{ g/cc.}$$

Determination of moisture content: (w):

① ↳ oven dry method • → (most accurate method (mostly used))
② Pycnometer method
③ Radiation method
④ Calcium carbide method • → (fastest method (PSC))
within 5 minutes → result.

1. Oven drying method
step:

(i) wt. empty pan (m_1) :→ (silver pan) ⌴ → m_1
(ii) Put little ~~sam~~ wet soil in pan & weight (m_2)



(iii) keep wet soil with pan in oven overnight at temperature 105 °C.
(iv) weight pan with dry soil. (m_3)

$$\text{moisture content } (w) = \frac{m_w}{m_s} = \left(\frac{m_2 - m_3}{m_3 - m_1}\right) \times 100\ \%.$$

$$= \frac{\text{mass of water}}{\text{mass of dry soil.}} \times 100\%$$

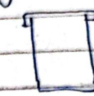
Sp. gravity test:

(1) Pycnometer method:
(2) Density bottle → more accurate than pycnometer.
(3) Shrinkage limit method. → time consuming.

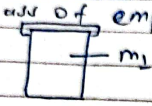
(1) Pycnometer method:

Procedure

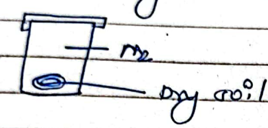
Pycnometer:



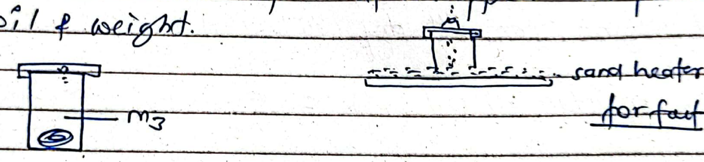
↳ Mass of empty pycnometer.



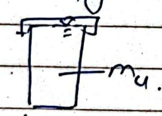
↳ put some dry soil & weight



↳ put water & make expell of entrapped air pocket from soil & weight.



↳ clean the pycnometer, put full volume of water & weight.



Derivation:

$$m_4 = m_3 - m_s + V_s \times \rho_w$$

$$m_4 = m_3 - m_s + \frac{m_s}{\rho_s} \times \rho_w$$

$$m_4 = m_3 - m_s + \frac{m_s}{G}$$

CamScanner

Q. What are the uses of index properties of soil? (5 marks)

$$\frac{m_s}{G} = (m_4 - m_3) + m_s$$

$$G = \frac{m_s}{(m_4 - m_3) + m_s}$$

$$\boxed{G = \frac{m_2 - m_1}{(m_4 - m_3) + (m_2 - m_1)}} \quad ; m_s = m_2 - m_1$$

Use: mainly for coarse grained soil.

Properties of soil:

- Index properties
  - Properties of soil which are not used directly in design of any structure on soil.
- Engineering properties:
  - Properties of soil which are used directly in design of any structure on soil.
    - shear strength
    - Compressibility
    - permeability

Use:

- To classify the soil.
  - LL, PL, grain size distribution curve, sensitivity, thixotropy
- To develop correlation with engineering properties.
  - eg: $C_c = 0.009(LL-10)$
  - $K = 100\, D_{10}^2$ Hazen's eqn. i.e. $K \propto D_{10}^2$ i.e. of particle size — objective question.

- for research on soil.

Index properties.

- Aggregate properties
  - loose soil → Relative density (D_r)
  - Fine soil → consistency limit (LL, PL, SL), sensitivity, Thixotropy, Activity
- Individual grain properties.
  - Grain size distribution
  - shape of soil particles.

- Relative density (D_r): (For coarse soil):
  - It indicates denseness of soil (sand) in field.

$$D_r = \left(\frac{e_{max} - e}{e_{max} - e_{min}}\right) \times 100\,\%$$

; e_{max} = max^m void ratio at very loose condition. $= \left(\frac{G\rho_w}{\rho_{dry(min)}} - 1\right)$

e_{min} = min^m void ratio at very dense condition $= \left(\frac{G\rho_w}{\rho_{dry(max)}} - 1\right)$

e = natural void ratio of soil in field $= \left(\frac{G\rho_w}{\rho_{dry}} - 1\right)$

↳ Man

Bentonit

D_r. >85

Status of soil: very

Construc tability very

Con

↳ Pos

Bulking:

Increase i

of parti

↳ specially

Q. Incr

(a)

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↳ Montmorillonite: यस्तो mineral उच्च आकारको volume change हुनसक्छ!

Bentonite slurry: montmorillonite यस्तो clay बाट बनाइने slurry अर्थात्.
↳ stability जनाउन use गर्छ → shrinkage & swelling potential high छ!

D_r	>85%	65-85%		35-65%	15-35%	<15%
Status of soil:	Very dense cond^n	Dense cond^n	—	Medium dense	loose	very loose
Construc. stability	Very good	Good		OK	• Not constructable *** → Recommend for deep compaction.	

