II JAI SRI GURUDEV II

SRI ADICHUNCHANAGIRI SHIKSHANA TRUST (R.)

S.J.C. INSTITUTE OF TECHNOLOGY

CHICKBALLAPUR - 562 101.

Laboratory Certificate

This is to certify that

Mr./Ms. LAKSHMI N.C

bearing USN 1SJ18CV056 Sem 7th Branch CIVIL has

satisfactorily completed the Practical Experiments

of Geotechnical Engineering Laboratory Laboratory, Prescribed by

the Visvesvaraya Technological University for the year 2021-22

$\frac{24}{24} + \frac{16}{16} = \frac{40}{40}$

Mark Obtained	40
Total Marks	40

31/1/22

Signature of the Teacher Incharge

Date : 31/1/22

31/01/2022

Head of the Department

Professor & Head
Dept. of Civil Engineering
SJC Institute of Technology
Chickballapur-562101

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24/24 + 16/16 = 40/40

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INDEX SHEET

Name of Student: LAKSHMI N.C Class: 7th Sec: 'B'

Exp No.	Date	Title of the Experiment	Page No.	Marks obtained A (4 M)	B (8 M)	C (4 M)	D (8 M)	Total (24 M)	Sign of staff
01.	11-10-21	Water content of soil	6	4	8	4	8	24	[signature]
02.	11-10-21	Specific Gravity of soil solids by Pyconometer method	7-8	4	8	4	8	24	[signature]
03.	11-10-21	Specific Gravity by Density bottle method	9	4	8	4	8	24	[signature]
04.	26-10-21	Particle size Distribution of solids.	10-12	4	8	4	8	24	[signature]
05.	29/10/21	Core cutter method	13-14	4	8	4	8	24	[signature]
0.6	9/11/21	Sand replacement	15-18	4	8	4	8	24	[signature]
0.7	20/11/21	Plastic limit	19-21	4	8	4	8	24	[signature]
08	20/11/21	Liquid limit	22-23	4	8	4	7	23	[signature]
09	20/11/21	Shrinkage limit	24-26	4	8	3	7	22	[signature]
10	14/12/21	Standard proctor test	27-29	4	8	4	8	24	[signature]
11.	21/12/21	Constant head permeability test	30-34	4	8	4	8	24	[signature]
12.	21/12/21	Variable head permeater test	35-37	4	8	4	8	24	[signature]
13.	4/01/22	Direct shear test	38-42	4	8	4	8	24	[signature]
14.	11/1/22	unconfined compression test	43-45	4	8	4	8	24	[signature]
15.	18/1/22	vane shear test	46-48	4	8	4	8	24	[signature]
16.	29/1/22	Traxial compression test	49-51	4	8	4	8	24	[signature]

FOR 40 MARKS:

Sl No.	DESCRIPTION	MARKS
1.	**CONTINUOUS EVALUATION**	24
	a. Observation write up & Punctuality	4
	b. Conduction of experiment & Output	8
	c. C. Viva Voce	4
	d. Record Write up	8
2.	**LAB INTERNAL TEST**	16

Name of Experiment : Introduction   Date : 11/10/21
Experiment No :   Experiment Result :   Page No. 1

CLASSIFICATION AND IDENTIFICATION OF SOILS

Soil survey and soil classification are at present being done by several organization in this country for different purpose. The engineering department & research abroad have done a great deal of work in regard to soil exploration and classification in fields, relating to the field of irrigation have two objective, namely the suitability of soil when it is irrigated. with regard to the road & highway investigations have been undertaken to class them from the point of view of their suitability for construction of embankments, sub-grades & wearing surface.

Soil seldom exists in nature separately as sand (or) any other single component but are usually for as mixture with varying proportion of particles of differing. This version is essentially based on the verified soil classification system with the modification that the fine grained soils have been subdivided into three subdivisions of low, medium & compressibility, instead of 2-sub divisions of the original unified soil classified system. The system is based on these characteristics soil which indicate how it will behave (or) a construction material. This system is not limited to a particular location. It doesnot conflict with other system in fact the use of geologic pedologic, textural (or) local is encouraged as a supplement to but not a substitute for definitions. actual soils.

Teacher's Signature :

Scope :- This standard covers a system for classification & identification of soils for gravel engineering purposes. the information given in this standard should be considered for guidance only for treating the soil for engineering purpose.

Clay :- An aggregate of microscopic & sub-microscopic particles derived from the chemical decomposition & disintegration of rock constitute. It is plastic within a moderate to wide range of water content

Silt :- A fine-grained soil with little (or) no plasticity. if shaken in the palm of the hand. a part of standard inorganic silt expels enough water to make its surface appear glossy. If the part is pressed (or) squeezed b/w the fingers. its surface again becomes dull

Sand & gravel :- Cohesionless aggregates of angular. sub rounded, rounded flaky (or) flat elongation of more (or) less unaltered rocks (or) minerals.

Name of Experiment : .... Date : .... Page No. 2

Experiment No : .... Experiment Result : ....

CLASSIFICATION AND IDENTIFICATION

Division :- Soils shall be broadly divided into 3-division.

Coarse grained soils :- In these soils more than half the total material by weight is larger than 75-micro IS sieve size

Fine grained soils :- In these soils more than half of the material by weight is smaller than 75 μ IS sieve size

Highly soils & other miscellaneous soil nature : These soils contain large percentage of fibrous organic matter such as peat & particles to decomposition & vegetation. In addition, certain soils containing shall convections cinders & other non-soil material in sufficient quantities are also grouped in division

Sub division :- The first two division and shall be further divided as

Coarse grained soils : The coarse grained soils shall be divided into two sub-division namely

Gravel :- In these soils more than half the coarse frame is larger than 4.75 mm IS sieve size, this sub division includes gravels & gravelly soils.

Sands :- In these soils, more than half the fraction (4.75 μ)

Teacher's Signature : ____________

is smaller than 4.75mm sieve size this subdivision Includes sands and sandy

Fine-grained soils:- The fine-grained soils such shall be divided into 3- subdivisions on the basis on the following arbitarily selected values of liquid.

a) Silt & clays of low compressibility:
having liquid limit less than 35

b) Silt & clays of medium compressibility?
liquid limit greater than 35 & less than 50
(represents the symbol I)

c) Silts & clays of high compressibility
Having a greater than 50 (represent symbol by I)

Groups:
The coarse grained soils. shall be further into eight basic soil groups. The fine grained soil be further divided into the basic soil groups.

Name of Experiment : .... Date : ....

Experiment No : .... Experiment Result : .... Page No. 3

FIELD IDENTIFICATION AND CLASSIFICATION PROCEDURE:

The field method is used primarily in the field to classify and describe soils. Visual observation are employed in place of precise laboratory tests to define the basic soil properties. The procedure is in fact, a process of elimination beginning on the left side of the classification chart & working to the right untill the proper group name is obtained. The group name should be supplemented by detailed word description including the descriptions of the in-place condition for soils to be used in place as foundation. A representative sample of the soil is selected which is spread on a flat surface or in the palm of the hand. All particles larger than 75mm are removed from the sample only the fraction of the sample smaller than 75mm is classified the sample is classified as CE graine (or) Fg. by estimating the percentage of a gravel sized particles from 4.75 to 75 micr IS sieve size.

b) Sand size particules size range from 4.75 to 75μ IS sieve size (&) c) silt & clay size particles size range smaller than 75μ IS - sieve.

Gravelly soils :- If the percentage of gravel is greater than that of sand the soil is a gravel. Gravels are further divided identified as being clear dirty depending upon the % 5 to 12% fines are given.

Teacher's Signature : ______

Classification:- If the soil is obviously clear the classification shall be either

a) well graded gravel (GW) :- If there is good representation of all particle sizes

b) poorly graded gravel (GP). If there is an excess (or) absence of intermediate particle sizes

c) silty gravel (GM) if the fines have little (or) no plasticity

d) Clayey gravel (GC) :- If the fines are of low of medium (or) high plasticity

Sandy soils:- If the percentage of sand is greater than gravel the soil is a sand. the same procedure is applied as for gravels except that the word sand replaces gravel & the symbols S replace G The group classification for the clean sand will be either

a) well graded sand

b) poorly graded sand (SP) & the dirty sands shall be classified

c) silty sand (SM) if the fines have little (or) no plasticity

d) clayey sand (SC) if the fines are of low to medium (or) high plasticity.

Fine Grained soils:- If it has been determined that the soils is fine grained it is further identified by estimate the % of gravel sand, silt & clay like particles & performing the identification tests for dry strength dilatancy & toughness by comparing the results of these tests with the requirements given for the fine fine-grained soil group. the approximate group name & symbol is assigned.

Name of Experiment :.. Date :..
Experiment No :.. Experiment Result :.. Page No. 4

Manual identification Tests :- The following tests for identifying the fine-grained soils shall be performance on the fraction of the soil finer than the 4.25 IS-sieve

a) Dilatancy [reaction to shaking]

Take a small represent sample in the form of a soil pat of the size of about 5 cubic centimeter & add enough water to nearly saturate it place the pat in the open palm of one hand & shake horizontally striking vigorously against the other hand several times. Squeeze the pat b/w the fingers the appearance & disappearance of the water with shaking & squeezing is referred to as a reⁿ. This reaction is called quick if the water appears & disappear slowly to change observe and record type of reaction as descriptive information.

b) Toughness [consistency near plastic limit] :- Dry the patern used in the dilatency test by working and mould until it has the the consistency of putty. The time required to dry the pat is the indication of its plasticity. Roll the pat into a thread about 3mm in dia. fold and rerace the thread repeatedly in diameter so that its moisture content is gradually reduced until the 3mm thread just crumbles. The moisture content at this time is called the plastic limit is called the toughness. After the thread crumbles. If the lump can still be moulded slightly greater than the plastic

Teacher's Signature : ______________

limit & if high pressure is required to roll the thread b/w the palms of the hand the soil is described as having high toughness, medium toughness is indicated by medium threads slightly below the plastic limit will crumble while low toughness is indicated by a weak thread that breaks easily & cannot be lumped together when drier than the plastic limit. Highly organic clays have very weak & strongy feel at the plastic limit non-plastic soils cannot be rolled into thread of 3mm in diameter at any moisture content observe & record the toughness as descriptive information

c) Dry strength (crushing resistance):- Completely dry the prepared soil pat, then measure its resistance to crumbling & strength is a measure largely by the colloidal fraction content. the dry strength is described as low. if the dry pat can be easily powdered. medium if considerable finger pressure is required & high if it cannot be powdered at all observe & record the dry strength as descriptive information.

d) Organic content & colour:- Fresh wet organic soils usually have a distinctive colour of decomposed organic matter this colour can be made more noticable by heating the wet sample. Another indication of the organic matter is the distinctive dark colour. In tropical soils. the dark colour may be (or) may not be due to organic matter. it is associated with poor drainage. dry organic clays develop on earthy colour upon which is distractive from that of dumposed organic matter.

c) Other than identification tests

1) Acid test:- Acid test using dilute hydrochloric acid is primearily a test for the presence of carbonate for soils with high dry strength, a strong reaction indicates that the strength may be calcium carbonate as counting agent rature than collidal clay. the results of this test should be included in the soil description if pertinant

2) Shine test:- This is a quick supplementary procedure for determining the presence of clay. The test is performed by cutting a lump of dry (or) slightly moist soil with a shine the shiny surface impart to the soil indicates highly plastic clay while a dull surface indicates silt (or) clay of low plasticity

3) Miscellaneous test:- other criteria undoubtedly may be developed by the individual as the gain experience in clarifying the soils.

12/10/21

Tabular columns:

Cup no.	weight of empty cup W_1 (g)	weight of cup + wet soil in (g) W_2	wt of cup + dry soil in (g) W_3	weight of dry soil W_3-W_1 (g)	weight of water W_2-W_3 (g)	water content (%) $W = \frac{W_2-W_3}{W_3-W_1} \times 100$
21	16	47	40	24	7	29.16%
22	14	40	34	20	6	30 %
11	16	46	40	24	6	25%

$$W_C = \frac{W_2 - W_3}{W_3 - W_1} \times 100$$

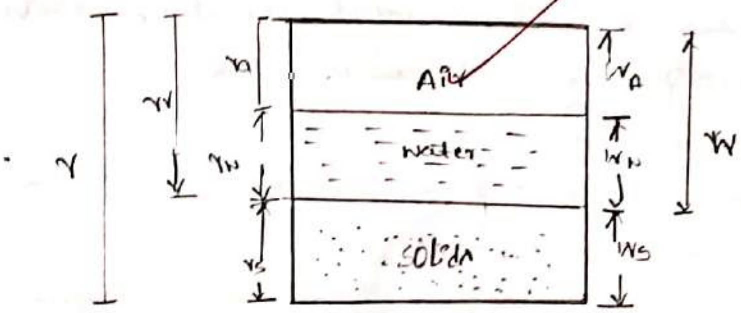
Trial 1: $\frac{47-40}{40-16} \times 100 = 29.16$

Trial 2 = $\frac{40-34}{34-14} \times 100 = 30$

Trial 3 = $\frac{46-40}{40-16} \times 100 = 25$

Avg water content = $\frac{29.16+30+25}{3}$

$= 28.05\%$



V_w = Volume of water in the soil

V_v = Volume of Voids in the soil

V_a = Volume of air in the soil

W_a = Weight of air

W_s = Weight of solids

W_w = weight of water

Name of Experiment : Water content Date : 11/10/21
Experiment No : 01 Experiment Result :

WATER CONTENT OF SOIL

Aim :- Determination of water content of the given soil sample

Theory :- perhaps the important factors that greatly affect many soil properties is the water present in a soil. Its determination is very important. It is generally expressed as a percentage by weight of dry solids in soil mass

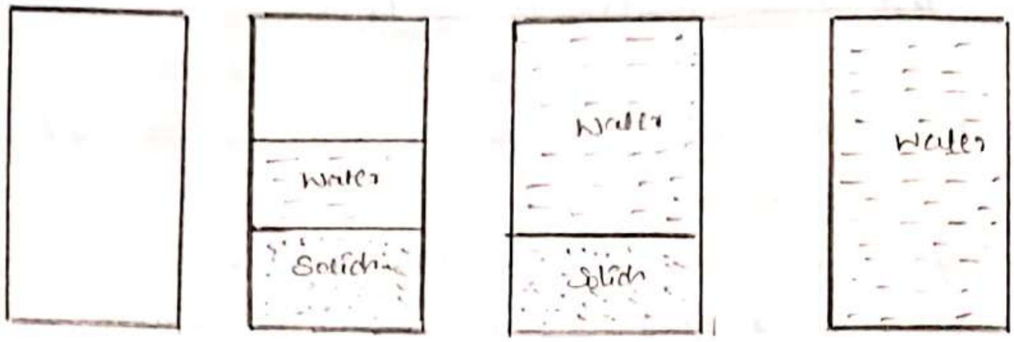
Apparatus :- water content cups, Hot air oven, Balance, weights

Procedure :- clean dry & weight the container with lid accurately let it be w_1
Then place the wet soil into the container & weight it be w_2
Then soil sample with container is kept in an oven maintained at temp of 100° to 105°c for 24 hours
The oven dried sample is weighed again let be w_3
Determine the weight of dry $w_d = w_3 - w_1$
Determine the weight of water $w_w = w_2 - w_3$

→ Comment :- The water content is 28.05%. Then soil behaves as semi solid.
→ Result :- The water content of the given soil sample is 28.05%.

⇒ Applications:
1) water content of soil is used to determine water holding capacity of soil
2) It is important to know the optimum moisture content of soil in order to achieve maximum density compaction & bearing capacity
3) Most importantly used in embankment & construction of roads.

Teacher's Signature :



a) Empty pycnometer wt. W_1

b) pycnometer + Wet soil wt. W_2

c) pycnometer + Wet soil + Water wt. W_3

d) pycnometer + Water wt. W_4

pycnometer Bottle.

DETERMINATION OF SPECIFIC GRAVITY OF SOIL SOLIDS BY PYCONOMETER METHOD

Aim: To determine the specific gravity of soil solids by pycnometer bottle method.

Theory: Specific gravity of a soil is the ratio of the mass of unit volume of soil at a stated temp to the mass of the same volume of gas-free distilled water at a stated temp. soil contains water, air & solid particles. It is given volume of soil weight of soil including water & other matter is taken in to account we get mass specific gravity Gm. If solid particles are only taken into account we have the specific gravity of solids.

Apparatus: pyconometer, 4.75mm IS sieve, glass rod, pipette, distilled & deaired water, thermometer, balance

Procedure:

1) Clean & dry the pycnometer & weigh it along with the conical cup W_1 g

2) Take about 1/3rd of 4.75mm IS sieve passing soil in the bottle & weight of this W_2 g

3) Add sufficient distilled water to cover the soil about half full & shake well to remove the entrapper air.

4) After removing the entrapped air, fill the bottle with water completely upto the mark

Teacher's Signature :

Tabular column:

Sl. NO	Particular	Trail 1	Trial 2	Trail 3
1.	weight of empty pyconometer W_1 (g)	631	635	635
2.	weight of empty pycnometer + Soil sample W_2 (g)	940	940	1050
3.	weight of pycnometer + soil + full of water W_3(g)	1713	1713	1725
4.	weight of empty pyconometer + full of water W_4(g)	1513	1531	1525
5.	Specific gravity (G)	2.43	2.47	1.93

Specific gravity $G = \frac{\text{weight of soil}}{\text{weight of equal vol of distilled water}}$

$$G = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$$

temperature = 28°c

Trial 1 :- $\frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)} = \frac{1050 - 635}{(1525 - 635) - (1725 - 1050)} = 1.93$

Trial 2 :- $= \frac{940 - 635}{(1531 - 635) - (1713 - 942)} = 2.47$

Trial 3 :- $= \frac{940 - 631}{(1531 - 631) - (1713 - 940)} = 2.43$

Average $= \frac{2.43 + 2.47 + 1.93}{3} = 2.27$

5) Thoroughly dry the bottle from outside & weigh it & record it as W_3 g
6) Record the temp of the content in the degree centigrade
7) clean the bottle with water upto the mark extra water is removed using pipette & record and weigh W_4 grams
8) Then calculate the specific gravity of soil by using formula.

Result:

The specific gravity of soil solids obtained is 2.27
This value falls below 2.6
Hence the type of soil is organic soil.