Consistency limit: (for fine soil)

↳ Possibility of high variation of moisture in fine soil:
↓ effect

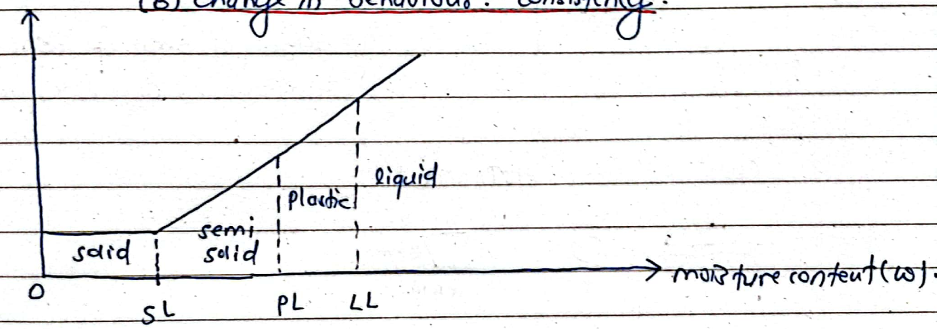
(A) Volume instability

swelling: increase in volume of soil mass with increase of moisture.
shrinkage: decrease in volume of soil mass with decrease of moisture.

> Bulking:
> Increase in volume of particles.
> specially in sand.

Q. Increase in volume of soil mass due to increase in moisture content is -
ⓐ swelling ⓑ bulking ⓒ both ⓓ None.

(B) Change in behaviour: consistency.



Q. Ceramic product → clay बाट (plasticity high भएको)

Q. The moisture content below which soil mass does not show reduction in volume is - - -
ⓐ LL ⓑ PL ⓒ SL ⓓ All

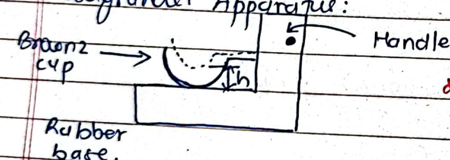
Flowdity (w↑) ←opposite→ Rigidity (w↓)
↑ moisture content.

Consistency limit:

↳ limit of moisture at which clay shows change in behaviour.
a. LL.
b. PL
c. SL
} Atterberg limit.

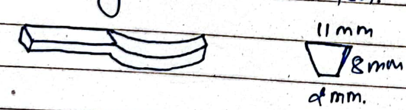
*: Determination of liquid limit (LL):

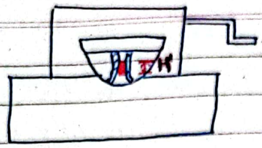
↳ Casagrande's method:
Casagrande's Apparatus:



***
h = height of drop of bronze cup
= 10 mm. (objective question)

Cutting tool: ASTM tool.





H' = 10mm cilSem? portion.

Measurement:

Test NO:	No. of blows	Moisture
I	N_1	ω_1
II	N_2	ω_2
III	N_3	ω_3

$N \not> 50$ in any case

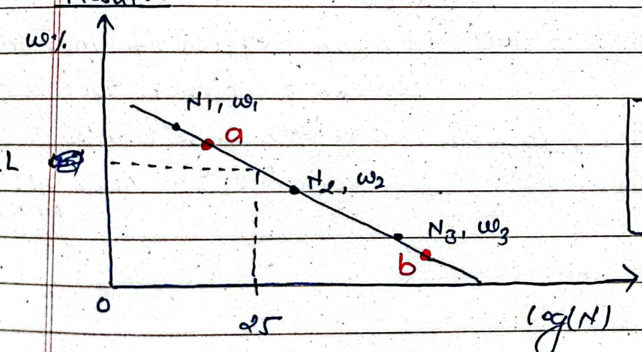
Among 3 values any one N should be greater than 25 & any one N should be less than 25.

Q. In casagrande's test for LL. No. of blows should be:

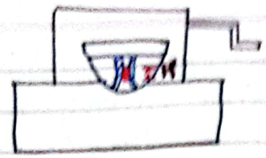
Ans: $N \not> 50$
any one $N < 25$
any one $N > 25$
} All three are mandatory.

Result:

semi-logarithmic.



LL = moisture content at 25 no. of blow in casagrande method.



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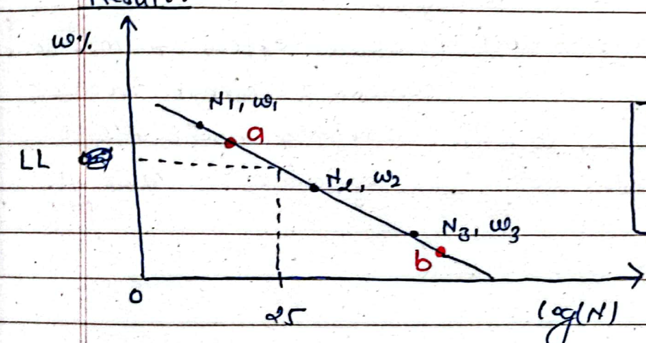
any one $N > 25$
} All three are mandatory.

Result:

semi-logarithmic.



LL = moisture content at 25 no. of blow in casagrande's method.

CamScanner

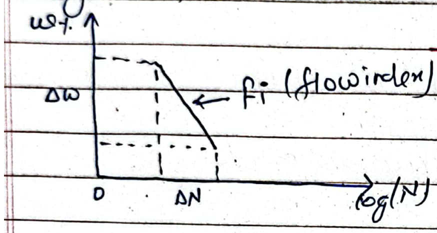
for line ab.

slope of ab: flow index (fi) $= \dfrac{w_a - w_b}{\log\left(\frac{N_a}{N_b}\right)}$

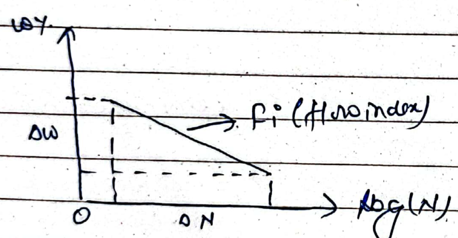
Higher the flow index, it means,
a) shear strength variation is high
b) " " " is low.
c) both d) None.

lower the flow index, it means,
a) shear strength variation is low
b) shear strength variation is high. c) both. d) None.

Higher flow index:



fi (flowindex) It means effect of moisture content is smaller in shear strength of soil due to variation in moisture. ***



*** fi (flow index) It means effect of moisture content is higher in shear strength of soil due to variation in moisture. ***

Q. Which is not true....
a) Higher flow index, effect of moisture content is smaller in shear strength
b) lower flow index, effect of moisture content is higher in shear strength.
c) Higher flow index, effect of moisture content is higher in shear strength
d) All of above.

Determination of plastic limits:-
↳ Hit and trial method:-
- Rolling soil on glass below palm changing moisture content.

PL: The moisture at which clay can be rolled to 3mm diameter thread.

some index:

1. plasticity index (Pi)
$P_i = LL - PL$

: physical meaning:
↳ Range of moisture difference for plastic behavior.
- for gravel & sand (P_i) = null (0)
- for silt = 0 to some limited value.
- for clay = high.

2. liquidity index (Li)
$L_i = \dfrac{w_N - PL}{P_i}$; w_N = natural moisture content.

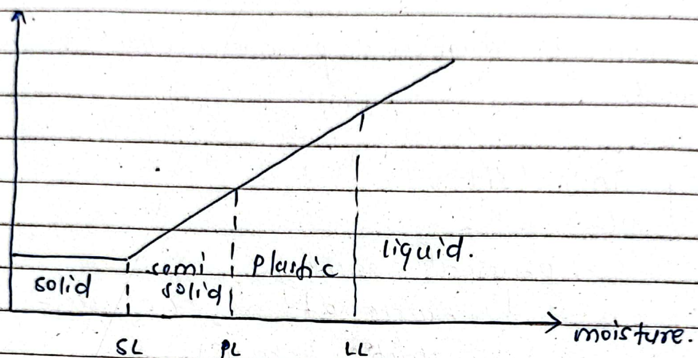
3. consistency index: (C_i)

$$C_i = \frac{LL - w_N}{P_i} ;$$

4. ~~Flow index~~ Toughness index: T_i

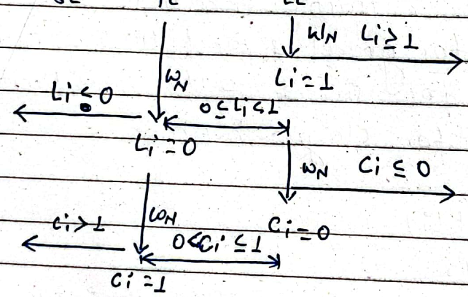
$$T_i = \frac{P_i}{F_i}$$ (Range: 0 to 3.)

; f_i = flow index obtained from casagrande test for liquid limit.



$$L_i = \frac{w_N - PL}{P_i}$$

$$C_i = \frac{LL - w_N}{P_i}$$



*** Note:

$$\boxed{C_i + L_i = 1}$$

Always holds true!!!

Sensitivity:

↳ Fine soil specially clay show reduction of strength after remoulding even at same density and moisture, this property is known as sensitivity.

$$S_u = \frac{S_u \text{ (UD soil)}}{S_u \text{ (remoulded soil)}}$$

; Vane shear test: to measure S_u.

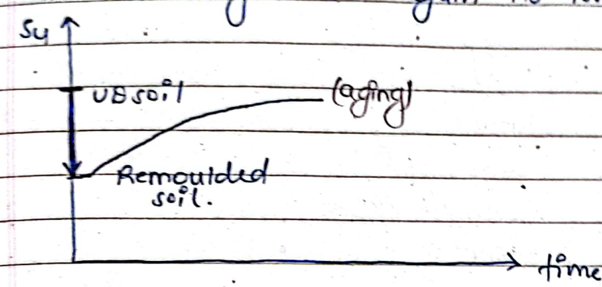
for Ktm:

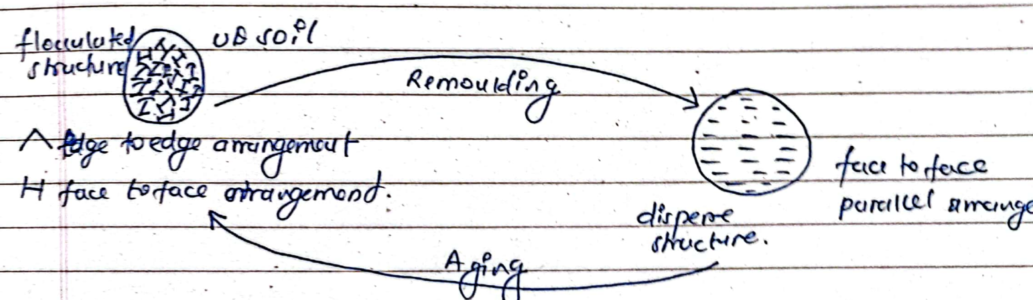
$S_n = 5$

$S_n = 4$

Thixotropy:

↳ Remoulded clay start to regain its lost strength with time(aging)





comparision

Parameter.	Flocculated structure	Dispersed structure.
shear strength	Higher	lower.
Compressibility	lower	Higher
Permeability	Higher	lower
Swelling / shrinkage	Higher	Higher.