=> Comment:- The type of soil is organic soil

=> uses / application:

1) Specific gravity of soil used to calculate the density of soil solids
2) It is used to calculate void ratio
3) It is used to calculate degree of saturation
4) It is used to calculate porosity.
5) specific gravity is used to determine the types of soil
 - sand - 2.64 to 2.67
 - Silt - 2.67 to 2.7
 - clay - 2.7 to 2.8
 - Clay with iron content = 2.83 to 2.9
 - Organic soil = 1.26 to 2.2

28/24 21/10/21

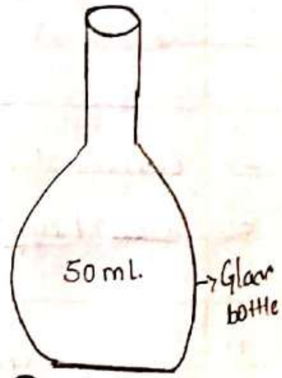
Teacher's Signature :

Tabular column:

Sl. NO.	Particular	Trail 1	Trail 2	Trial 3
1.	weight of empty bottle W_1(g)	26	26	26
2.	weight of empty bottle + soil sample W_2(g)	44	48	51
3.	weight of bottle + soil + full of water W_3(g)	87	89	92
4.	weight of bottle + with full of water W_4(gr)	76	76	76
5.	specific gravity 'G'	2.57	2.44	2.77

Specific gravity $G = \frac{\text{weight of soil}}{\text{wt of equal volume of distilled water}}$

$$= \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$$



Density bottle

Trial 1:- $\frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)} = \frac{44 - 26}{(76-26) - (87-44)} = 2.57$

Trial 2:- $\frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)} = \frac{48 - 26}{(76-26) - (89-48)} = 2.44$

Trial 3:- $\frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)} = \frac{51 - 26}{(76-26) - (92-51)} = 2.77$

Average $= \frac{2.37 + 2.44 + 2.77}{3}$

Average $= 2.69$

Name of Experiment : Density bottle method Date : 11/10/21

Experiment No : 03 Experiment Result : Page No. 9

DETERMINATION OF SPECIFIC GRAVITY OF SOIL SOLIDS BY DENSITY BOTTLE METHOD

Aim :- To determine the specific gravity of soil solids by density bottle method.

Apparatus :- Specific gravity bottle, pipette, distilled water, balance, 600 micron IS sieve.

Procedure :

1) Clean & dry the density bottle & weigh it along with the stopper W_1 in g

2) Take about 1/3rd of 600 micron IS sieve passing soil in bottle & weight as W_2 g

3) Fill the density bottle with distilled water up to half its height & stir the mix with a glass rod. Add more water & stir it. Place the stopper on top & take the weight W_3 g

4) Remove the contents from the density bottle, clean it thoroughly & fill it with distilled water, weight it W_4 g

5) Use above eqn for determining 'G'

6) Repeat the same process for additional tests

Result :

The specific gravity of soil is 2.59

The value falls below 2.6

Hence the type of soil is organic soil.

21/10/21

Teacher's Signature :

Name of Experiment :.................................... Date :..

Experiment No :.................................... Experiment Result :.................................... Page No.

=> Comment :- The specific gravity is 2.59 hence the type of soil is Organic soil.

=> Application :

1) Specific gravity of soil used to calculate the density of soil solids

2) It is used to calculate void ratio

3) It is used to calculate degree of saturation

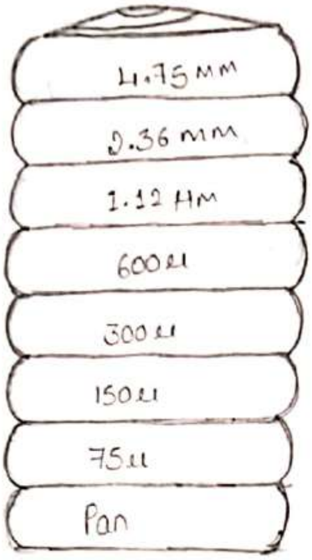
4) It is used to calculate porosity.

5) Specific gravity can be used to determine if an object will sink or float on water.

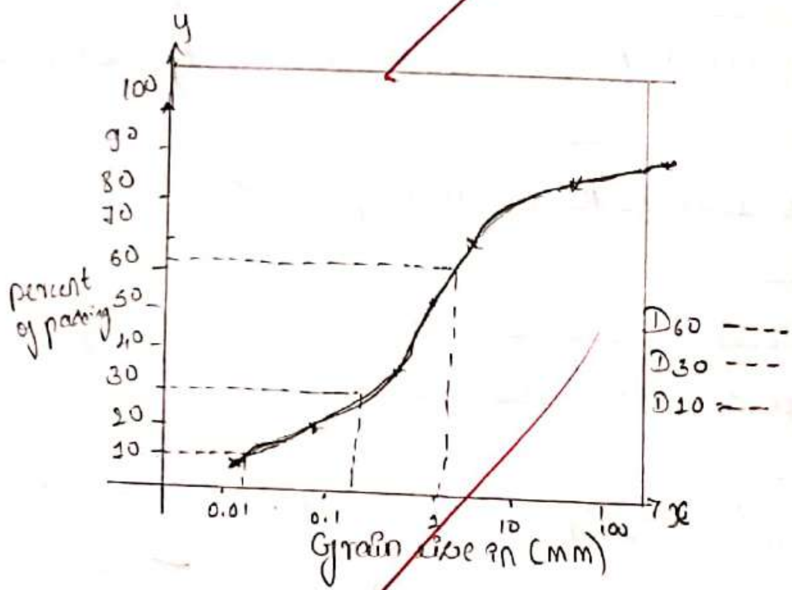
6) Knowing the specific gravity will allow determination of a fluid's characteristics compared to a standard, usually water at a specified temperature.

Teacher's Signature : ____________

Figure



IS- Sieves



Graph

Name of Experiment : Particle size distribution Date : 26/10/21

Experiment No : Q.H. Experiment Result :

PARTICLE SIZE DISTRIBUTION OF SOILS

Aim:- To determine the particle size distribution of the given soil sample (sieve analysis)

Theory :- It was thought earlier that most of the physical properties of soil are governed by the grain size distribution But it is well established now that most of the physical properties have no relation to grain size distribution. However a detailed description of the grain size distribution will not be out of place because (a) also the development of a feel for the soil behavior it may aid in the interpretation of the results obtained

For particles bigger than 0.075 mm sieve analysis is used. for finer soils sedimentation method is adopted.

Apparatus:- Sieve shaker

- Balance brush

IS sieves size - 4.75 mm, 2 mm, 1.2 mm, 0.6 mm, 0.3 mm 0.15 mm, 0.075 mm, pan.

Procedure:

A known weight of dry soil usually 500 g is taken & powdered breaking the lumps. A set of sieves as above are arranged so that largest opening size is kept at top & others in the order of decreasing size the least size being at bottom

Teacher's Signature :

Tabular columns:

Wt. of soil taken for the test = 1000 gm.

$\frac{145}{1000} \times 100$

Sl. NO	IS sieve size in mm	Wt of empty sieve in gm	Wt of sieve + soil remained in g	Wt of soil retained in g	Cumulative Wt. of soil Retained in g	Cumulative percentage retained in gm	percentage of finer N in (%) 100 - Cumulative % retained
1	4.75	743	888	145	14.5	14.5	85.5
2	2.36	509	649	140	14.0	28.5	71.5
3	1.18	367	422	55	5.5	34	66
4	600µ	380	543	163	16.3	50.3	49.7
5	300µ	370	613	243	24.3	74.6	25.4
6	150µ	353	486	133	13.3	87.9	12.1
7	75µ	350	407	57	5.7	93.6	6.4
8	pan.	303	332	29	2.9	96.5	3.5

Calculations:

uniformity coefficient $= C_u = \frac{D_{60}}{D_{10}} = \frac{0.91}{0.12} = 7.68$

Coefficient of gradation $= C_c = \frac{D_{30}^2}{(D_{60} \times D_{10})} = \frac{(0.37)^2}{0.9 \times 0.12} = ~~12~~ 1.253$

Name of Experiment :..................................... Date :..

Experiment No :... Experiment Result :......................................

Each of the sieve is brushed & cleaned & empty weight of each found earlier & the set is placed in a sieve shaker & sieved for 10 to 15 min. The soil gets sieved & graded according to individual grain sizes. each of the sieve with material retained are weighed & the soil passing the least sieve is set aside for sedimentation analysis.

1) Weigh the each sieve to 0.1g which is to be used make sure that each sieve is clean before weighing it.

2) Select with care a test sample which is representative of the soil to be tested. Break the soil into individual particles with finger as a rubber tipped pestle.

3) Weigh 500g of oven dried sample. If the soil to be tested has many particles coarser than 4.75mm larger weight of the soil should be used.

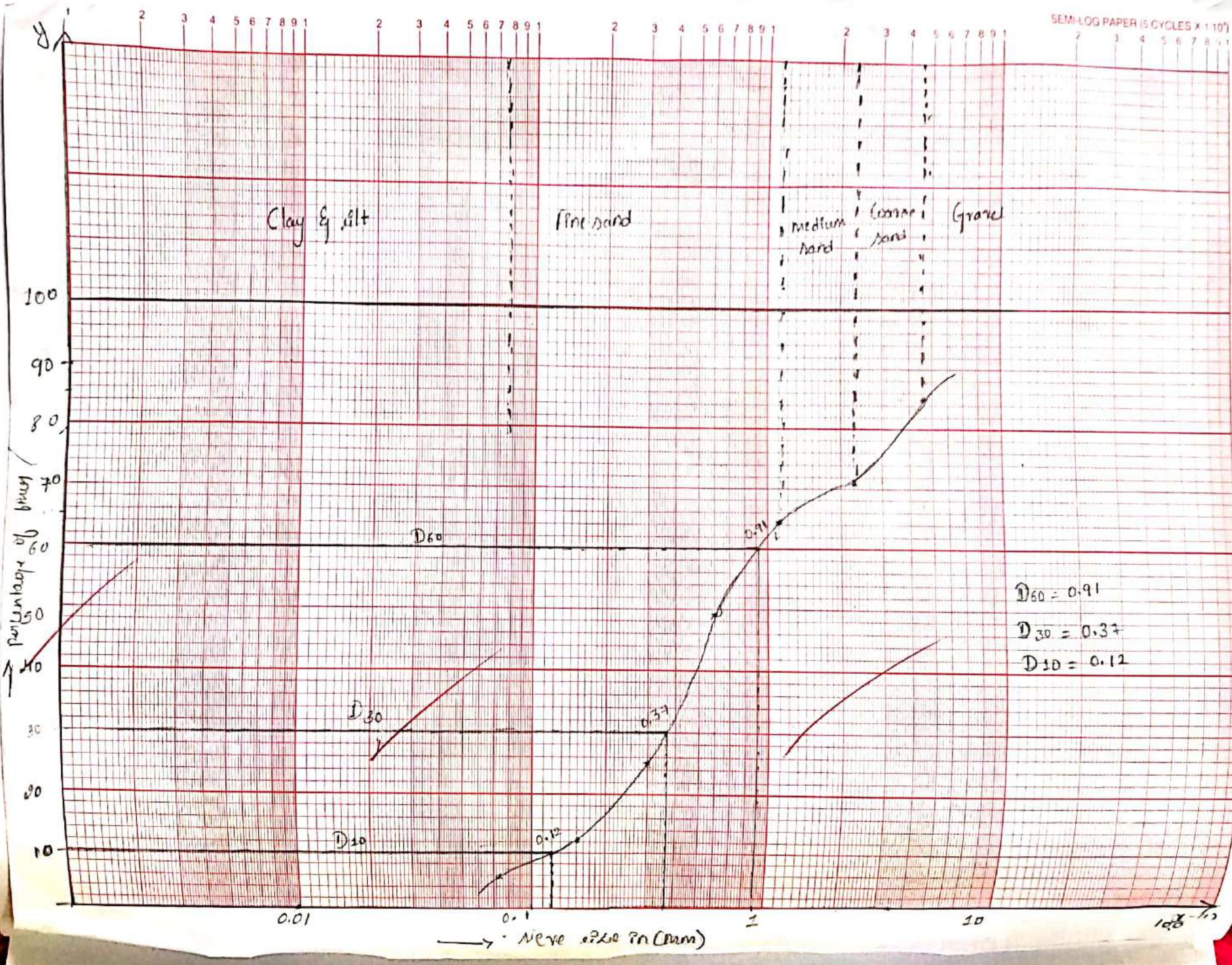
4) Sieve the soil through the set of sieves by hand shaking 15min using a motion of horizontal rotation (or) using a mechanical shaker atleast 10min of hand sieving is desirable for soils with small particles.

5) weight the sieves & pan with the soil retained on them

6) Subtract the weight obtained in step 1 from those of step 5 to give the weight of soil retained on each sieve

7) If a sizeable portion of the soil is retained on 75micron sieves it should be washed. This is done by placing sieve & retained soil in the pan & pouring than water on the screen. use a spoon or glass rod in case of slurry to stir.

Teacher's Signature : ____________



Scanned with CamScanner

Recover the soil which is washed dry & weigh. it the weight recovered should be subtracted from the weight retained on 75micron sieve & added to the weight retained on the pan.

Graphs- Particle size (log scale) vs percent finer (arithmetic scale)

Precautions :- selection of representative sample is essential 2) The lump are to be broken into individual particles 3) Dry sieving is not accurate wet sieving may be preferred. the soil is soaked for 24h, so that all lumps are broken into individual grains & it is dried weighed & then sieve analysis continued as above. soil particles passing through 0.075mm sieve is used for sedimentation analysis.

Result:

(Cu) uniformity coefficient is 7.58 therefore it is well Graded. Gravel
Cc coefficient of gradation is 1.253

Comment:

∴ It is well Graded Gravel.

Application

1) particle size distribution is important for classification of soil
2) It is also used for the design of drainage filters
3) It is used for selecting filling materials for embankment, earthen dams, road sub-base etc.
4) Particle size distribution also used to estimate performance of grouting chemical injection

2/11/21

Teacher's Signature :

Tabular columns:

Weight of empty core = W_1 = 925 g

Weight of core + soil = W_2 = 2726 g

Weight of soil $(W_2 - W_1)$ = 1801 g

Diameter of core cutter D = 10 cm = 100 mm

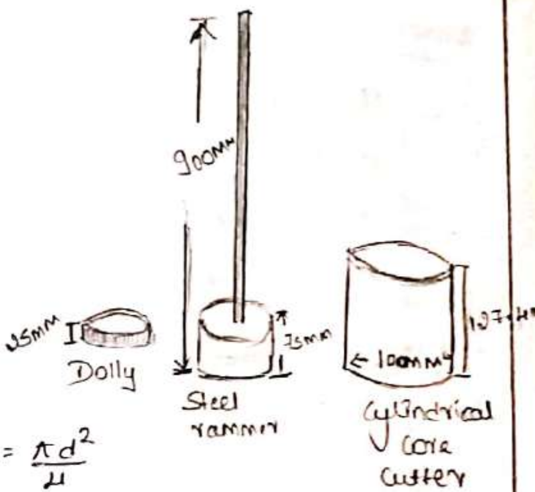
Height of the core = H = 13 cm = 130 mm

Volume of the core = $V = \frac{\pi D^2 H}{4}$

$= \frac{\pi (100)^2 \times 130}{4}$

$V = 1.02 \times 10^6 \, mm^3$

$V = 1021.01 \, cm^3$



$A = \frac{\pi d^2}{4}$

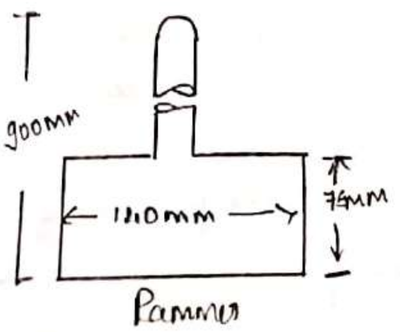
$A = \frac{\pi \times 10^2}{4} =$

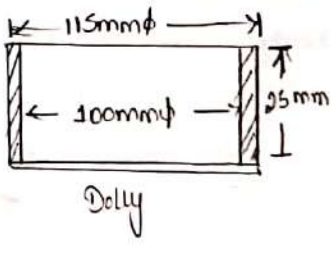
$A = 78.53 \, cm^2$

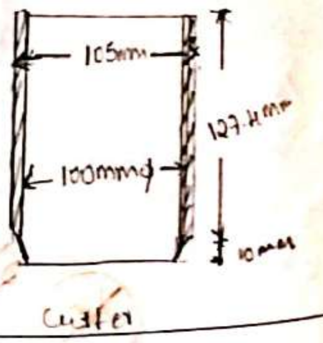
Moisture content Determination.

cup No.	weight of empty cup in (g) W_1	weight of cup + wet soil in (g) W_2	wt. of cup + dry soil W_3	wt. of dry soil in g $W_3 - W_1$	wt. of water (g) $W_2 - W_3$	water content (%) $W = \frac{W_2 - W_3}{W_3 - W_1} \times 100$
18	17	49	46	29	3	10.34 %
7	19	38	37	18	1	5.55 %
20	20	39	37	17	2	11.76 %

Avg = W = 9.21 %







Name of Experiment : core cutter method Date : 29|10|21

Experiment No : 6 Experiment Result : Page No.

FIELD UNIT WEIGHT TEST CORE CUTTER METHOD.

Aim:- To determine the mass density of soil by core cutter method.

Apparatus:- cylindrical core cutter (height 12.74cm & internal diameter 10cm), steel rammer steel dolly [25cm height & 10cm internal diameter]. knife. steel value. spade or percause straight edge. balance [accuracy of 0.01gm] desicator, oven, moisture content cups.

Procedure:

1) A standard core cutter is taken it's inside surface cleaned & oiled. Measure the height & internal dia of the core cutter

2) weight the clean core cutter. let it be W_1 gms

3) Clean & level the place where density is to be determined.

4) press the cylinderical cutter into the soil to its full depth with the help of steel rammer.

5) Remove the soil round the cutter by spade

6) Lift up the core cutter.

7) Trim the top & bottom surface of the sample carefully

8) clean the outside surface of the core cutter,

9) weigh the core cutter with the soil let it be W_2 gms.

Teacher's Signature :

Calculation:

1) Bulk unit weight of soil in field = $\frac{W_2 - W_1}{\text{vol of core cutter}}$

$= \frac{2726 - 925}{1021.01}$

$\gamma_b = 1.76 \text{ g/cm}^3$

2) Dry Density of soil in field = $\frac{\text{Bulk unit weight}}{1+w}$

$= \frac{1.76}{1 + \left[\frac{9.21}{100}\right]}$

$\gamma_d = 1.61 \text{ g/cm}^3$

3) Void ratio, $e = \frac{G\gamma_w}{\gamma_d} - 1$

$= \frac{2.65 \times 1}{1.61} - 1$

$e = 0.64$

4) Degree of saturation $S = \frac{wG}{e} \times 100$

$= \frac{9.21 \times 2.65}{0.64}$

$S = 37.41\%$

5) porosity $\eta = \frac{e}{1+e}$

$= \frac{0.64}{1+0.64}$

$\eta = 0.39\ \%$

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10. Remove the soil core from the cutter & take representative sample in the crucible to determine the moisture content.
11. Then the calculations are done as shown in the observation part.

Result:-

Degree of saturation = 37.41%
Bulk unit weight of soil in field = 1.76 g/cm³
Dry density of soil in field = 1.61 g/cm³
Void ratio = 0.64
∴ porosity = 0.39%.

Comment :- It is only used in fine grained cohesive soil without stone

Applications:

1) Density is used in calculating the stress in the soil due to its overburden pressure.
2) It is needed in estimating the bearing capacity of soil foundation system settlement of footings earth pressure behind the retaining walls, dams, embankments.
3) It is the density which controls the field compaction of soils permeability of soils depends upon its density.
4) Stability of natural slopes, dams, embankments & cuts checked with the help of density of those soils.

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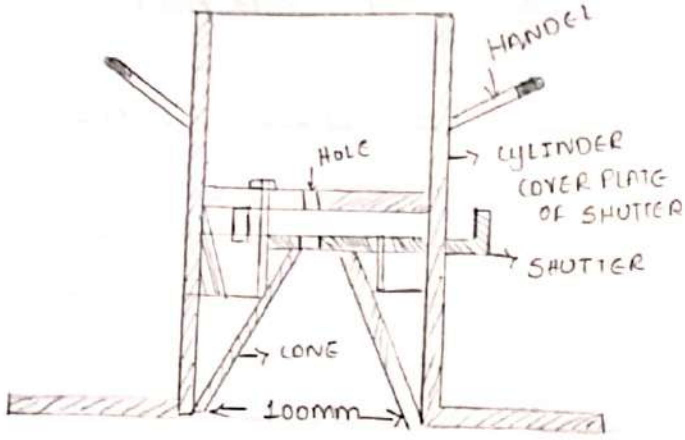
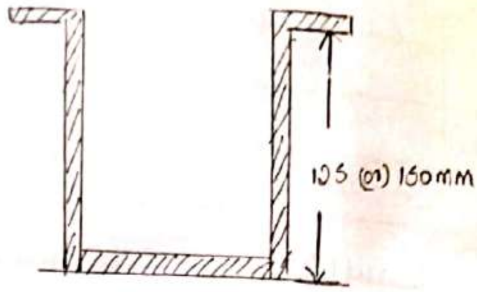
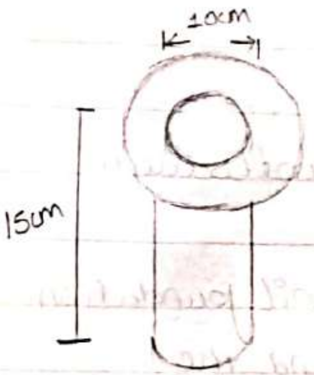
Figure:



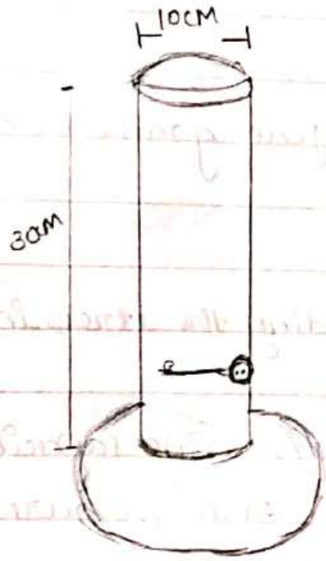
a) SAND POURING CYLINDER



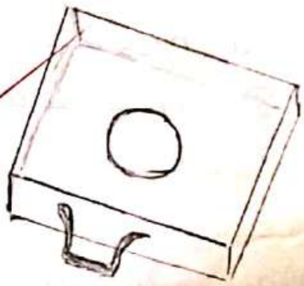
b) CALIBRATING CONTAINER



Calibrating Container



Sand pouring cylinder



Metal tray with a hole

Name of Experiment : Sand replacement. Date : 9/11/21
Experiment No : 6 Experiment Result : Page No. 15

SAND REPLACEMENT METHOD

Aim:- To determine the mass density of soil by sand replacement method & estimate void ratio & degree of saturation.

Theory:- In this method a hole is made in the field & its volume is determined by replacing it with sand which had earlier been calibrated.

Apparatus :- Sand pouring cylinder, trowel or bent spoon, cylindrical calibrating container, metal with hole (30cm square with 10cm hole in the centre). sand (clean oven dried passing (600 micron sieve) auger calibration, balance (accuracy 1gm to 0.01gm) oven, desicator, glass plate (about 45cm square) Scrapped tool. measuring Jar (1000cc) moisture content cup.

Procedure:

Calibration of sand :- a sand cylinder is taken and filled fully with coarse & passing IS sieve 600micr & retained on IS sieve 300 micron size. It is weighed with sand then a calibration vessel is taken & its volume determined. The sand pouring cylinder is placed on the calibration vessel the sand is allowed into the calibration vessel until the flow stops. The weight of sand to fill the conical peak. the weight of sand cylinder after sand is poured to vessel

Teacher's Signature :

Tabular column:- a) Calibration of sand

Sl.No	observation & Calculations.	Symbol	Trial
1.	weight of sand pouring cylinder & full sand	W_1 (g)	6852 g
2.	weight of sand in cone	W_2 (gm)	362 g
3.	Volume of calibrating container	V_a (cm^3)	1178.09 cm^3
4.	weight of cylinder & sand after filling calibrating container	W_3 (gm)	4930. g
5.	weight of sand filling calibrating container $W_a = W_1 - W_3 - W_2$	W_a (gm)	1560. g
6.	Bulk density of sand $\gamma_s = \frac{W_a}{V_a}$	γ_s (g/cm^3)	$= \frac{1560}{1178.09} = 1.32 g/cm^3$

b) Field Density test:

Sl. No	observation & calculation	Symbol	Trial
1.	weight of sand pouring cylinder with full sand	W_1 (gm)	6852 g
2.	weight of moist soil from excavated hole	W (gms)	1408 g
3.	weight of cylinder & sand after filling the excavated hole	W_4 (gm)	5184 g

is again weighed. Then the cylinder is placed over a plain surface & sand allowed to flow. The sand that has flown out is weighed. This weight of sand to fill the conical portion. The density of sand is then calculated by dividing the weight of sand to fill the calibration vessel by the volume of calibration vessel.

2] Actual field test: place a tray with a central hole (150mm dia) at the centre of a field where the field density is to be found. By using an auger drill a hole through the tray & collect the material so drilled and find its weight. place the sand cylinder with sand which has been pre weighed on the hole drilled in the field. Allow the sand to flow into the hole, untill the flows stops. Then again weigh the cylinder with remaining sand. Take a small sample of soil from the field & find the water content by usual method.

4.	weight of sand in the excavated hole $W_b = W_1 - W_4 - W_2$	W_b (gm)	1306 g
5.	Volume of sand filling the excavated hole $V = \frac{W_b}{\gamma_s}$	V cm³	$= \frac{1306}{1.32} = 989$ cm³
6.	Insitu bulk density of wet excavated hole $\gamma_b = \frac{W}{V}$	γ_b (g/cm³)	$= \frac{1408}{9.89} = 1.42$ g/cm³
7.	moisture content determination moisture content crucible no. mass of crucible Mass of crucible + wet soil Mass of crucible + dry soil moisture content of the excavated soil $W = \frac{m_2 - m_1}{m_3 - m_1}$	 m_1 m_2 m_3 W %,	
8.	Dry density of dry soil $\gamma_d = \frac{\gamma_b}{1+w}$	γ_d (g/cm³) $= 1.41$ g/cm³	

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

$$= \frac{1.42}{1 + \frac{0.6233}{100}}$$

$$\gamma_d = 1.40 \text{ g/cm}^3$$

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moisture content Determination.

cup no.	weight of empty cup in (gm) w_1	weight of cup+wet soil in (gm) w_2	wt. of cup+dry soil in (gm) w_3	weight of dry soil in (gm) w_3-w_1	weight of water in (gm) w_2-w_3	water content (%) $w=\frac{w_2-w_3}{w_3-w_1}\times100$
8.	14	35	29	15	6	40%
12.	16	31	24	8	7	87%
3.	19	35	29	10	6	60%

W = 62.33%

water content (%) = $\frac{40+87+60}{3}$

$w = 62.33\%$

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

$$= \frac{1.42}{1+\frac{0.623}{100}}$$

$\gamma_d = 1.40\ g/cm^3$

Result:

In the field the bulk density of the excavated soil is $\gamma_b = 1.412\ g/cm^3$

Dry density of the soil is $\gamma_d = 1.140\ g/cm^3$

comment:

- Bulk density of soil in lab = $1.32\ g/cm^3$
- Bulk density of soil in ground = $1.412\ g/cm^3$

Hence Bulk density of soil in the ground is more compared to lab bcoz so. Ground soil don't require more compaction.

Applications

1) The sand replacement method is used to determine in-place density.

2) The results obtained from the sand replacement method are more approriate than core-cutter method.

3) It used to determine the bulk density and dry density of a soil.

4) The sand replacement method is used to determine the field density of soils.

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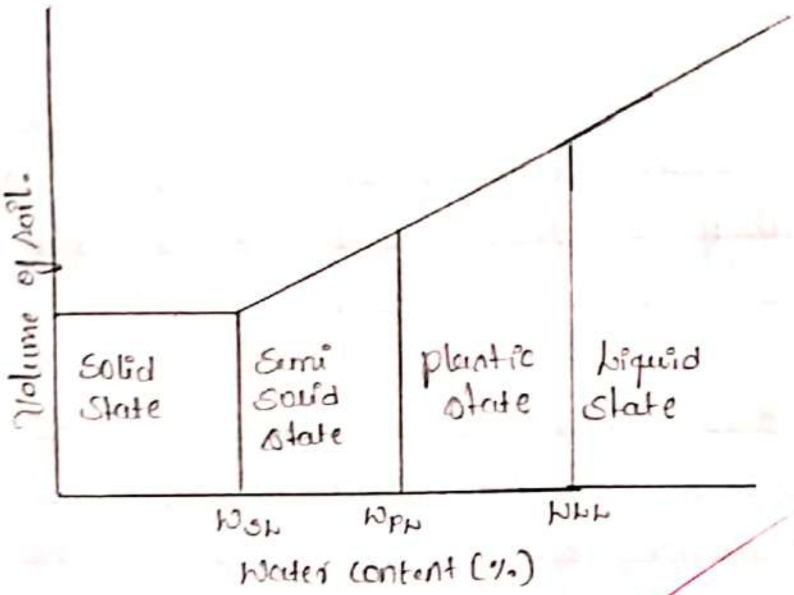
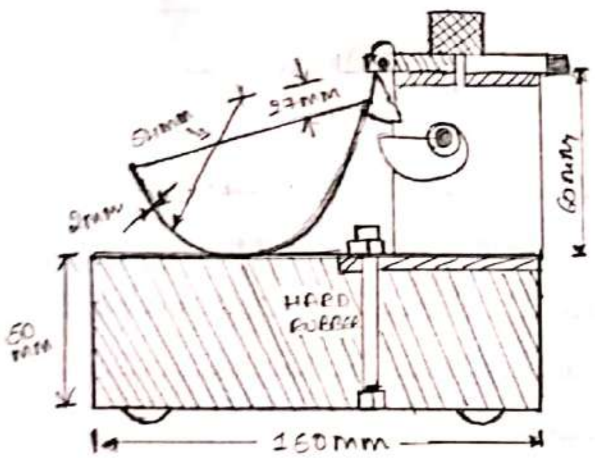
Teacher's Signature : ________________

FIGURE:

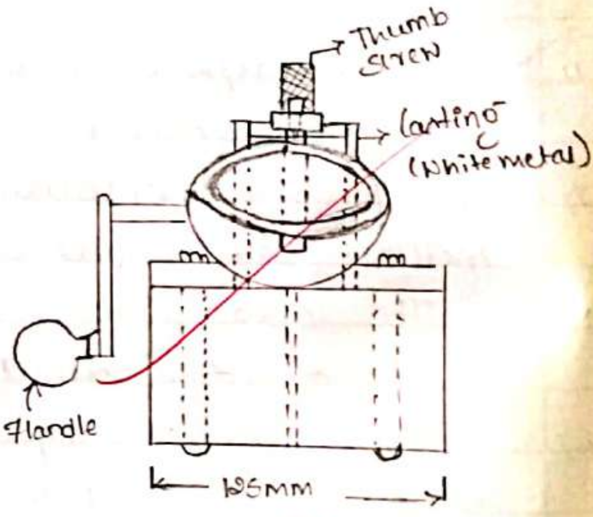


Relationship between Volume of soil & its moisture content



Section

CASAGRAND TOOL



Elevation.

Divided soil cake Before Test

Soil cake after tests.

Name of Experiment :
Experiment No : 7
Date : 20/11/21
Experiment Result :
Page No. 19

CONSISTENCY LIMITS OF SOILS.

Consistency is one of the most important index property of fine grained soils. The consistency are expressed as a soft, medium stiff hard. These are only vague terms. The physical properties of clay differ greatly at different water content. It may be almost like a liquid, plastic, very stiff.

LIQUID LIMIT OF SOILS.

Aim:- To determine the liquid limit of the given soil sample.

Apparatus :- A casagrande's liquid limit device, beaker, measuring jar, B.S grooving tool, spatula, & desiccators, water content cup, balance, oven. Casagrande's liquid limit device consists of a brass cup mounted on a hinge mounted on a rubber base. The cup is attached with an eccentric cam & a handle when the handle is rotated the cup raises & falls. This fall may adjusted to 10mm. A counter is attached to note down the no of blows that the cup given.

Procedure :

1) Adjust the cup of the liquid limit apparatus with the help of grooving tool guage & the adjustment plates to given a drop of exactly 1cm on the point of contact on the base.
2) Take about 120g of an air dried sample passing 425micron I.S sieves.

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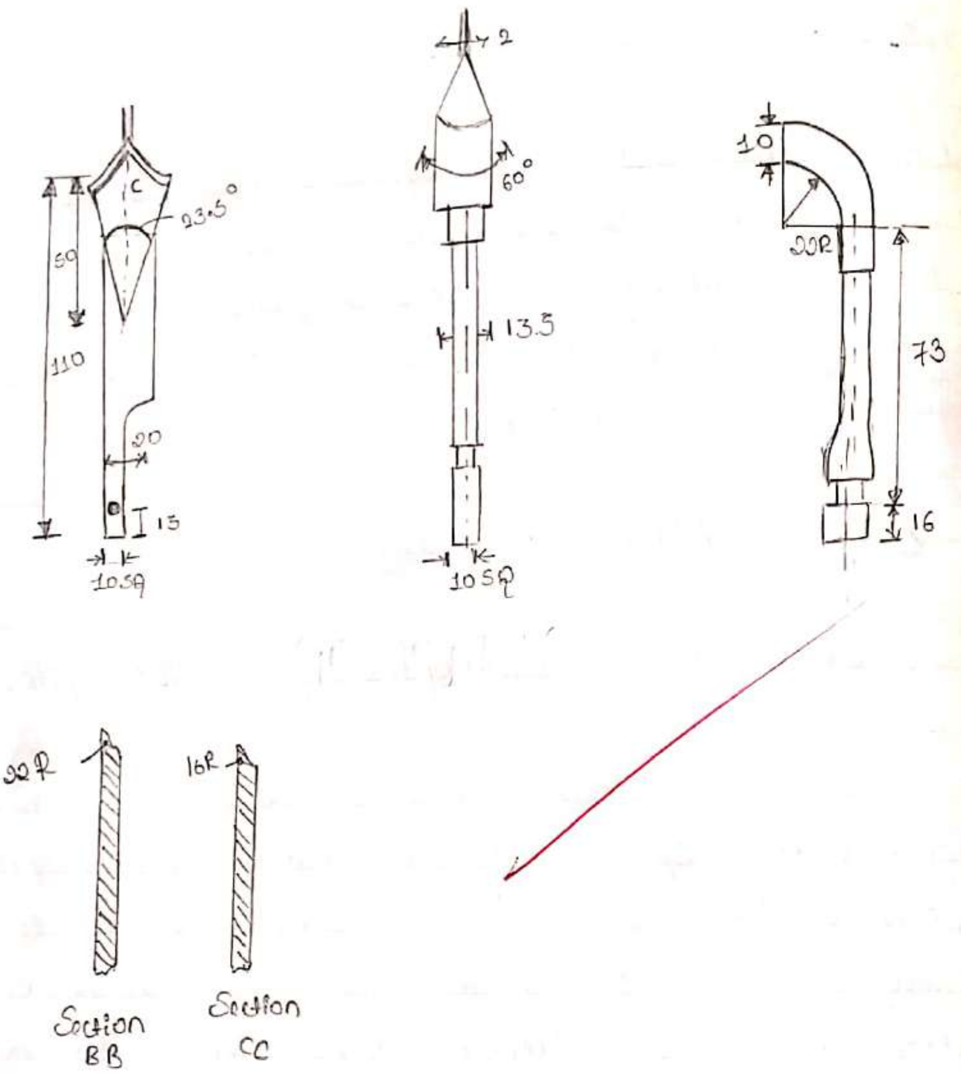


Grooving tools.

3) Mix it thoroughly with some distilled water to form a uniform paste

4) The soil paste is then filled into the cup of liquid limit device smooth the surface with a spatula to a minimum of 10mm or 1cm & such that cup is 1/2 to 3/4 full.

5) Dependending upon the type of soil & using the corresponding grooving tool a channel is cut by drawing the grooving tool through the sample along the symmetrical axis of the cup. the grooving tool should always be held normal to the cup at points of contact

6) The handle is next turned on the rate of about 2-Revolution per second & the number of blows necessary to close the groove along the bottom for a distance about 10mm to 12mm is noted.

7] Transfer about 15G of the soil forming the edges of groove that flowed together for a water content determination cup & determine the water content by oven drying.

8] Atleast 3-tests should be carried by adjusting the water content in such a way that the no of blows required to close the groove may fall b/w range 10 to 40 blows.