*: Activity :-

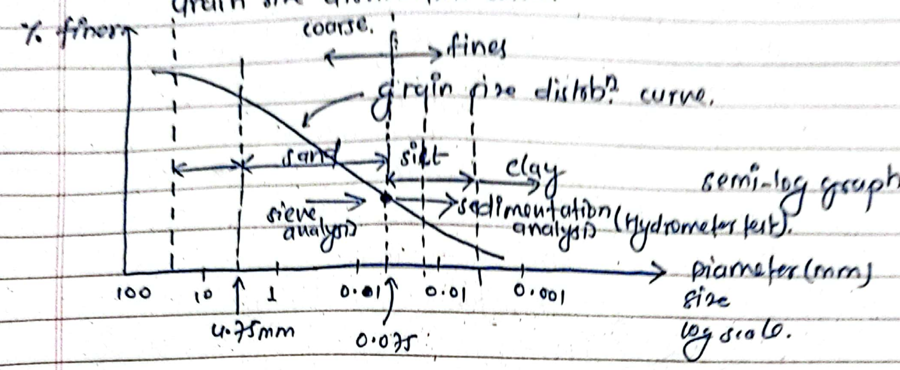
$$A = \frac{P_i}{\%\ \text{of clay fraction}}$$

; clay fraction: finer than 2μ size (0.002mm)

Activity	status of clay
> 1.25	very active
0.75 < A ≤ 1.25	moderate active.
< 0.75	inactive

Individual grain property:

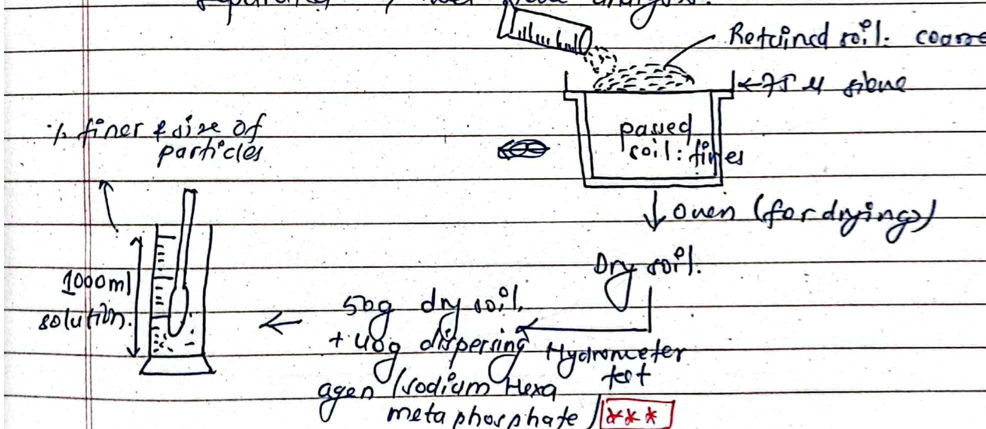
Grain size distribution curve:



80 – 300mm : Boulder
> 300mm : cobbles

if soil mass contains < 5% fines ⇒ sieve analysis (dry sieve)

if soil mass contains ≥ 5% fines ⇒ fines should be separated → wet sieve analysis.



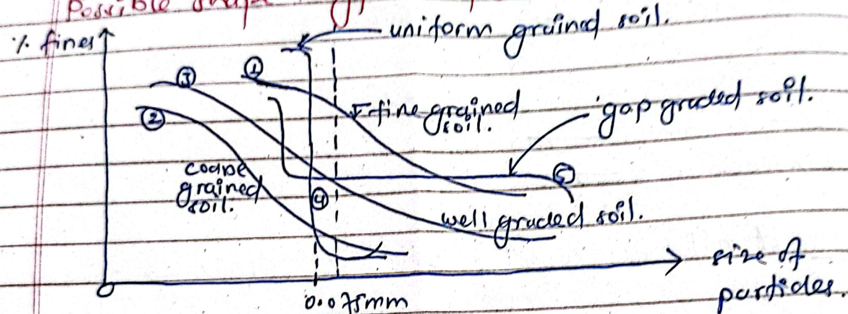
coarse sieve set

- 80 mm
- 40 mm
- 20 mm
- 10 mm
- 4.75 mm

fine sieve set:

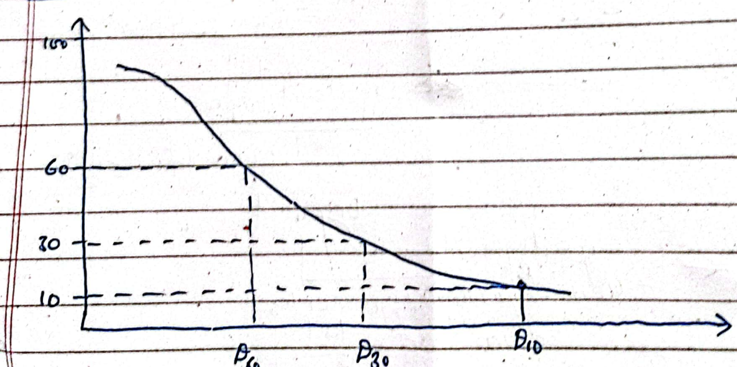
- 4.75 mm
- 2.36 mm
- 1.18 mm
- 600 μm
- 425 μ
- 300 μ
- 150 μ
- 75 μ

Possible shape / types of curve:



From grain size distrb^n curve:

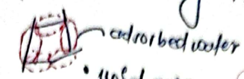
↳ Two coefficients



***

Q. Which water reduces permeability in soil?

→ Adsorbed water.