9] Then plot a graph water content vs the number of blows. The slope of the curve gives the value of flow index (I_f)

$$I_f = \frac{N_1 - N_2}{\log_{10} N_2 - \log_{10} N_1}$$

(or)

$$I_f = \frac{[N_1 - N_2}{\log_{10}(N_2 - N_1)}$$

Teacher's Signature : ____________

Tabular columns

Sl. No	No of blows	Cup No	wt of empty cup in (g) W_1	wt of empty cup + wet soil in (g) W_2	wt of empty cup + dry soil in (g) W_3	wt. of dry soil (g) W_3-W_1	wt of water W_2-W_3	water content (%) $W=\frac{W_2-W_3}{W_3-W_1}\times100$
1.	17	7	19	35	32	13	3	23.07
2.		13	18	37	32	14	5	35.71 } 29.39%
2.	15	20	18	42	36	18	6	33.33
		11	18	47	40	22	7	31.81 } 32.57%
3.	30	21	14	29	26	12	3	25
		8	14	34	29	15	5	33.33 } 29.165%

From graph

$N_1 = 15$ $W_1 = 32.57\%$ $W_L = 31\%$

$N_2 = 30$ $W_2 = 29.165\%$

Flow Index $(I_f) = \frac{W_1 - W_2}{\log\left(\frac{N_2}{N_1}\right)} = \frac{32.57 - 29.165}{\log\left(\frac{30}{15}\right)}$

$I_f = 11.31\%$

plastic limit = 18.35%

liquid limit = 31%.

plastic index $(I_p) = W_L - W_P$

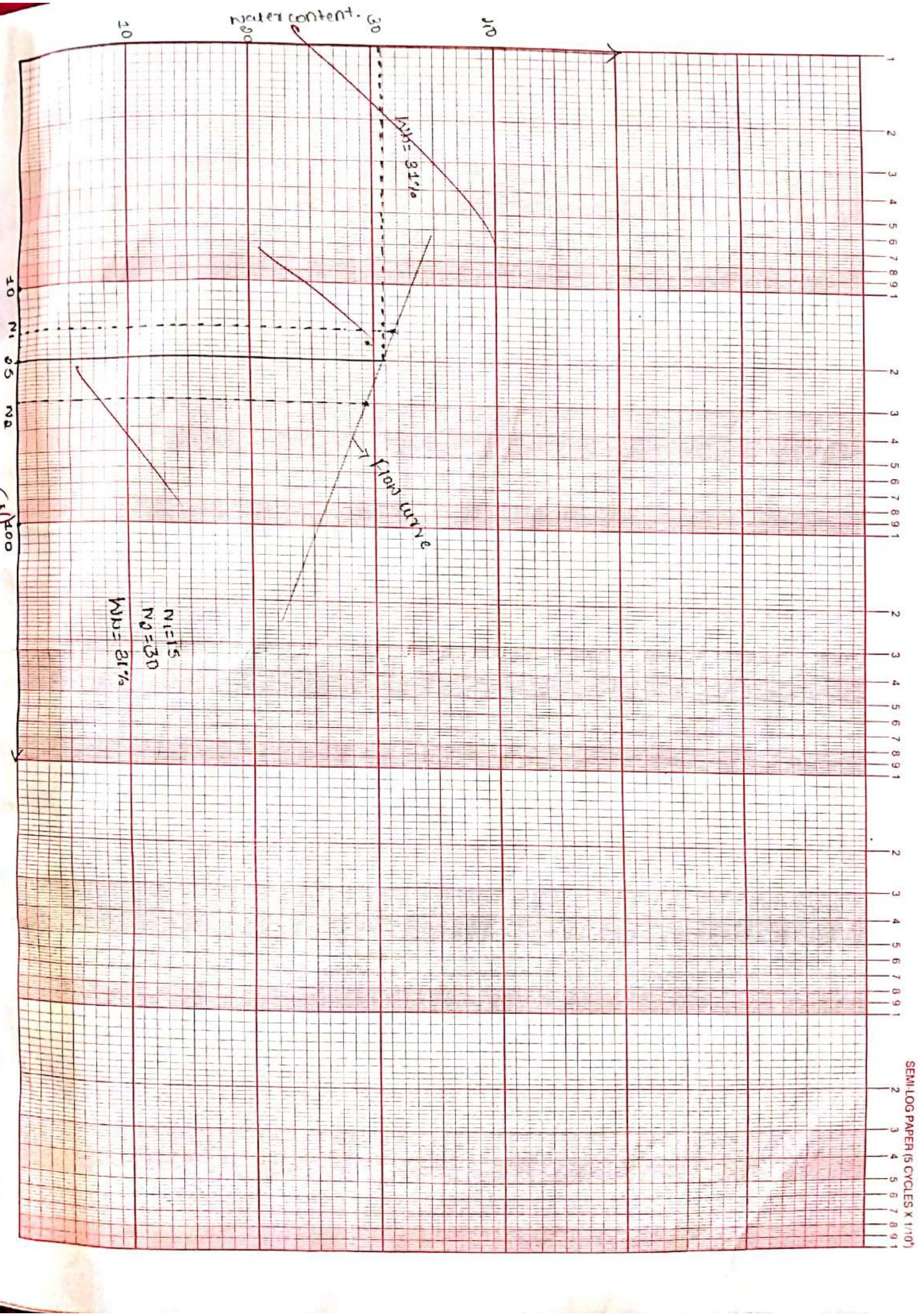
$= 31 - 18.35$

$I_p = 12.65\%$

Toughness index $I_t = \frac{\text{Plasticity index } (I_p)}{\text{flow index } (I_f)}$

$= \frac{12.65\%}{11.31\%}$

$I_t = 1.118\%$


Water content
10
20
30
40
WL = 31%
Flow curve
Number of blows (N)
N1
25
N2
100
N1=15
N2=30
WL = 31%
SEMI-LOG PAPER

Toughness Index (I_t)

which is the ratio of plasticity index to the flow index is determined using

$$I_c = \frac{W_L - W}{I_p}$$

where, I_p = $W_L - W_P$

W = natural water content.

Result: The flow Index I_f = 11.31%

The toughness index I_p = 12.66%

The liquid limit of soil is = 30%, the plastic limit is = 18.35%.

Comment: Based on plasticity chart the soil is classified as silt of medium compressibility.

Application:

1) The values of liquid and plastic limit are directly used for classifying the fine grained cohesive soil according to IS on soil classification.

2) The values of these index are also used in the flow index, toughness index & relative plasticity index

3) Atterberg shows the correlation b/w the plasticity index soil type, degree of plasticity and degree of cohesiveness.

4) It is useful in giving an idea about the plasticity characteristics, compressibility, shear strength, permeability consistency & state of cohesive soils.

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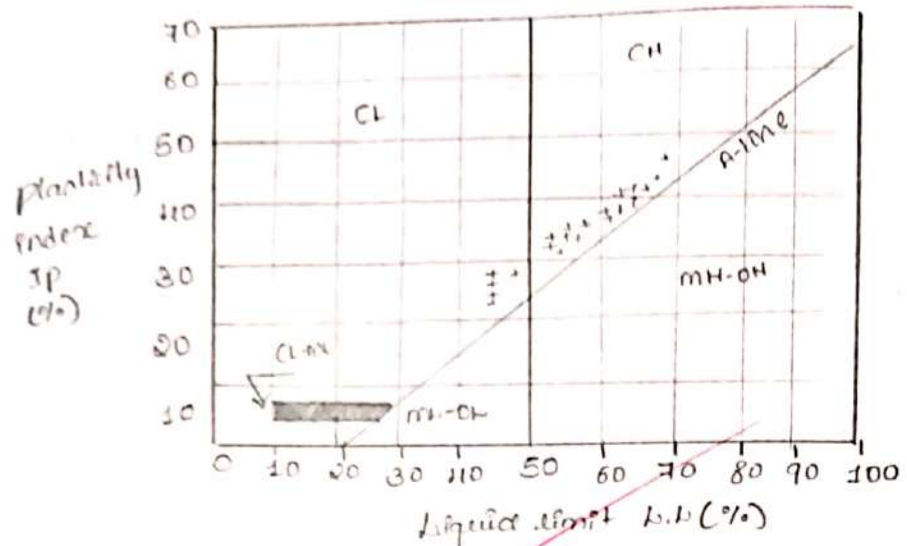


plasticity chart (1.5)

In plasticity chart following symbols are used

CL = clay of low compressibility
CI = clay of medium compressibility
CH = clay of high compressibility
ML = silt of low compressibility
MI = silt of medium compressibility
MH = silt of high compressibility
OL = Organic soil of low compressibility
OI = organic soil of low compressibility
OH = Organic soil of high compressibility

PLASTIC LIMIT OF SOILS

Aim :- To determine the plastic limit of the soil sample and calculate plasticity index, toughness index etc

Apparatus :- China dish, spatula, Glass plate, 3mm diameter road, 425micron IS sieve, water content cup, Balance, oven.

Procedure :

1) Take about 30gms of air dried sample passing 425 μ IS mix thoroughly with distilled water on the glass plate untill it is plastic enough to be shaped into a small ball

3) Take about 10gm of the plastic soil mass & roll it b/w the hand & the glass plate to from the soil mass into a thread, if the dia of the thread beome less than 3mm without cracks. It shows that the water is added in the soil is more than its plastic limit hence the soil is kneaded further & rolled into thread again.

4) Repeat this rolling & remoulding process until the thread starts just crumbling at a dia of 3mm

5) If crumbling is starts before 3mm dia thread in step 3 it shows that the water added in step 2 is less than the plastic limit of the soil, hence somemore water should be added & mixed to a uniform mass & rolled again, until the thread start just crumbling at a dia of 3mm

Teacher's Signature :

Tabular column.

Sl.NO	Determination no.	1	2	3
1.	cup number	1C	16	18
2.	wt of empty cup in (gm)	15	14	17
3.	wt of empty cup + wet soil in (g)	40	42	41
4.	wt of empty cup + dry soil in (g)	36	37	38
5.	wt of dry soil (g)	21	23	21
6.	wt of water (g)	4	5	3
7.	water content w(%)	19.04	21.73	14.28
8.	Average water content		18.35%	

plastic index = 18.35%.

$w_L = 31\%$

$w_p = 18.35\%$

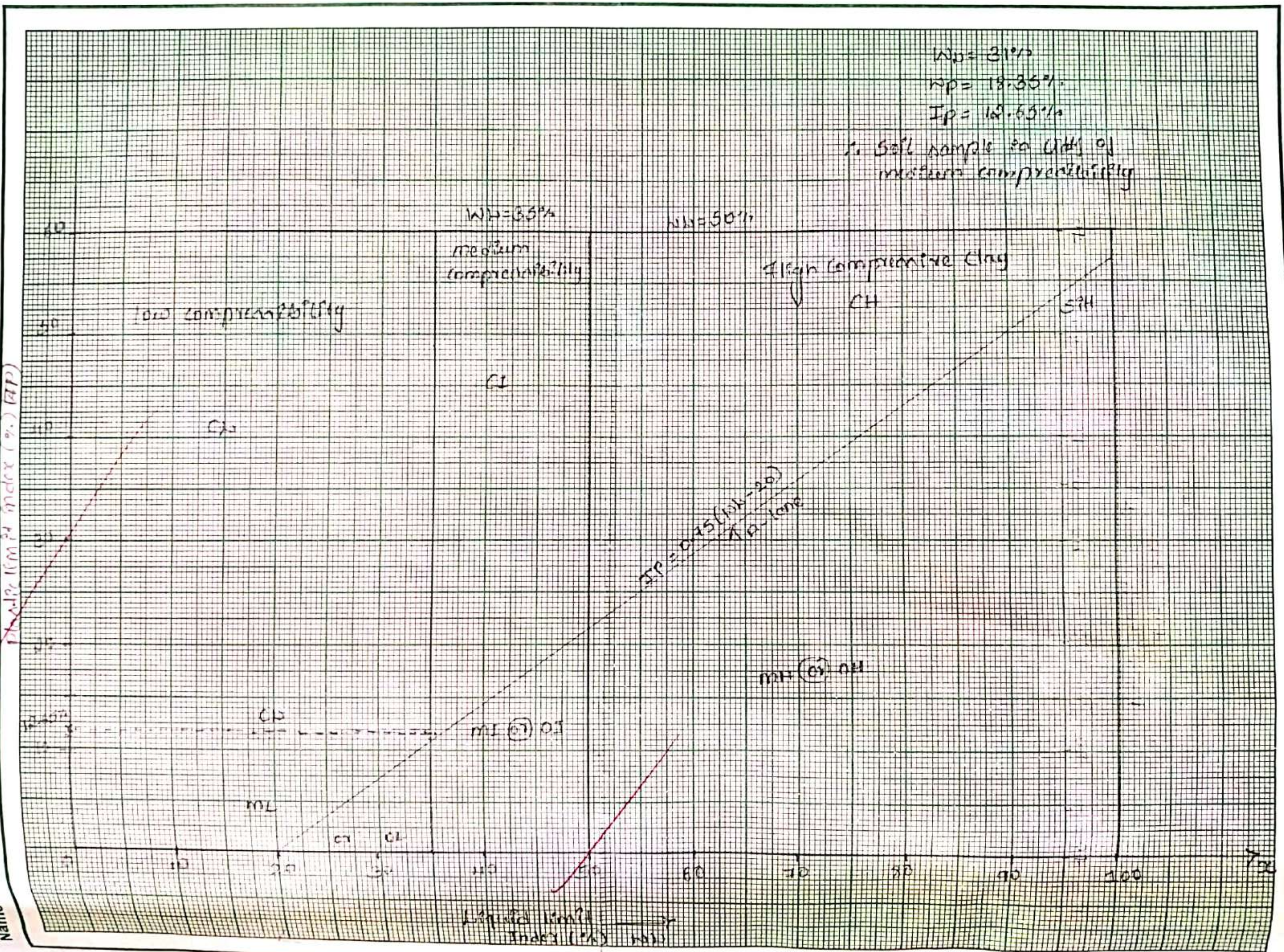
$I_p = w_L - w_p$

$= 31 - 18.35$

$\boxed{I_p = 12.65\%}$

Date :

Name :


Wp = 31%
Ip = 12.65%
WL = 35%
WL = 50%
medium compressibility
low compressibility
High compressive clay
CH
CI
CL
CL
ML
MI or OI
MH or OH
Ip = 0.73 (WL - 20)
A-line
Plastic limit index (%) (IP)
Liquid limit Index (%) WL
0
10
20
30
40
50
60
70
80
90
100

6) collect the pieces of crumbled soil thread at 3mm diameter in an air tight container & determine moisture content.

7) Repeat this procedure twice more with fresh samples of 10gm each.

8) Then the values of plasticity Index, toughness Index, liquidity Index & consistency index are calculated using the eqn shown in observation & calculation part.

Result :- The plastic limit of the soil sample is = 18.35%.

comment :- The plastic limit & liquid limit, based on observation plastic limit is <7 hence the soil is classified as silt clay of medium compressibility

<35 - low
35-50 - medium
50 - high compress

Application:

1) The values of liquid & plastic limit are directly used for classification the fine grained cohesive soil. according to IS on soil classification.

2) Once the soil is classified it helps a lot in understanding the behaviour of soil & selecting the suitable methods of design

Plasticity Index	soil type	Degree of plasticity	Degree of cohesiveness
0	sand	non-plastic	noncohesive
<7	silt	low-plastic	partly cohesive
7-17	silt clay	med plastic	cohesive
>17	clay	high plastic	cohesive

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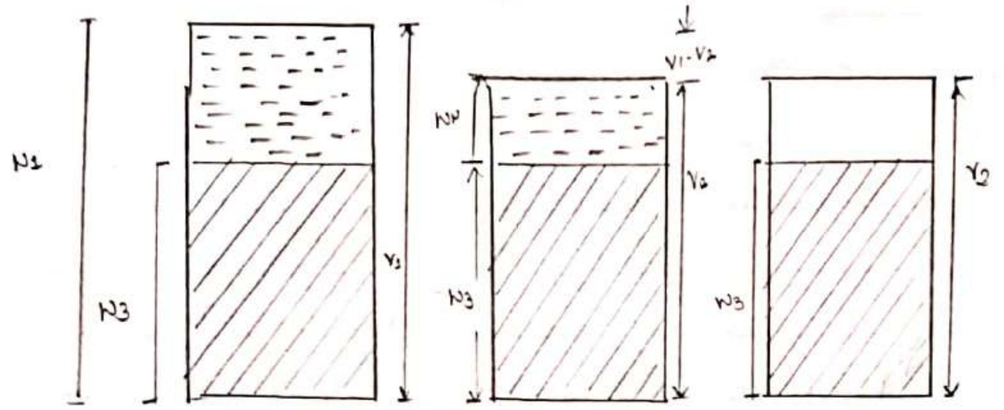
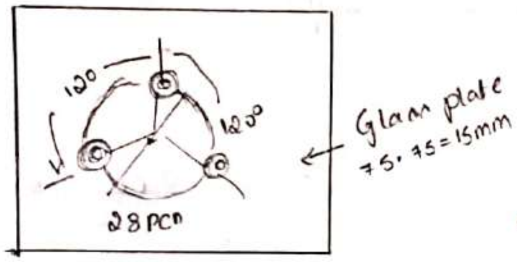
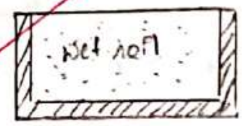
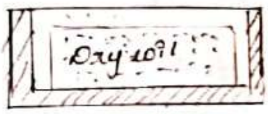
Teacher's Signature :



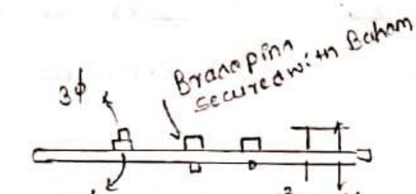




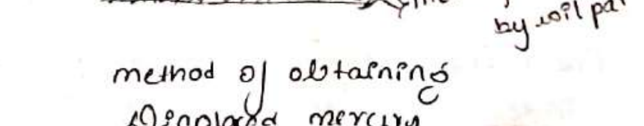
Before shrinkage



After shrinkage



Detail of Glass plate



method of obtaining Displaced mercury

SHRINKAGE LIMIT OF SOIL

Aim: To determine the shrinkage limit of soil sample and calculate shrinkage factors.

Apparatus:- Three circular shrinkage limit dish (porcelain, stainless steel / brass with flat bottom about 4.5cm in dia & 1.5cm height). Three porcelain evaporating dish one glass plate with three prongs one plain glass plate (7.5cm x 7.5cm) one glass or stainless steel cup (about 5.0cm in dia & 2.5cm high with level & smooth ground top rim) mercury, 425 micron IS sieve, spatula edge, desiccator, balance, oven.

Procedure:

1) mix about 50gm of soil 425 micron sieve with distilled water. the water added should be sufficient to make the soil pasty enough to be readily worked into the shrinkage dish without inclusion of air bubbles.

2) Coat the inside of two dish immediately with vaseline place the soil sample in the dish. by giving gentle taps.

3) weigh the shrinkage dish immediately full of wet soil W2. Dry the dish in air about 24 hour & then in oven about 24 hours

4) weigh the shrinkage dish with dry soil pat. let it be (W3) or W3

5) clean & dry the shrinkage dish & determine its empty mass let it be W1

Tabular columns;

Sl.No.	Description	Symbols	
1.	Shrinkage dish number		32.9
2.	weight of empty shrinkage dish	W(g)	70.9
3.	mass of dish + wet soil pat	W_1(g)	66.2
4.	mass of dish + dry soil pat	W_2(g)	
5.	mass of water Ww $W_w = W_1 - W_2$	Ww(g)	4.7
6.	mass of dry soil pat $Wd = W_2 - W$	Wd(g)	33.3
7.	Intial water content $w_i = (Ww / Wd) \times 100$	w_i(%)	14.11
8.	mass of empty weighing dish	WA (g)	50.4
9.	mass of weighing dish + mercury	WB	349
10.	mass of mercury	W Hg (g)	298.6
11.	Volume of wet soil pat V1 $\frac{WHg}{13.66}$	V_1 cm³	21.85
12.	mass of weighing Dish + Displaced mercury by dry soil pat	Wc (g)	342
13.	mass of mercury displaced $W_D = W_C - W_A$	W_D (g)	291.6
14.	Volume of dry soil pat $V_2 = \frac{WD}{13.66}$	V_2 cm³	21.34

6) Also weigh an empty porcelain dish which will be used for weighing mercury. This dish will be known as mercury weighing dish.

7) Keep the shrinkage dish in a large porcelain dish fill the shrinkage dish with mercury remove the excess by pressing the plain glass plate over it, Determine the weight of the shrinkage dish (v_1)

8) The final volume v or v_2 or v_d is determined as follows the glass cup is inside the porcelain dish it is filled with mercury upto the level. the glass plate with 3-prongees is inserted as a result of this a volume of 3-prongs spills out the spilled out mercury is carefully takeout. the beaker or glass cup with remaining mercury is again placed in the crucible. the dried soil pat is then immersed in the beaker pressing with the prong. the weight of mercury spilledout is carefully determined this weight is determined by density of mercury gives the volume of mercury displaced that is equal to the volume of dried soil pat $v_2 = v_1 = v_d$ (constant)

9) Then the values of shrinkage limit, shrinkage factor & volumetric shrinkage are determined using of the formulas shown in observation part.

Teacher's Signature : ____________

Calculation

1) Shrinkage limit (W_{SL})

$$W_{SL} = W_i - \left(\frac{V_1 - V_2}{W_d} \times 100\right)$$

$$= 14.11 - \left(\frac{21.85 - 21.34}{33.3} \times 100\right)$$

$$W_{SL} = 12.58\%$$

2) Shrinkage Ratio (SR)

$$SR = \frac{W_d}{\gamma_w \times V_2}$$

$$= \frac{33.3}{1 \times 21.34}$$

$$SR = 1.560\%$$

3) Volumetric Shrinkage (V_S)

$$V_S = (W_i - W_{SL})\,SR$$

$$= (14.11 - 12.58) \times 1.560$$

$$V_S = 2.38\%$$

4) Linear shrinkage (LS)

$$LS = 100\left[1 - 3\sqrt{\frac{100}{V_S + 100}}\right]$$

$$= 100\left[1 - 3\sqrt{\frac{100}{2.38 + 100}}\right]$$

$$LS = 70.69\%$$

Result:-

Shrinkage limit of the a soil sample = 10.58%
Shrinkage ratio of a soil sample = 1.560%
Volumetric shrinkage of a soil sample - 2.38%
Linear shrinkage of a soil sample = 70.69%.

Applications:

1) The shrinkage limit is used in soil classification an considered in relation to the natural moisture content of soil in the field.

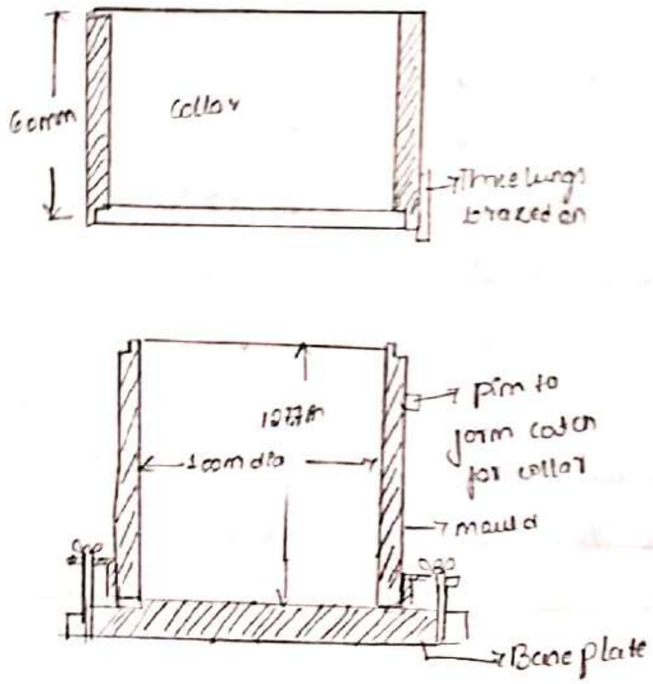
2) Indicates the moisture content at which no further shrinkage of the specimen occurs.

3) It helps in assessing the suitability of soil as a construction material in foundations, roads, embankments & dams.

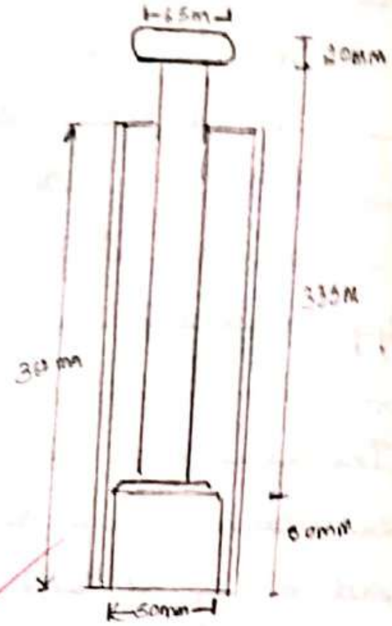
Comments:

It assessing the suitability of soil as a construction materials in foundations roads embankments & dams Hence if shrinkage limit <15% then shall not be used as founding strata for backfill. 12.58% shrinkage in the cohesive soil can use for backfilling

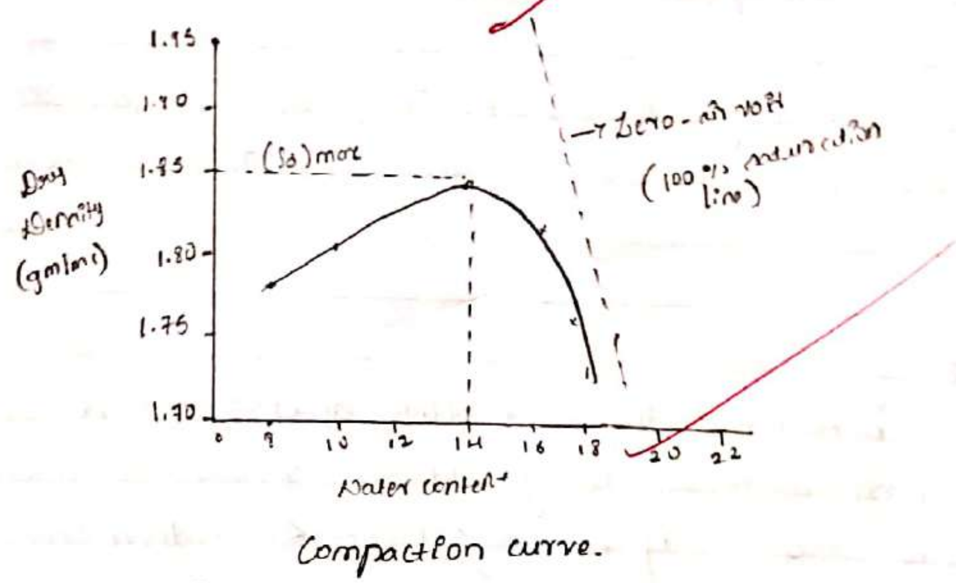
Teacher's Signature : ________



PROCTOR MOULD



RAMMER



Compaction curve.

LABORATORY UNIT WEIGHT TEST

* Standard proctor unit weight test *

Aim:- To determine the optimum moisture content & maximum dry density of a soil by proctor test.
2. To plot the curve of zero air void.

Light compaction test:
Apparatus:- Standard proctor mould volume about 1000 mm³
- mould placed on a detachable metallic plate & has a detachable collar about 50mm height
- Standard hammer 25.5N falling through a distance of 310mm. It contained in a outer metallic sleeve that guides it's movements.
- Balance, moisture content, cup, spatula

Procedure:
3kg of air dried soil sample passing 4.75mm. IS sieve is taken and mixed thoroughly with a quantity of water & is filled in 3- layers into the standard mould which is fixed a collar. Each layer is compacted by the hammer giving 25-blows. Each compacted layer is racked with a spatula before placing the next layer. After compaction the collar is detached & the top of mould is trimmed off to remove extra soil. The total weight of wet soil with the mould is taken.

Teacher's Signature :

OBSERVATION AND CALCULATIONS:

Specific gravity of soil grains = ~~20 cm~~ 2.5 cm

Diameter of mould (d in cm) = 10 cm

Height of mould (h in cm) = 12.5 cm

Volume of mould (v in cm³) = 981.74 cm³

Mass of mould (W_1 in gm):

Type of test = Standard proctor test

Weight of rammer = 2.6 kg

Number of layers = 3

Number of blows = 25

Compaction energy = wt of hammer x free fall x No of layer x no of blows

2.6 x 31 x 3 x 25

= 60415

Tabular columns

Sl.No.	Particulars	Symbol	Trials				
1.	percentage of water added	%	8%	10%	12%	14%	16%
2.	weight of empty mould	W_1 (g)	3824	3824	3824	3824	3824
3.	weight of mould + compacted soil	W_2 (g)	5667	5771	5890	5913	5787
4.	weight of compacted soil $W = W_2 - W_1$	W (g)	1843	1947	2066	2089	1963
5.	Wet density / bulk density $\gamma_b = W/v$	γ_b (g/cm³)	1.87	1.98	2.10	2.12	1.99
7.	Dry density of dry soil $\gamma_d = \frac{\gamma_b}{1+w}$	γ_d (g/cm³)	1.64	1.74	1.83	1.86	1.67
8.	Dry density at 100% saturation $\gamma_d = \frac{G\gamma_w}{1+wG}$ $n_a = 0$, $\gamma_{sat} = 1$	γ_d (g/cm³)	1.98	1.92	1.9	1.91	1.75

Scanned with CamScanner

A representative sample of soil in the mould is taken for moisture content determination. the test is repeated by adding more water each times say about 2%, until the weight of mould with wet soil reduces.

Tabular column:- (moisture content determination)

Percentage of water added	Cup no	Empty wt of cup (g) W_1	Wt of cup + wet soil (g) W_2	Wt of cup + dry soil (g) W_3	Wt of dry soil (g) $W_3 - W_1$	Wt of water in (g) $W_2 - W_3$	Water content $w = \frac{W_2 - W_3}{W_3 - W_1} \times 100$	Average	dry unit wt g/ml
8%	22	16	44	41	25	3	12		
	17	16	45	43	27	2	7.4	12.0	1.64
	1	20	48	44	24	4	16.6		
10%	18	17	46	43	26	3	11.53		
	20	18	51	47	29	4	17.79	13.44	1.74
	10	15	38	35	20	3	15		
12%	72	9	36	33	24	3	12.5		
	3	15	38	35	20	3	15	13.61	1.83
	14	16	33	31	15	2	13.33		
14%	22	10	35	32	22	3	13.63		
	14	10	35	33	23	2	8.69	13.85	1.86
	2	9	40	35	26	5	19.23		
16%	9	11	40	36	25	4	16		
	13	9	39	34	25	5	20	18.66	1.67
	16	9	39	34	25	5	20		

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

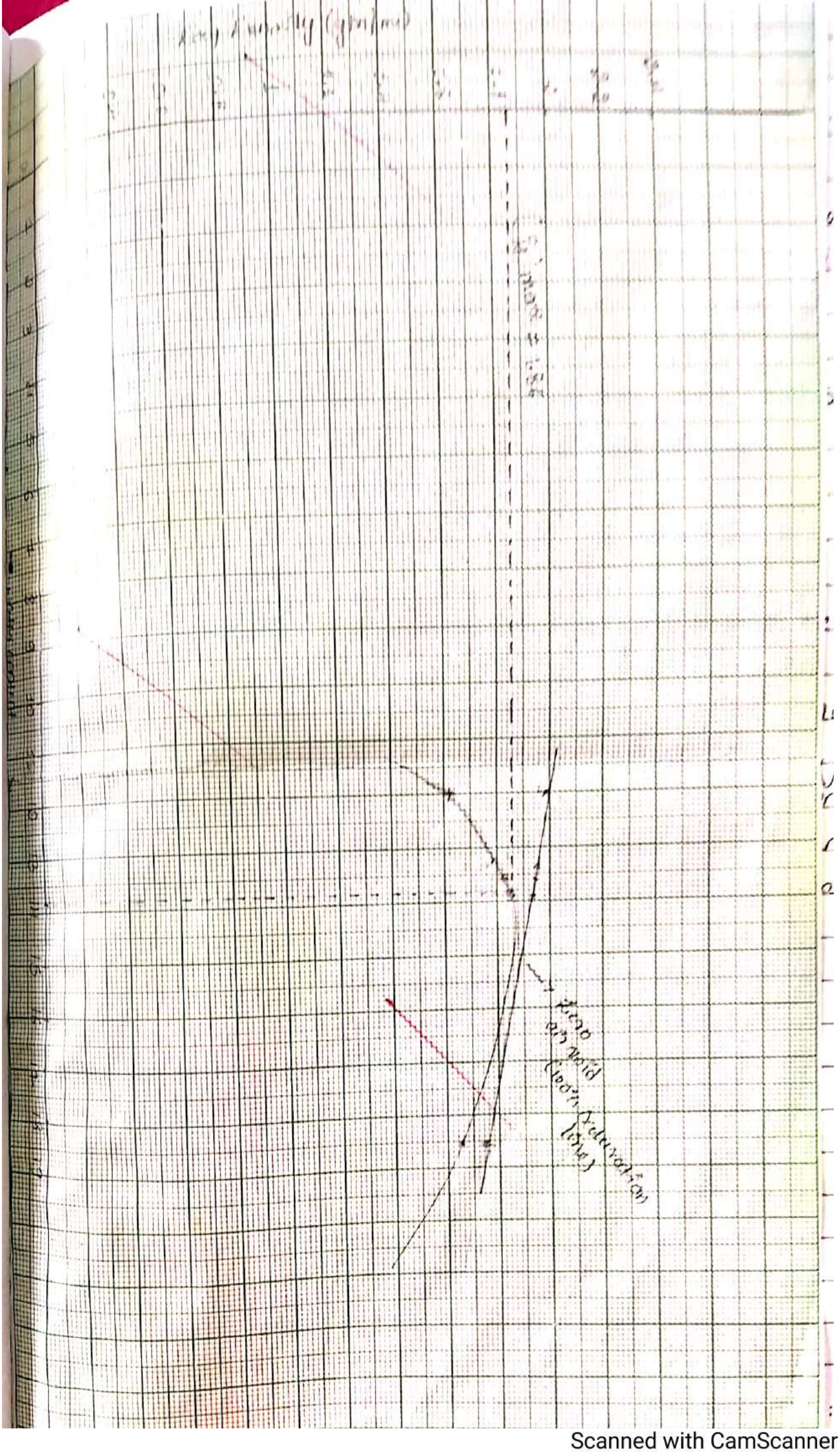
$8\% = \frac{2.6 \times 1}{1 + \frac{12.04}{100} \times 2.6} = 1.98$

$10\% = \frac{2.6 \times 1}{1 + \frac{13.4}{100} \times 2.6} = 1.92$

$12\% = \frac{2.6 \times 1}{1 + \frac{13.61}{100} \times 2.6} = 1.92$

$14\% = \frac{2.6 \times 1}{1 + \frac{13.85}{100} \times 2.61} = 1911$

$16\% = \frac{2.6 \times 1}{1 + \frac{18.66}{100} \times 2.61} = 1.75$


Zero air void (100% saturation line)

Result:

The optimum moisture content in percentage = 13.85%
Maximum dry density γ_d g/cm³ = 1.86 g/cm³

Comment:

Based on the zero-air-void line the soil doesn't required further compaction

Application:

- Soil compaction is an essential part of the construction process
- It provides the necessary flat base which provides the crucial support for buildings construction of foundations pavements roads & various other construction structure.
- The process of compaction gives the soil underneath these supports higher resistance & greater stability.

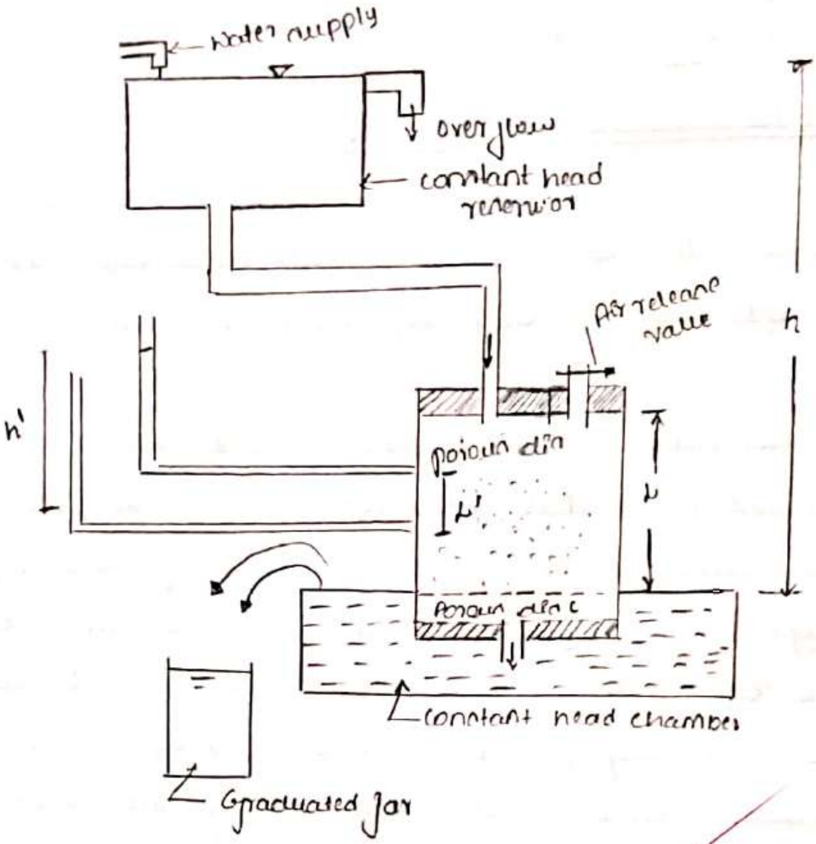
14/12/21 21/21

PERMEABILITY OF SOILS

Aim:- To determine the co-efficient of permeability of the given soil sample at desired density by suitable method.

Apparatus:- Permeameter mould [Internal dia = 10mm, effective height 127.3mm capacity 1000 cc) Accessories of the permeater (cover, base, detachable collar, porous stones, dummy plate) Round filter paper 100mm dia static or dynamic compaction device (if remoulded samples are used) constant head reservoir graduated glass stand pipe (internal dia 5 to 20mm, preferably 10mm) variable head) support frame & clamp (variable head), funnel measuring flask (constant head)

Theory:
The flow of water through soil is governed by "Darcy's law" The Darcy's law state that the rate of flow in an isotropic homogeneous soil is proportional to the hydraulic gradient $q = A K i$.
q = rate of flow through a total cross sectional area 'A' of the soil mass, i = hydraulic gradient
K = coefficient of permeability.
The coefficient of peremeability is a very important property it indicates whether the soil is more permeable or less permeable.



Constant Head Permeameter.

CONSTANT HEAD PERMEATER TEST

Aim:- To determine the co-efficient of permeability of a given soil sample at desired density by suitable method

Apparatus:- Constant head permeameter, measuring Jar, stop watch

Theory :- By Darcy's law.

$\frac{Q}{t} = \frac{Akh}{L}$ Q = Quantity of water
t = time

$k = \frac{QL}{Ath}$ A = Area of cross section of sample
h = Constant head causing flow
L = Length of sample.

- Coefficient of peremeability depends on the void ratio of the soil, type of soil, shape of particles, unit wt. of soil, pore fluid property
- Void ratio depend on the density of the sample

Procedure:

1) Remove the cover of the mould and apply a little grease on the side of the mould
2) Weigh the mould with dummy plate
3) Measure the internal dia & effective height of the mould. then attach the collar & the base plate
4) Compact the soil at given dry density & moisture content by suitable static or dynamic device for remoulded samples.