• void area decreases

Coefficient of uniformity (C_u):

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

$C_u > 4$ → gravel } for well graded soil.
$C_u > 6$ → sand }

coefficient of curvature (C_c):

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

$1 < C_c < 3$ for well grained.

***

Q. $D_{10} = 0.325$ mm means → 0.825 mm કરતાં નાના particle 10 % છે.!!!

D_{60} = આખી soil ના વધારે coarse soil નો avg size છે!

D_{10} = " " " " fine soil નો avg. size છે!!

D_{30} = જ્યાં point ના curvature form થાય છે!!!

Type of water in soil:

Broadly:

Free water.

↳ flow by gravity

↳ accumulation of free water : GWT

• Adsorbed water

↳ in surface of soil particles

↳ hydroscopic water.

• Absorbed water

↳ pore water.

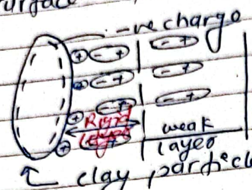
Held water.

↳ Electro chemically bonded.

↳ classification

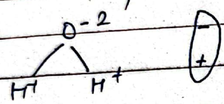
- Pore water
  - ↳ in void
  - ↳ Removed by heat
  - eg: absorbed water.
- Hygroscopic water
  - ↳ in surface of soil particles
  - ↳ removed within oven but taken immediately outside or from atmosphere.
  - eg: adsorbed water.
- Structural water
  - ↳ H_2O component in mineral of clay
  - ↳ can't be removed by heat.
  - ↳ can be removed by breaking structure.
- Capillary rise
  - ↳ in void
  - ↳ Removed by heat

Adsorbed water
- In surface of soil particles
- Diffuse double layer.
- hydroscopic water.



cation:
⊕

water: Bipolar



Absorbed water:
- in void → (void मा पानी ~~[illegible]~~ बसेको water).
- pore water.

Structure and fabric of soil:-
- soil particles arrangement
- soil particles arrangement with interparticle forces.

Types of structure:
(A) For fine soil:-

clay:
- flocculated structure
- Disperse structure

silt:
- Honeycomb structure  sensitive for dynamic load.

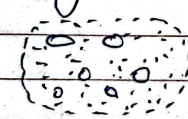
fine sand:
- Honeycomb.

(B) For coarse soil:

sand, gravel
- loose structure.  void धेरै
- dense structure.  void कम

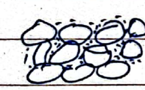
(C) Mixed soil structure:

(i) clay matrix. structure.



सबै load finer ले धान्छ! eg: माछा in समुद्र !!!

(ii) coarse skeleton structure.



load coarse particles ले धान्छ !!!

Geology: (1 marks)

Petrology: study of formation of types & occurrence of rock.

Magma: molten material at crust of earth.

lava: magma erupted to surface of earth.

Types of Rock:

↳ Depending on formation:

- Igneous
- Sedimentary
- Metamorphic

Igneous, Sedimentary → original rock.

Metamorphic → transformed rock.

Igneous rock:

↳ formed by cooling and solidification of magma.

Extrusive rock

↳ volcanic rock

↳ cooling of lava on ground surface.

↳ Very fast cooling rate (within 1 month)

→ fine grain size / microscopic

eg: Basalt, Rhyollite, Dacite, Trachytes, Perodotites

Intrusive rock

- **Hypabyssal**
  - ↳ cooling of magma within 2 km depth
  - ↳ intermediate rate of cooling
  - ↳ medium grained
  - eg: Dolerite, porphyries
- **Plutonic**
  - ↳ formed at 7-10 km depth
  - ↳ very slow rate of cooling
  - ↳ coarse grained
  - eg: Gabbro, Granite, syenites, char-kites, ~~[illegible]~~, Pegmatities, Aplite (fine grained)

Grained of soil:

< 1mm	fine
1-5 mm	medium
> 5mm	coarse.

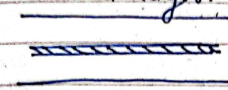
Depending on occurrence:

Concordant bodies

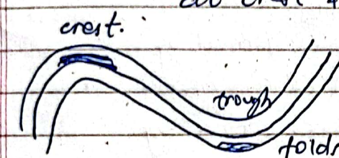
↳ Magma is cooled along or parallel to structural features of old rock layer.

Types:

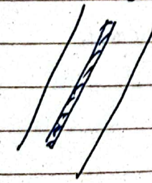
1. Sills: In between two H_2 sedimentary rock layer.



2. Phacoliths: Magma cooled & placed at crest & trough of fold.



3. lopoliths: magma cooled in betw² two inclined rock layer (center to earth).



4. Lacoliths: magma cooled in arched up layer.

Discordant bodies.

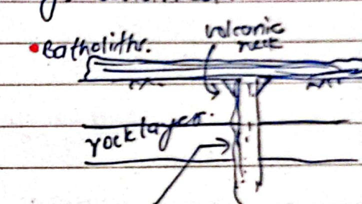
↳ Doesnot follow structural feature

↳ Magma cooled tranverse to structural features.