Teacher's Signature :

Tabular column:

1) Diameter of sample = 10cm

2) Height of sample = 13cm

3) Volume of sample = $\frac{\pi(d)^2}{4} \times h = \frac{\pi(10)^2}{4} \times 13 = 1021.017 cm^2$

4) Wt. of soil sample =

5) Bulk unit wt. of soil sample = 2.01g/cm³

6) Area of cross section sample (A) = $\frac{\pi(d)^2}{4} = \frac{\pi(10)^2}{4} = 78.53 cm^2$

Tabular column:

Sl.NO	Time				Quantity of water in mm³				K = QL/Ath cm/sec
	T_1	T_2	T_3	T	Q_1	Q_2	Q_3	Q Avg	
1st	20	20	20	20	39	40	42	= 40.33	3.22×10^{-3}
2nd	40	40	40	40	85	84	85	= 84.66	3.38×10^{-3}
3rd	60	60	60	60	128	128	128	= 128	3.4×10^{-3}
					Average = 84.33				Average = 3.3×10^{-3}

Name of Experiment :.. Date :..

Experiment No :.. Experiment Result :..

For undisturbed samples trim off the undisturbed specimen in the form of a cylinder about 85mm in dia & height equal to that of mould place the specimen centrally over the bottom of the porous disc & filter paper.

5) Remove the collar & the base plate. trim off the excess soil, & level with the top of the mould

6) Clean the outside top the mould & dummy plate

7) weight the mould with soil & dummy plate. Difference of this mass taken in step (0) will give the mass of soil used.

8) Apply grease around the porous stone & base plate. put the porous stone inside the base plate & filter paper on porous stone.

9) Remove the dummy plate & place the mould with washer on the base plate

10) put the sample small quantity of the soil sample in drying oven to determine the moisture around content.

11) Clean the edges of the mould & the collar & apply the grease in the groove around them

12) Place a filter paper, porous stone & washer on the top of the soil sample & fix up the collar again.

13) connect the reservoir with water to the outlet at the bottom of the mould & allow the water to flow in. wait till the water has been able to travel up & saturate the sample. allow about 1cm depth of free water to collect on the top of the sample

14) fill the remaining portion of the cylinder with desired water without disturbing the surface of the soil.

15) Fix the cover plate over the collar & tighten the nuts in the rods

Teacher's Signature : ____________

Calculation

1st trial = $K = \frac{QL}{Ath}$

$= \frac{40.33 \times 13}{78.53 \times 20 \times 103.5}$

$K = 3.225 \times 10^{-3}$ cm/sec

2nd trial $K = \frac{QL}{Ath}$

$= \frac{84.66 \times 13}{78.53 \times 40 \times 103.5}$

$K = 3.38 \times 10^{-3}$ cm/sec

3rd trial $K = \frac{QL}{Ath}$

$= \frac{128 \times 13}{78.53 \times 60 \times 103.5}$

$K = 3.41 \times 10^{-3}$ cm/sec

Average $= \frac{(3.225 + 3.38 + 3.41) \times 10^{-3}}{3}$

$K = 3.33 \times 10^{-3}$ cm/sec

16) Disconnect the reservoir from the outlet at bottom & connect the stand pipe to the inlet at the top plate. Fill the stand pipe with water.

17) Disconnect the reservoir from the outlet at the bottom & connect to the inlet at the top plate.

18) Open stop clock at the cover and allow water to flowout so that all the air in the cylinder is removed

19) When all the air has escaped close the stop clock & open the outlet. Allow the water to flow through the soil & establish a steady flow.

20) When steady flow is reached collect the water in a measuring flask for convenient time intervals. Repeat this thrice quantity of the water collected must be same otherwise observation are repeated

21) Repeat step (20) for atleast two more different time intervals

22) Stop the flow of water, disconnect all parts.

23) Take a small quantity of soil sample from the mould in drying crucible & put inside the drying oven for moisture content

24) Measure the temp of the water.

Result:

The co-efficient of permeability of the given soil sample is $K = 3.33 \times 10^{-3}$ cm/sec

31/12/21 $\frac{24}{24}$

Teacher's Signature :

Comment:

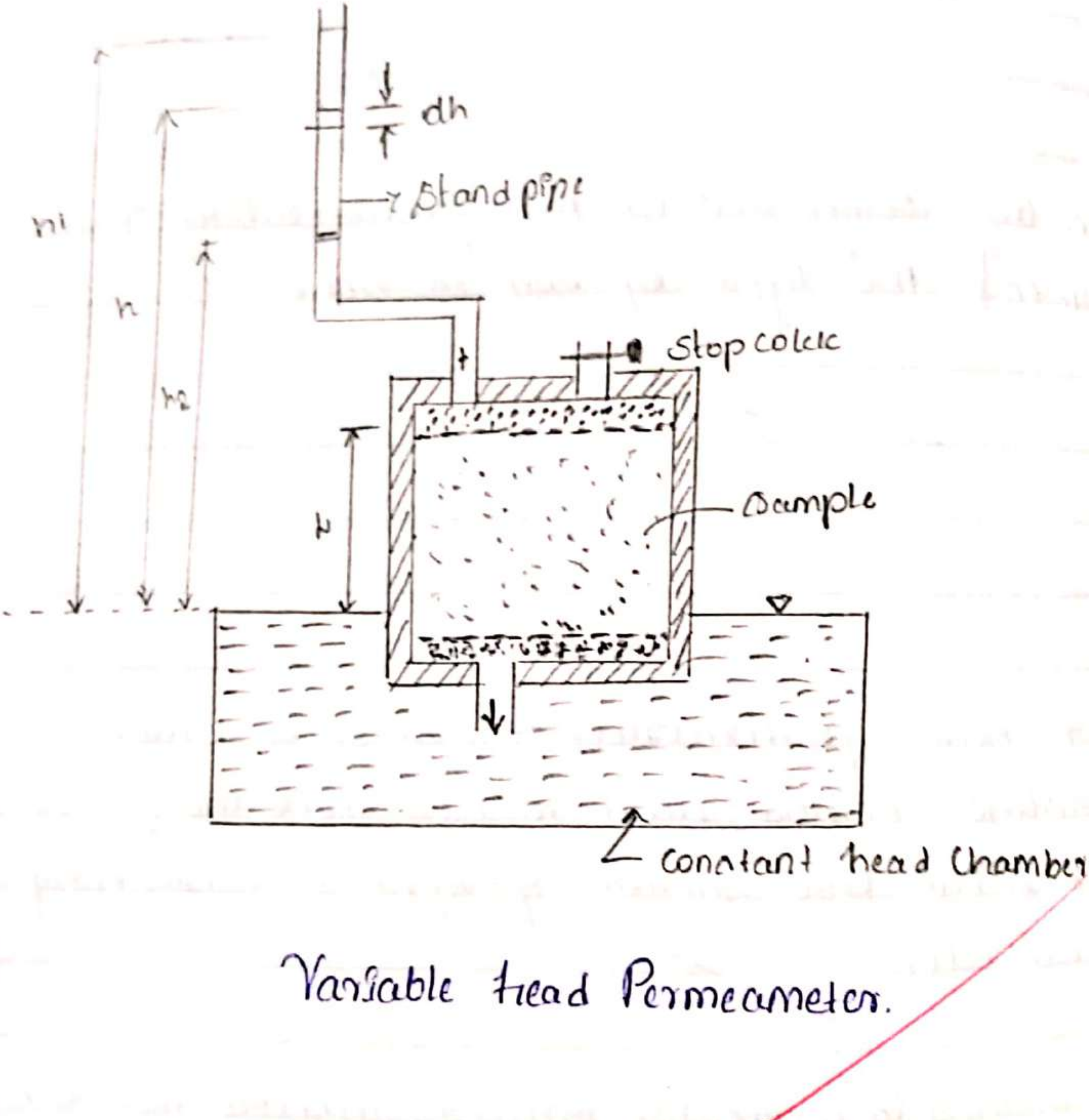
Based on the co-efficient of the permeability value [$K = 3.33 \times 10^{-3}$ cm/sec] the type of soil is silt.

Applications:

1) The constant head permeability test is a common laboratory testing method used to determine the permeability of granular soils like sands & gravels containing little (or) no silt.

2) This testing method is made for testing reconstituted (or) disturbed granular soil samples

3) This method used for coarse-grained soils.



Variable head Permeameter.

Name of Experiment : Variable head permeability Date : 21|12|21

Experiment No : Experiment Result : Page No. 35

VARIABLE HEAD PERMEATER TEST

Aim:- To determine the co-efficient of permeability of the given soil sample at desired density by a suitable method.

Apparatus :- Variable head permeameter, stop watch, scale.

Theory :- In constant head permeameter the water flowing through soil has to be collected. But in fine grained soil the flow is very slow. To collect a measurable quantity sufficiently more time is required. Hence for given fine grained soils Variable head permeameter is used. hence for a known elapsed time the drop in level of water in stand pipe is noted.

$$k = 2.303 \times \frac{aL}{At} \log_{10} \frac{h_1}{h_2}$$

a = Area of cross section of stand pipe

A = Area of cross section of soil sample

L = Length of soil sample

t = time

h_1 = Initial head of water

h_2 = Final head of water.

Procedure:

The sample is taken in the mould as described in a constant head permeameter test. It is connected to a stand pipe. The dia of stand pipe is noted, water is filled into the stand pipe & sample completely saturated.

Teacher's Signature :

Tabular columns

Diameter of stand pipe = 40mm = 4cm

Diameter of soil sample = 10cm

length of soil sample = 13cm

Area of cross section of standard pipe (a) = $\frac{\pi (d)^2}{4} = \frac{\pi (4)^2}{4} = 12.56 cm^2$

Area of cross section of soil sample (A) = $\frac{\pi (d)^2}{4} = \frac{\pi (10)^2}{4} = 78.53 cm^2$

Sl.no	time	Initial level of water h_1	Final level of water h_2	Coefficient of permeability K (cm/sec)
1	107 sec	101	83.5	3.698×10^{-3} cm/sec
2	120 sec	101	83.5	3.297×10^{-3} cm/sec
3	113 sec	101	83.5	3.501×10^{-3} cm/sec

Calculations

$$K = 2.303 \frac{al}{At} \log_{10} \left[\frac{h_1}{h_2}\right]$$

1st trial = $2.303 \times \frac{12.56 \times 13}{78.53 \times 107} \log_{10} \left[\frac{101}{83.5}\right] = 3.698 \times 10^{-3}$ cm/sec

2nd trial = $2.303 \times \frac{12.56 \times 13}{78.53 \times 120} \log_{10} \left[\frac{101}{83.5}\right] = 3.297 \times 10^{-3}$ cm/sec

3rd trial = $2.303 \times \frac{12.56 \times 13}{78.53 \times 113} \log_{10} \left[\frac{101}{83.5}\right] = 3.501 \times 10^{-3}$ cm/sec

Average = $\frac{(3.698 + 3.50 + 3.297) \times 10^{-3}}{3} = 3.49 \times 10^{-3}$ cm/sec

Then the initial level of water in stand pipe is noted on the scale attached to it & a stop watch started. After the elapsed time stop watch is stopped & the final level of water is noted. The procedure same as constant head permeater test up to (17 steps)

- Open the stop clock at the top & allow water to flow out so that all the air in the cylinder is removed
- Fix the height h_1 & h_2 on the pipe from the centre of the outlet such that $(h_1 - h_2)$ is about 30 to 40cm. Mark the level of $\sqrt{h_1 h_2}$ from the centre of the outlet.
- When all the air has escaped close the stop clock & allow the water from the pipe to flow through the soil & establish a steady flow
- Record the time intervals for the head of fall from h_1 to $\sqrt{h_1 h_2}$ & from $\sqrt{h_1 h_2}$ to h_2 the time intervals should be same. Otherwise steady flow is established
- Change the height h_1 & h_2 & record the time intervals
- Stop the flow of water disconnect all parts
- Take a small quantity of soil sample from the mould in the drying crucible & put inside the drying oven for moisture content determination.
- Measure the temperature of the water.

Result:

The co-efficient of permeability of given soil sample is $= 3.49 \times 10^{-3}$ cm/sec

Comment:

Based on the co-efficient of permeability value (10^{-3}) (3.117×10^{-3} m/sec) the type of soil is silt.

Applications

1) Variable head permeability test is one of the several techniques by which the permeability of soil is determined.

2) It is used to evaluate the permeability of fairly less previous soil.

3) Permeability is the measure of the ability of soil to allow water to flow its pores or voids.

4) It is mainly used for fine-grained soils.

[signature] 21/21

Name of Experiment :................................ Date :................................

Experiment No :................................ Experiment Result :................................

SHEAR STRENGTH OF SOILS

Theory:

The most important property of a soil is its shear strength. the shear strength of soil is the resistance of soils offers to shear stress applied it. The basic concept of shear strength of soil is given by coulomb.

$$S = C + \sigma \tan\phi$$

S = Shear strength of soil

C & ϕ are called shear parameters.

C = is called cohesion

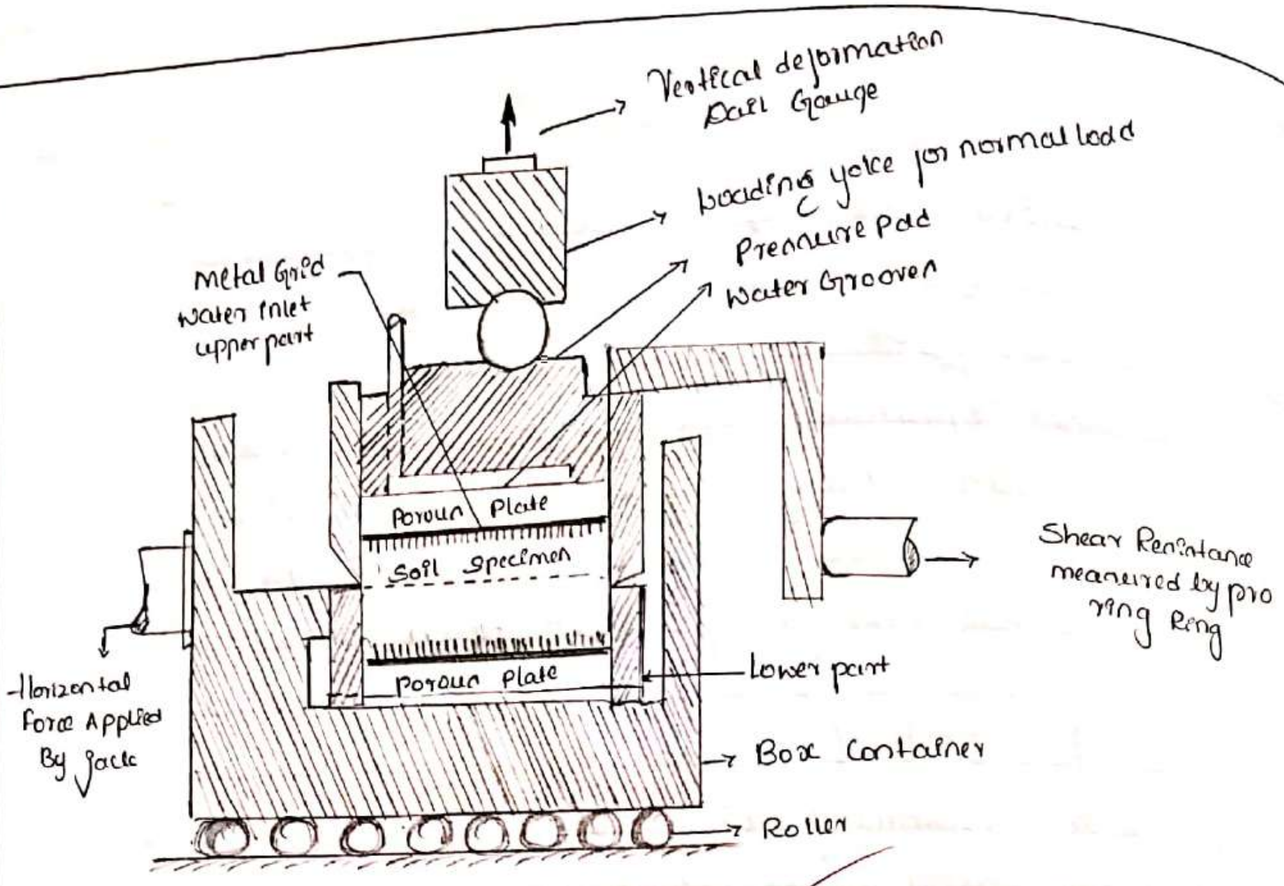
ϕ = is called of internal friction.

Shear parameter depends on the type of soil of testing, drainage condition etc.

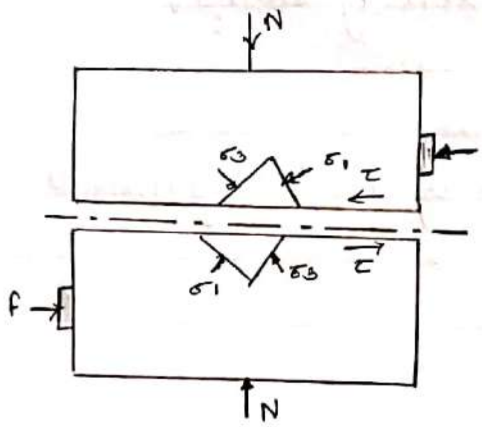
The shear parameters can be determined by laboratory method

1) Direct or Box shear test
2) unconfined compression test
3) Triaxial compression test
4) Vane shear test (field test)

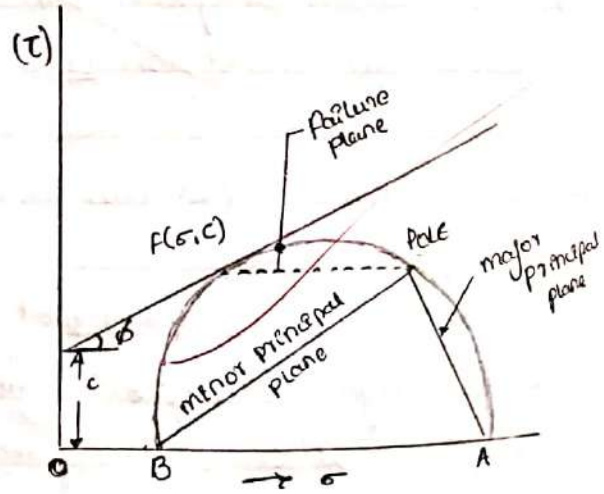
Teacher's Signature : ________________



SHEAR BOX



PRINCIPLE OF DIRECT SHEAR BOX



MOHR'S ENVELOPE AND PRINCIPAL STRESSES DURING THE TEST

DIRECT SHEAR TEST:

Aim:- To determine the shear strength parameters angle of shearing resistance & cohesion of given soil sample.

Apparatus :- Shear box (60mm x 60mm x 50mm), container for shear box, grid plates (two plain & two perforated depth of serration 1.5mm), base plate (non corrosive metal with cross grooves on its top face), porous stones (two 6mm thick), loading frame, loading yoke, proving ring with dial gauge, static/dynamic compaction device.

Procedure:

1) Prepare a soil specimen of size 6m x 6m x 2m either from undisturbed soil sample or from compacted & remoulded sample, soil specimen may directly be prepared in the box by compaction.