Types:

1. Batholiths:
   ↳ large body formed by volcanic eruption.
   eg: cortarica.

• Batholiths.



columnar body: Dikes/Dykes

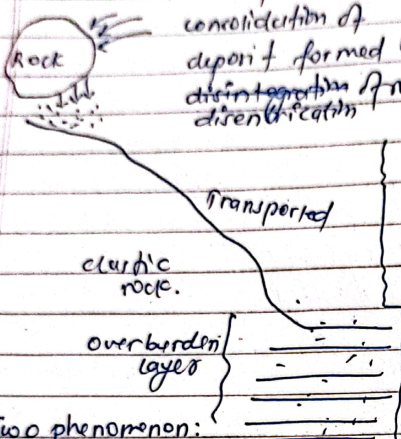
(i) Dykes/Dikes

(ii) volcanic rocks.

Batholiths → only extrusive bod

Sedimentary rock:-
↳ formed by layered by layered deposition:
| Depending on formation.

clastic rock : compaction & consolidation of deposit formed by disintegration of rock. ~~disintegration~~



Two phenomenon:
(i) welding : pressure & heat
(ii) cementing : due to foreign binding material.

Examples:
sandstones, shales, mudstone, conglomerate, Breccias, Grey wackes, Arkoses, Tillite

Non-clastic rock.

Chemical Non-clastic rock
↳ solidification of precipitated chemical
examples:
• lime stone: formed by ppt. of carbonic water
• salt stone: formed by ppt. of salt in sea.

Examples:
Gypsum, anhydrite, Dolomite, flint & chert.

Organic clastic rock
↳ consolidation carbonates (organic matter)
examples:
• coal:

Examples:
coal.

Metamorphic rock:
Metamorphism $\xrightarrow{\text{Result}}$ Transformed rock → Metamorphic rock.
↓ ↳ change in mineral.
process

Causes:
Heat: Thermal metamorphism
Pressure: Dynamic "
Chemical environment: Chemical "
Heat + Pressure: Dynamo thermal "
⇓
Also called as "Regional metamorphism" → large area HT SSS!

Depending on arrangement of minerals:

Foliated Rock.
↳ Parallel arrangement of minerals
eg. Slate, Phyllite, schist, Gneiss

Non folliated Rock.
↳ Non-parallel arrangement of minerals.
eg: Marble, Quartzite, amphibolites, soap stone, Hornfels, soap stone.

Shales $\xrightarrow{\text{low grade metamorphism}}$ Slates $\xrightarrow[\text{metamorphism}]{\text{Dynamo thermal}}$ Phyllite
Phyllite $\xrightarrow{\text{Further metamorphism}}$ schists.

shales $\xrightarrow[\text{metamorphism}]{\text{Dynamo thermal}}$ Phyllite.

Tibetian plate - Indian plate मिलना चालू आता है!

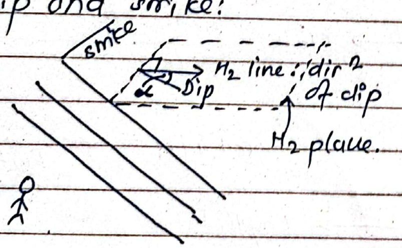
Structural Features of Rock:

Primary structures
- structural features formed during formation of rock.
- Mostly in Igneous & sedimentary rock.

Secondary structures
- Modified structural features due to change in new form, new shape & rearrangement of minerals & grains.
- Cause: stress & heat.
  - causes:
  - (i) Tectonic movement
  - (ii) Magma ~~extruption~~ extrusion, intrusion
  - (iii) stress due to huge ~~deposit~~ sediment deposits.

structural features:
1. Dip & strike
2. Fold
3. fault
4. Joint
5. shear zone
6. Rock cleavage:

1. Dip and strike:



strike: Geographical extension of rock layer.
- line formed by any assumed H_2 plane & rock layer.

Types of Dip:
(a) True dip (α)
- Inclination of rock layer with h_2 line $\perp$ to strike

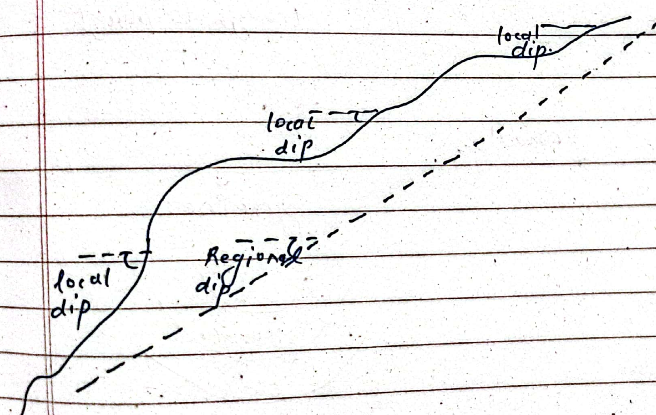
(b) Apparent dip (β)
- Inclination of rock layer measured with other line beside than H_2 line $\perp$ to strike.