2) Fix the upper part of the box to the lower part by the fixing screws. Attach the base plate to the lower part

3) place a porous stone in the box

4) For undrained test, place the grid on the stone, keeping the serration of the grid at right angle to the direction of the shear. for consolidated undrained & drained tests use the perforated grid in place of plain grid

Observation:

1) Least count of dial gauge, cm/Div = 0.001
2) proving ring constant kg/Div = 0.002
3) Area of the box 'Ao' (cm²) = 6×6 = 36cm²
4) Diameter of the sample 'd' cm = 2.4cm
6) volume of the mould (V) cm³ = $\frac{\pi d^2}{4} \times h$ = 6×6×2.5 = 90cm³
7) weight of the sand taken (gm) = 168.

Trial-01:-

Load σ = 0.8 kg/cm²
Shear rate = 1.25

S.I No.	D.G.R	Shear displacement $\delta = LC \times DGR$ in cm	Changed area, cm² $A_c = A_o\left[1-\frac{\delta}{3}\right]$	σ = normal stress				
				P.R.R	K	Shear load (P) = PRR × K	$\frac{\tau}{\sigma}$	C = P/A
1	0	0	36	0	2.5	0	0	0
2	50	0.05	35.4	11	2.5	27.5	0.96	0.77
3	100	0.1	34.8	17	2.5	42.5	1.52	1.22
4	150	0.15	34.2	22	2.5	55	2	1.60
5	200	0.2	33.6	26	2.5	65	2.41	1.93
6	250	0.25	33	29	2.5	72.5	2.73	2.19
7	300	0.3	32.4	30	2.5	75	0.88	2.31
8	350	0.35	31.8	31	2.5	77.5	3.03	2.43
9	400	0.4	31.2	29	2.5	72.5	0.9	2.32
10	450	0.45	30.6	27	2.5	67.5	2.75	2.20
11	500	0.5	30	23	2.5	57.5	2.38	1.99

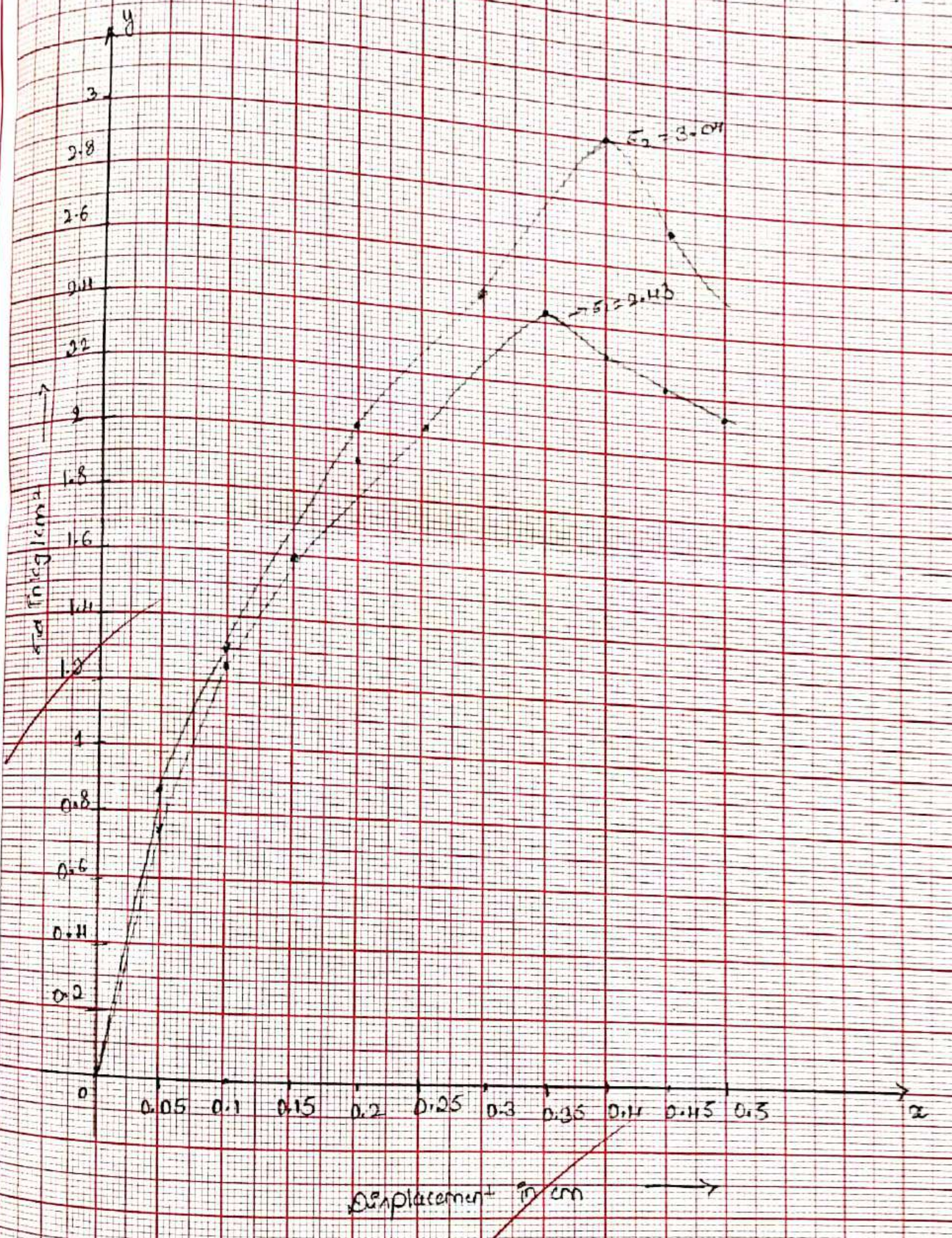
5) Weight the box with base plate, porous stone & grid
6) Transfer the soil specimen prepared in the box
7) Weigh the box with soil specimen
8) Place the upper grid porous stone & loading pad in the order on soil specimen
9) place the box inside the container & then mount it on loading frame.
10) Bring the upper half of the box in contact with proving ring assembly contact is observed by a slight movement of proving ring dial gauge
11) Fill the container with water if soil is to be saturated.
12) Mount the loading yoke on the ball placed on the loading pad
13) Mount one dial gauge on the yoke to record the vertical movement & other dial gauge on the container to record the shear movement.
14) Put the weights on the loading yoke to apply the normal stress intensity 0.5N/cm² Add the weight of yoke also in estimating the normal stress intensity
15) For consolidated undrained & drained tests allow the soil it to consolidate fully under this normal load. this step is avoided for undrained test.
16) Remove the joining screws from the box & raise slightly the upper half box with the help of spacing screws. Remove the spacing screws also

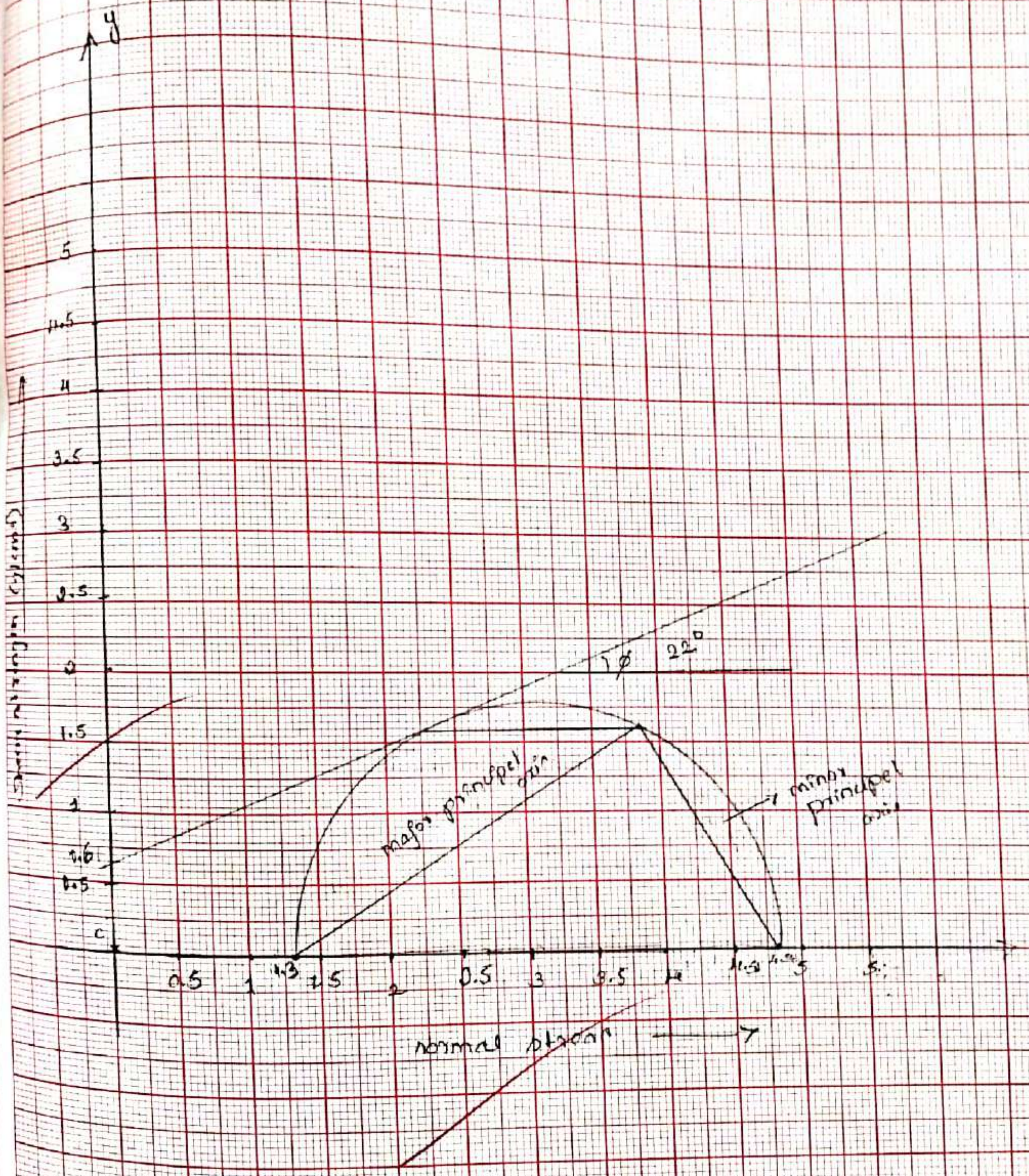
Trial-2:- Load = 1.3 kg/cm²
Shear rate = 1.25

Sl No.	D.G.R	Shear displacement $\Delta = LC \times DGR$ in cm	Changed area, cm² $A_c = A_0\left[1-\frac{\Delta}{B}\right]$	σ = normal stress.				
				P.R.R	K	Shear load (kg/cm²) (P) = PRR × K	$\frac{\tau}{\sigma}$	$\tau = \frac{P}{A}$
1	0	0	36	0	2.5	0	0	0
2	50	0.05	35.4	12	2.5	30	0.64	0.84
3	100	0.1	34.8	19	2.5	47.5	1.04	1.36
4	150	0.15	34.2	22	2.5	55	1.23	1.60
5	200	0.2	33.6	28	2.5	70	1.6	2.08
6	250	0.25	33	27	2.5	67.5	1.56	2.04
7	300	0.3	32.4	30	2.5	75	1.77	2.31
8	350	0.35	31.8	33	2.5	82.5	1.99	2.59
9	400	0.4	31.2	38	2.5	95	2.33	3.04
10	450	0.45	30.6	34	2.5	85	2.13	2.77
11	300	0.5	30	33	2.5	82.5	2.11	2.75

$\sigma_1 = 2.43 + 0.8 = 3.23$

$\sigma_2 = 3.04 + 1.3 = 4.34$





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17) Adjust all three dial gauges to read zero.

18) Shear load is applied at a constant rate of strain is 1.5mm to 2.5mm per minute in sand and 1 to 1.5m/min in clays.

19) Record readings o proving ring dial gauge & vertical & shear movement dial gauges at every half minute.

20) Continue the test until the specimen fails.

21) Repeat the test on identical specimen under increasing normal stress 0, 5, 1, 2 & 4 kg/cm².

22) Determine the moisture contents of the specimen before & after the test.

Result:

Angle of internal friction $\phi = 22^\circ$
cohesion (c) = 0.66

17/1/22 $\frac{24}{24}$

Applications

1) Direct shear test is simple and faster to operate.

2) As thinner specimens are used in shear box, they facilitate drainage of pore water from a saturated sample in less time.

3) This test is also useful to study friction b/w two materials one material in lower half of box & another material in the upper half of box.

OBSERVATION:

Diameter of sample = 3.8cm

Height of sample = 8.6cm

volume of sample = $\frac{\pi(3.8)^2}{4} \times 8.6 = 97.53cm^3$

weight of sample = dry density x volume

proving ring no = 89277

least count of proving ring = 0.002cm

least count of dial gauge = 0.001 cm

Area (Ao) = $\frac{\pi(3.8)^2}{4} = 11.34 cm^2$

1. Trial - $\sigma = 1.25 kg/cm^2$

Sl No	Deformation		Axial strain $\epsilon = \frac{\Delta L}{L}$	Changed area $A_c = \frac{A_o}{1-\epsilon}$, $A_o = \frac{\pi d^2}{4}$	P.R.R	K	Load P = PRR x K	$\sigma_d = \frac{P}{A_c}$ kg/cm²
	D.G.R	Displacement DL = LC x DGR (cm)						
1	0	0	0	11.34	0	2.5	0	0
2	50	0.05	5.81×10^{-3}	11.40	2	2.5	5	0.43
3	100	0.1	0.011	11.466	5	2.5	12.5	1.09
4	150	0.15	0.017 0.023	11.54	6	2.5	15	1.29
5	200	0.25	0.029	11.6	13		32.5	2.81
6	250	0.3	0.034	11.67	14	2.5	35	2.99
7	300	0.35	0.04	11.73	15	2.5	37.5	3.19
8	350	0.4	0.046	11.81	16	2.5	40	3.38
9	400	0.45	0.052	11.88	18	2.5	45	3.78
10	450	0.5	0.068	11.96	20	2.5	50	4.18
11	500	0.55	0.063	12.03	22	2.5	55	4.57
12	550	0.6	0.069	12.11	25	2.5	62.5	5.16
13	600	0.65	0.075	12.18	27	2.5	67.5	5.54
14	650	0.7	0.08	12.25	30	2.5	75	6.122
15	700	0.75	0.087	12.32	34	2.5	85	6.899
16	750	0.8		12.42	36	2.5	90	7.24
17	800	0.85	0.093	12.60	32	2.5	80	6.4
18	850	0.85	0.098	12.57	30	2.5	75	5.96
19	900	0.9	0.104	12.65	29	2.5	72.5	5.73

UNCONFINED COMPRESSION TEST

Aim:- To determine the unconfined compressive strength of cohesive soil sample.
To determine the sensitivity of the soil sample
To determine the shear parameters of the soil sample.

Apparatus:-
Unconfined compression machine, proving ring capacity 500N & 1000N with least count 1.0 & 0.0N respectively dial gauge of least count 0.01mm split mould of internal dia 38mm & length 76mm, sampling tube of internal dia of 38mm & length 200mm, sample extractor.

Procedure:

1) Undisturbed push the sampling tube into the clay sample. Remove the sampling tube along with the soil.
2) Saturate the soil sample in sampling tube by a suitable method if possible
3) Coat the inside of the split mould with a thin layer of grease or oil to prevent adhesion of the soil.
4) ~~Extru~~ Extrude the specimen from the sampling tube to the split mould with the help of sample extractor & knife
5) Trim the two ends of the mould sample.

Teacher's Signature :

2) Trial - $\sigma = 1.5$ kg/cm^2

S.I NO	Deformation D.G.R	Displacement $DL = LC \times DGR$ in cm.	Axial Strain $\epsilon = \frac{\Delta L}{L}$	Changed area cm^2 $A_c = \frac{A_0}{1-\epsilon}$	P.R.R.	K	load (kg) P = PRR × K	$\sigma_d = \frac{P}{A}$ kg/cm^2
1	0	0	0	11.34	0	2.5	0	0
2	50	0.05	5.81×10^{-3}	11.40	5	2.5	12.5	1.09
3	100	0.1	0.11	11.46	9	2.5	22.5	1.96
4	150	0.15	0.017	11.54	13	2.5	32.5	2.81
5	200	0.2	0.023	11.6	19	2.5	47.5	4.09
6	250	0.25	0.029	11.67	22	2.5	55	4.71
7	300	0.3	0.034	11.73	25	2.5	62.5	5.32
8	350	0.35	0.041	11.81	30	2.5	75	6.35
9	400	0.4	0.046	11.87	34	2.5	85	71.5
10	450	0.45	0.052	11.96	36	2.5	90	7.52
11	500	0.5	0.058	12.03	39	2.5	97.5	81.3
12	550	0.55	0.063	12.11	41	2.5	102.5	8.52
13	600	0.6	0.069	12.18	43	2.5	107.5	8.82
14	650	0.65	0.075	12.25	45	2.5	112.5	9.18
15	700	0.7	0.08	12.32	46	2.5	115	9.33
16	750	0.75	0.087	12.42	44	2.5	110	8.85
17	800	0.8	0.093	12.50	41	2.5	102.5	8.2
18	850	0.85	0.098	12.57	39	2.5	97.5	7.75
19	900	0.9	0.104	12.65	37	2.5	92.5	7.31

6) Weigh the soil sample & the mould

7) Remove the sample from the mould by splitting it into two parts

8) Measure the length & diameter of the specimen

9) Place the specimen on the bottom place of the compression machine

10) Raise the bottom plate of the machine to make contact of the specimen with the upper plate.

11) Adjust the strain dial gauge & proving ring dial gauge to read zero

12) Apply the compression load by raising bottom of the machine to produce axial strain at a rate of 1/2 to 2% per minute.

13) Record the strain & proving ring dial gauges readings every 30 seconds.

14) Compress the specimen till it fails (or) 20% vertical deformation is reached which ever is earlier.

15) Note the least count of strain dial gauge in mm/div & load gauge in kg/div.

16) Measure the failure angle from horizontal if possible specially if soil sample is not fully saturated.