Relation:

$$\tan\beta = \tan\alpha \times \cos\theta$$

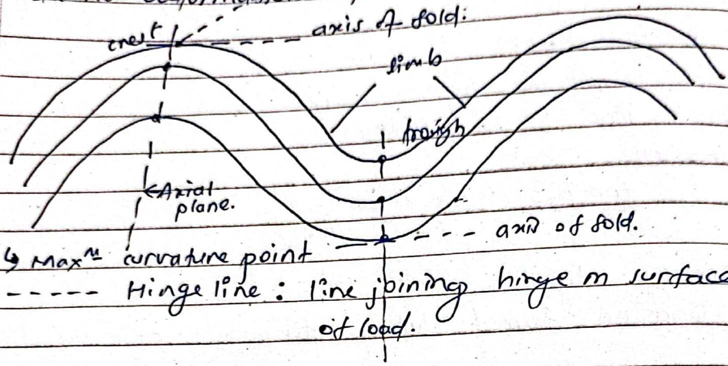
- **Primary dip:**
Inclination formed during formation of rock. ($0°$ to $20°$)

- **secondary dip:**
  - Modified dip due to stress.
  - upto $90°$ ($> 20°$ & $\le 90°$)



Fold:

↳ Undulation, curvature, bend, of rock formed due to ductile deformation of rock.



• Hing: ↳ Max^m curvature point

----- Hinge line: line joining hinge in surface of load.

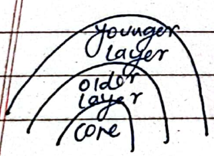
Q. fold में crest पर - tensile stress
fold में trough पर - compressive stress

One wave of fold: distance between crest to crest
" " " : " " trough to trough.

Types of fold:

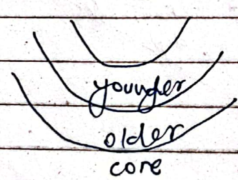
↓ Broadly.

Anticline



↳ convex upward
↳ arched up.

Syncline:

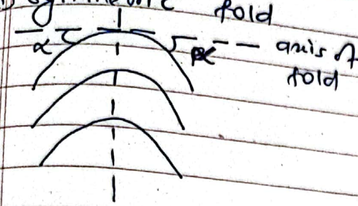


↳ concave upward.
↳ arched down.

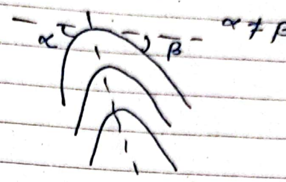
questions (MCQs)
axial plane $\perp^{er}$ to axial of fold.

other types:

(i) symmetric fold

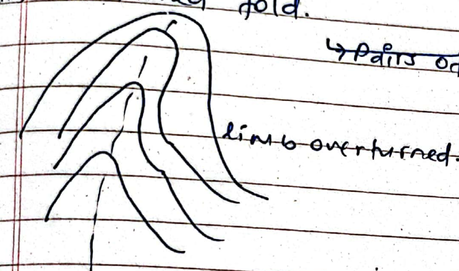


(ii) Asymmetric fold.



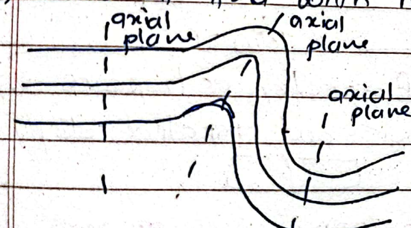
(iii) overturned fold.

~~↳ Pairs of fold with non-parallel axial plane.~~



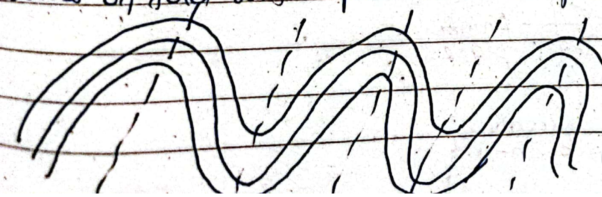
(iv) conjugate fold

↳ Pairs of fold with non-parallel axial plane.

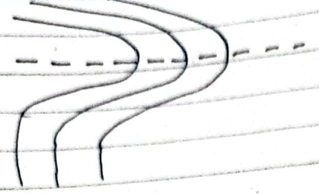


(v) Isoclinical fold.

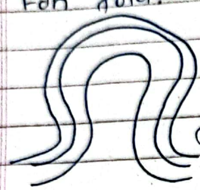
↳ series of fold with parallel axial plane



(vi) Recumbent fold:
↳ flow with H_2. axial plane.

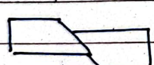
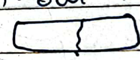
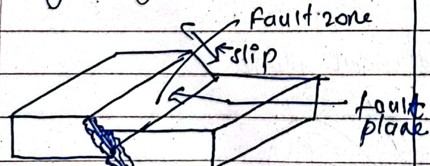


(vii) Fan fold:



fan ~~fold~~ shape.

Q. Fold with H_2. axial plane is
ⓐ syncline ⓑ Recumbent ⓒ overturned ⓓ symmetric

*: Fault	* Joint:
↳ Facture / crack / rupture in rock with relative displacement. 	↳ Fracture / crack / rupture in rock without ~~repative~~ relative displacement 
↳ large danger create.	↳ Relatively less danger
 Fault zone: clear cut discontinuity which drive rock into block.	

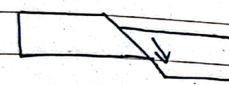
• Slip: Movement of hanging wall along fault plane.
Separation: H_2. distance betn two fault plane at same fault rock bed.

Gauge: Powder clay like particles formbed by rubbing of two block.

fault Brecia: Modular fragment (not power).

Types of fault:

(i) Normal fault:

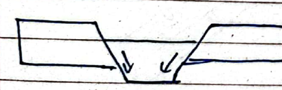


↳ Hanging wall तलातिर move गर्दै जाने।

(ii) Horst

↳ Double hanging wall moving downward.

(iii) Graben



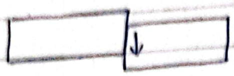
(iv) Reverse fault:

↳ If hanging wall moves upward.

CamScanner

(v) strike slip / Transcurrent fault:
↳ Two blocks moves horizontally from each other.

(vi) vertical fault:



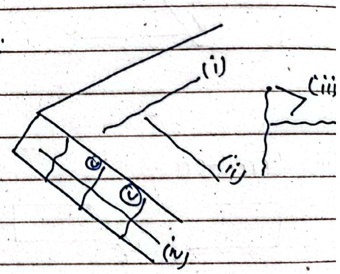
↳ If hanging wall moves vertically downward.

Joint:-

*: Depending on spatial relation
(a) systematic joint:
↳ Regular.
↳ can be mapped.

(b) Non systematic joint:
↳ irregular ~~cannot be mapped.~~
↳ can't be mapped.

*. Depending on ~~joint~~ geometry:
(i) strike joint
(ii) Dip joint
(iii) oblique joint.
(iv) longitudinal joint. or S-Joint.
(v) cross joint or Q-joint.

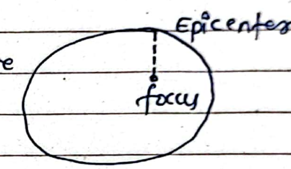


*) Depending on origin
(i) Tension joint
(ii) compression joint
(iii) shear joint.

Rock cleavage:
→ special structural features of metamorphic rock.
tendency to split the rock to parallel elements/layer.

*: Earthquake:-

Focus: A point at crust from where disturbance/cracks occurs/starts.



Epicenter: The point on G.S. vertically above focus on which vibrations reach first.

Seismic wave:
elastic wave generated due to release of energy stored in rock by elastic deformation

Types of waves:
(a) P-wave:
↳ Primary wave.
↳ Pull and push wave.
↳ Compression effect.
↳ longitudinal in nature.

longitudinal in nature:

- Particles vibrate in direction of propagation of wave.
- fastest wave.

$$v_p = \frac{\sqrt{\lambda + 2\mu}}{\rho}$$; λ & μ : elastic coefficient of medium

- Travel fast in hard rock. ρ = density of medium.

(b) S-wave:

- secondary wave
- shear wave / distortion wave.
- Transverse in nature : particles vibrate in $\perp^{er}$ direction with propagation

$$v_s = \frac{\sqrt{\mu}}{\rho}$$

Body wave:

P & S wave:

- travel deeper into depth of earth before reimmerge to ground surface.
- velocity increases with depth.

(c) L-wave:

- known as long wave.
- sluggish wave.
- surface wave : it mainly confined to surface of earth.

Types of L-waves:

(i) Reyleigh wave:

(ii) Love wave:

- Reyleigh wave:
- complex in nature
- particles vibrate partially in dir^n of propagation and partially in $\perp^{er}$ of propagation.
- zig-zag, wavy
- Destroy the surface

- Love wave:
  - small wave.
  - particles vibrates in direction of propagation

Measurement of earthquake:

In two terms:

a) Magnitude.

b) Intensity.

- Magnitude: (Richter scale)
- $\log_{10}$ of amplitude recorded at ~~100 km~~ seismogram of 100 km from epicenter.

$$M = \log_{10} A - \log_{10} A_0$$

; A = amplitude recorded at seismogram (100 km from epicenter).

A_0 = standard earthquake.

Two types:

(i) M_b = magnitude of body wave. for small EQ.

(ii) M_s = magnitude of surface wave. for large EQ.

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Type: category	Magnitude (M)
A	≥7.7
B	7.7 to 7.7
C	6 to 7
D	5.5 to 6
E	≤ 5.5

Intensity:
↳ ~~Based on~~ quantification of disaster.

(i) 10 point: Rosel Forel scale.

(ii) 12 point. : Mercali scale.

Types of earthquake:

(a) Shallow EQ.

focus: (0-60 km) depth

(b) Intermediate EQ.

focus: 60 - 300 km

(c) Deep EQ.

focus: 300 - 700 km. (Rare EQ)

Q. If focus shallow depth.
effect धेरै area मा
क्षति बढी: disaster बढी!

Depending on causes of EQ:

(a) Tectonic EQ:
↳ due to movement of tectonic plate.
↳ ~~due to~~ mostly occurrence.

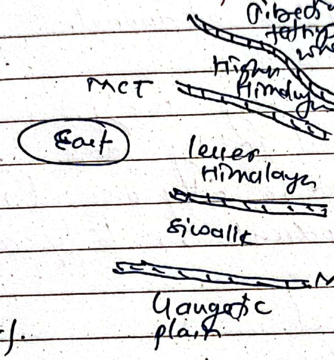
(b) Non-tectonic EQ:
↳ due to huge landslide, huge volcano, atomic explosion.

Geographical ~~Geological~~ division of Nepal:-

(i) Terai
15%.

(ii) Hills
68%.

(iii) Mountains
~~..~~ 17%.



Geological Division of Nepal:

(i) Tibetian tethys Himalaya

(ii) Higher Himalaya

West

(iii) lower Himalaya

(iv) Siwalik

(v) Gangetic plain.

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