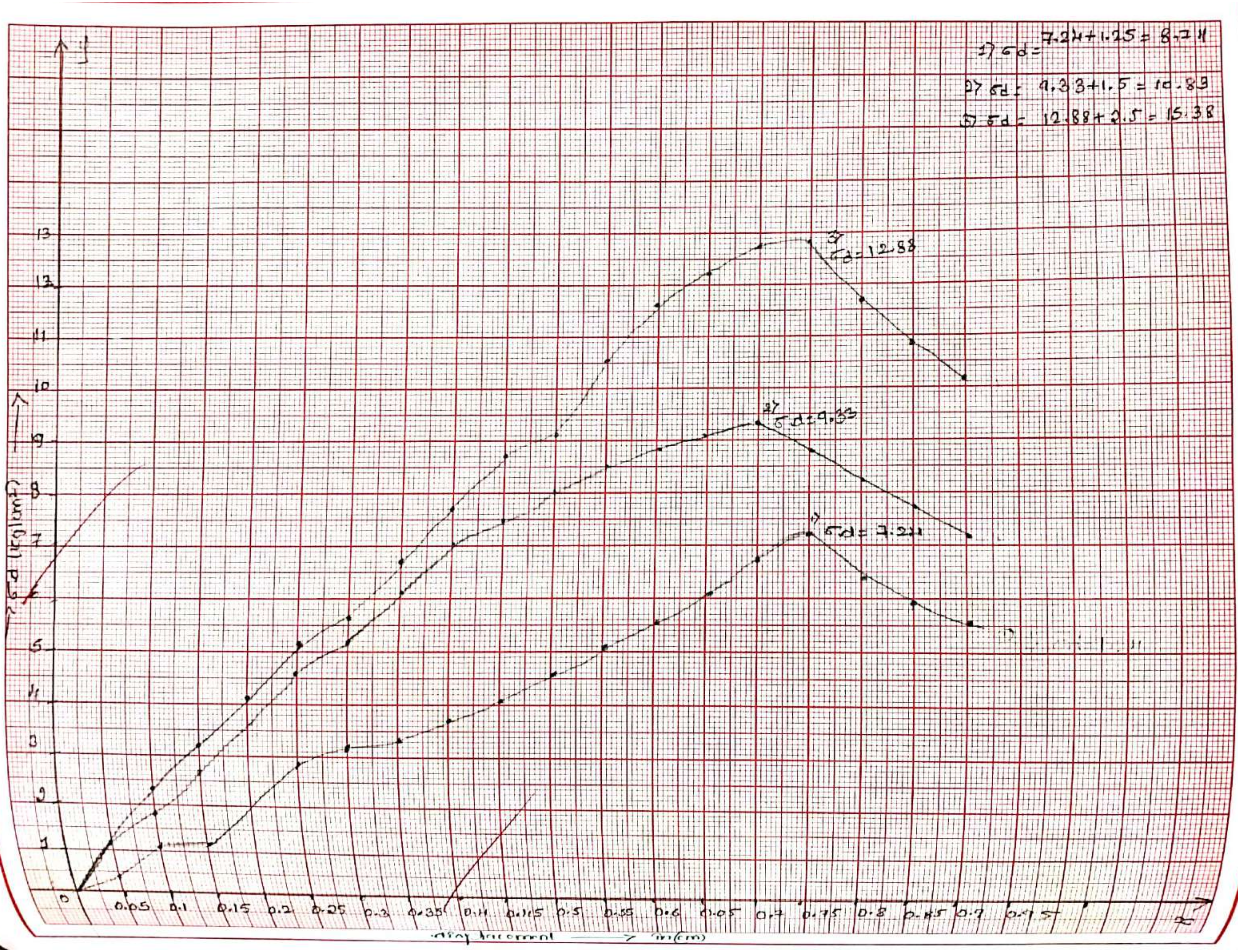
17) Determine the moisture content of the specimen.

Graph

1) Draw a mohr circle for the axial stress ($\sigma_3 = 0$) Dia of mohr circle = Axial stress σ_1 for pure clay soil $\phi = 0$

Trial 3:- 2.5 kg/cm²

Sl No	Deformation D.G.R	Displacement Δh = L.C × DGR	Axial strain $\epsilon = \frac{\Delta h}{H}$	Changed area cm² $A_c = \frac{A_0}{1-\epsilon}$	P.R.R	K	Load (kg) P = PRR × K	σ_d = P/A kg/cm²
1	0	0	0	11.34	0	2.5	0	0
2	50	0.05	5.21×10^{-3}	11.4	5	2.5	12.5	1.09
3	100	0.1	0.011	11.466	11	2.5	27.5	2.39
4	150	0.15	0.017	11.54	14	2.5	35	3.03
5	200	0.2	0.023	11.6	16	2.5	40	3.44
6	250	0.25	0.029	11.67	24	2.5	60	5.14
7	300	0.3	0.034	11.73	26	2.5	65	5.54
8	350	0.35	0.04	11.81	32	2.5	80	6.77
9	400	0.4	0.046	11.88	37	2.5	92.5	7.78
10	450	0.45	0.052	11.96	43	2.5	107.5	8.98
11	500	0.5	0.058	12.03	48	2.5	120	9.90
12	550	0.55	0.063	12.11	52	2.5	130	10.67
13	600	0.6	0.69	12.18	57	2.5	142.5	11.63
14	650	0.65	0.075	12.25	60	2.5	150	12.24
15	700	0.7	0.08	12.33	63	2.5	157.5	12.78
16	750	0.75	0.087	12.42	64	2.5	160	12.88
17	800	0.8	0.093	12.5	58	2.5	145	11.6
18	850	0.85	0.098	12.57	55	2.5	137.5	10.93
19	900	0.9	0.104	12.65	52	2.5	130	10.22
20	950	0.95	0.110	12.74	38	2.5	95	7.45
21	1000	1	0.116	12.82	32	2.5	80	6.24


1) σd = 7.24 + 1.25 = 8.74
2) σd = 9.33 + 1.5 = 10.83
3) σd = 12.88 + 2.5 = 15.38
σd = 12.88
σd = 9.33
σd = 7.24
σd (kg/cm²)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
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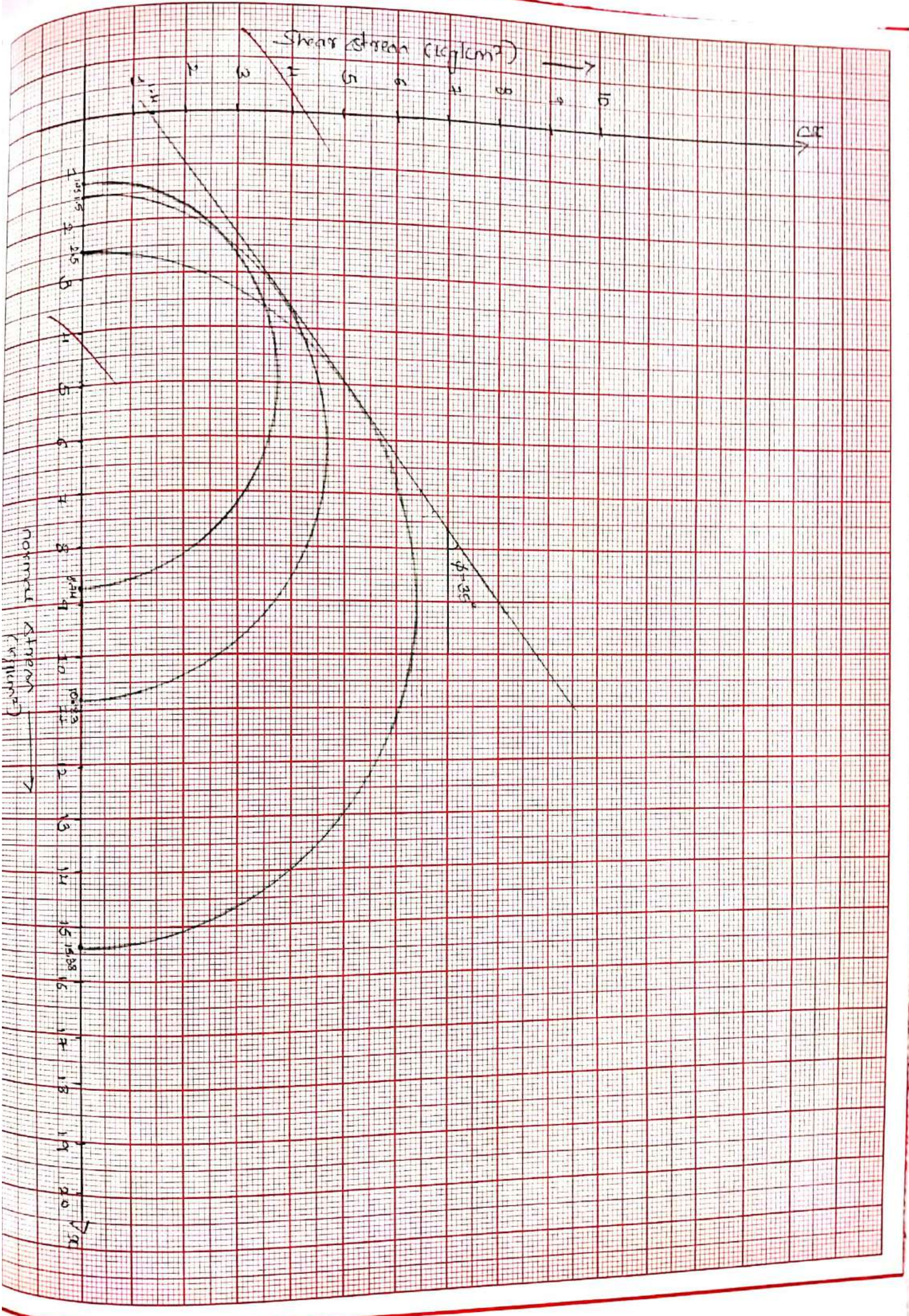

Shear stress (kg/cm²)
normal stress (kg/cm²)

Name of Experiment : .... Date : ....

Experiment No : .... Experiment Result : .... Page No. 115

draw a Mohr envelope (tangent to Mohr circle) horizontally. Measure $C = \sigma_1 / 2$

b) For partly cohesive soils, on the Mohr circle at the center set off an angle twice the measured failure angle. At the point this angle cuts the Mohr circle draw a tangent measure C & ϕ.
If required for other separate Mohr circle is drawn & other steps repeated. Average c & ϕ are found.

Result :

Angle of internal friction $\phi = 30°$
Cohesion $(c) = 1.4\ kg/cm^2$

Application

-> The primary purpose of the unconfined compression test is to quickly determine a measure of the unconfined compressive strength of rocks or fine-grained soils that possess sufficient cohesion to permit testing in the unconfined state.

24/1/22

Teacher's Signature :

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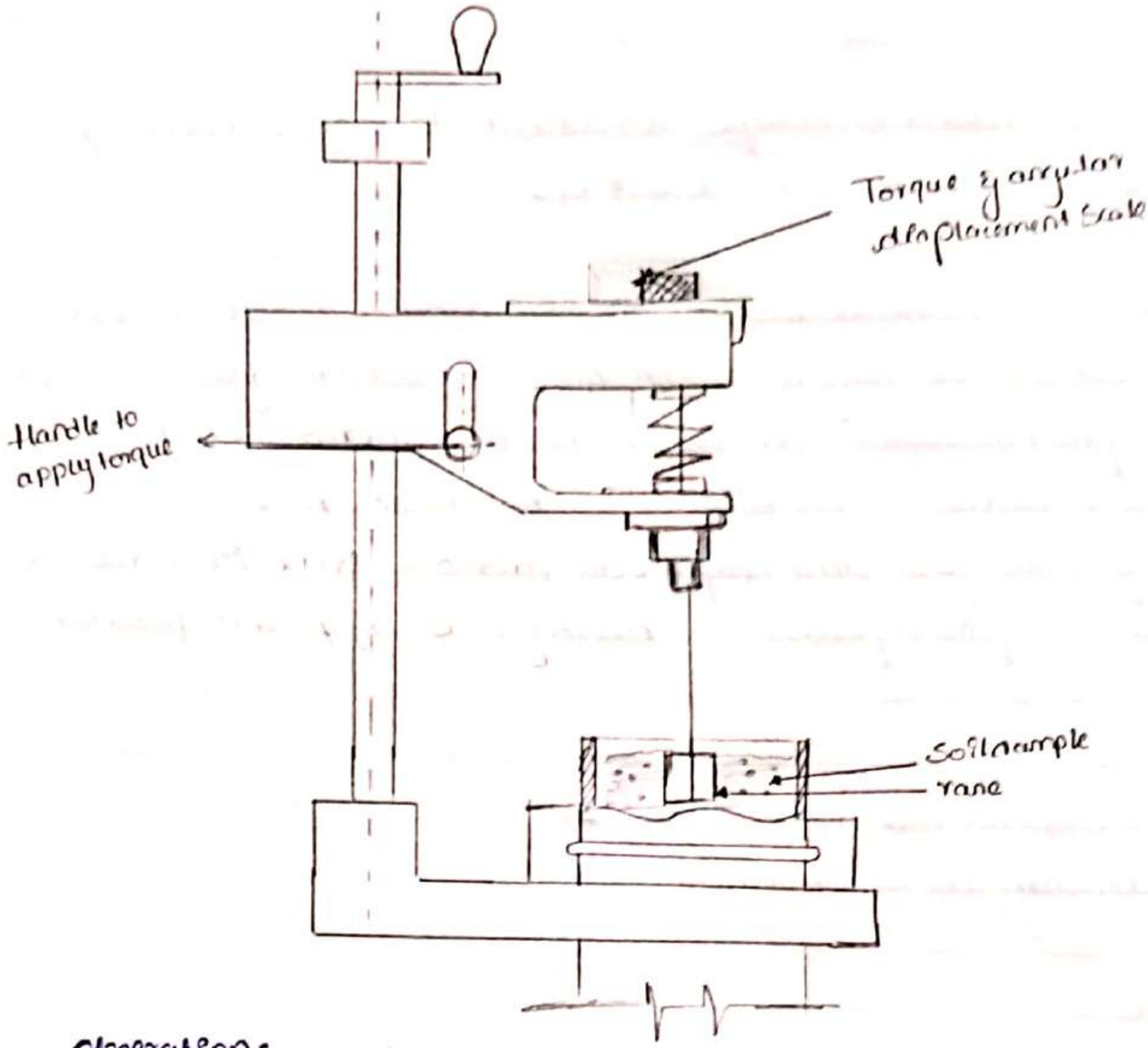

Observation:

Dia of vane shear mould = 3.8cm
Height of vane shear mould = 7.6cm
Height of vane shear blade = 2.4cm
Dia of vane shear blade = 1.2 cm

VANE SHEAR TEST

Aim :- To determine the undrained shear strength of soil using Vane shear test.

Apparatus :- Shear vane, torque mould on a stand, container & a metallic cover.

Preparation of mould : sample

Undisturbed Sample :- Force 50mm length of the sample out from sampler, cut it & trim it to 46mm dia. Place the trimmed sample container of 50mm internal dia & 50mm internal length. Fill the annual space in between the wall of the container & the sample with molten ~~mo~~ wax.

Disturbed sample : Compact the soil either in a proctor mould (or) CBR mould to give a particular dry density at particular moisture content. Then extract the sample of 46mm & 50mm dia. alternatively mix pre-determined quantity of water in a required quantity of soil of give a desired dry density. compact the soil in layers in to the container. level the top sample surface.

Teacher's Signature :

Calculation

1) Loading ring = 2kg.

Difference angle = $(360^\circ - 325^\circ) = 35^\circ$

$$T = \frac{35 \times 2}{180} = 0.38$$

$$S = \frac{T}{\pi\left[\frac{D^2H}{2} + \frac{D^3}{6}\right]}$$

$$= \frac{0.38}{\pi\left(\frac{(1.2)^2\ 2.4}{2} + \frac{(1.2)^3}{6}\right)}$$

$S = 0.05\ kg/cm^2$

2) Loading ring = 4kg

Difference angle = 17°

$$T = \frac{17 \times 4}{180} = 0.377$$

$$S = \frac{T}{\pi\left[\frac{D^2H}{2} + \frac{D^3}{6}\right]}$$

$$= \frac{0.377}{\pi\left[\frac{(1.2)^2 \times 2.4}{2} + \frac{(1.2)^3}{6}\right]}$$

$S = 0.053\ kg/cm$

3) Loading ring = 8kg

Difference angle = 12°

$$T = \frac{8 \times 12}{180} = 0.53$$

$$S = \frac{T}{\pi\left[\frac{D^2H}{2} + \frac{D^3}{6}\right]}$$

$$= \frac{0.53}{\pi\left[\frac{(1.2)^2 \times 2.4}{2} + \frac{(1.2)^3}{6}\right]}$$

$S = 0.083\ kg/cm.$

Procedure:

Mount the container with sample on the base of the vane shear apparatus & clamp it there firmly. Lower the shear vanes gradually without disturbing the soil specimen so that the top of the vane is at least 10mm below the top of the specimen. Bring the maximum pointer into contact with strain-indicating pointer into contact with strain-indicating pointer. Note the reading on the circular graduated scale. Operate the torque applicator handle until the specimen fails which is indicated by the return of the strain-indicating pointer.

Note down the reading of the maximum pointer. The difference b/w the two readings gives the angle of torque of the spring. This multiplied by the spring factor & divided by 180 gives the torque applied in kg-cm.

Formula:

$$\text{Shear strength, } S = \frac{T}{\pi\left(\frac{D^2H}{2}+\frac{D^3}{6}\right)}$$

S = Shear strength in kg/cm²

T = Torque in kg-cm

D = Over all diameter of vane in cm &

H = Height of vane in cm.

Teacher's Signature :

Result:

1) The undrained shear strength of the soil for 2kg loading ring = 0.05 kg/cm
2) The undrained shear strength of the soil for 4kg loading ring is = 0.053 kg/cm
3) The undrained shear strength of the soil for 8kg of loading ring = 0.083 kg/cm

Applications:

1) Vane shear test is used to determine the undrained shear strength of soft clay soils.
2) This test can be done in lab or in the field directly on the ground
3) The undrained shear strength of soil is of great concern in certain geotechnical engineering application
4) Vane shear test gives accurate results for soils of low shear strength.

OBSERVATIONS:

1) Diameter of sample = 3.8 cm
2) Height of sample = 8.6 cm
3) Least count of proving ring = 0.002 cm
4) Least count of dial gauge = 0.001 cm
5) Volume of sample = 97.53 cm^3
6) Weight of sample = 177.5 g
7) $A_0 = \frac{\pi (d)^2}{4} = \frac{\pi (3.8)^2}{4} = 11.34\ cm^2$

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Name of Experiment : Triaxial compression test Date : 29/1/22
Experiment No : Experiment Result : Page No. 117

TRIAXIAL COMPRESSION TEST

Aim:- To determine the shear strength parameters i.e. Angle of shearing resistance & cohesion of given soil sample.

Apparatus:- Triaxial test cell with base, perspex cell & head, compression machine (speed 0.05 to 7.5mm/min) capacity 50kN. Lateral pressure assembly (accuracy 0.5N/cm² with a pressure gauge) proving rings, rubber membrane stretcher rubber O rings, split mould 3.81cm dia & 7.62cm height. Vaccum pump.

Procedure:

1. Connect the outlet at the base of the cell to a burette for volume change measurements. Run the water from the burette to remove all the air in the line by flushing.
2. Put a porous cap on the pedestal
3. Seal the rubber membrane to the pedestal with sealing ring.
4. Place the split mould in position & take the membrane through it inside & stretch on the top.
5. Fill the membrane with desired water.
6. Weigh the required amount of sand & drop into the water without entrapping air.
7. After filling the required weight of sand, level the top
8. Put a solid cap and seal it by 'O' rings
9. Lower the burette & apply a slight vaccum
10. Remove the split mould & measure the dimension of the sample.

Teacher's Signature :

Trial-01 $\sigma_B = 1kg/cm^2$

Sl No.	Deformation		Axial strain $\epsilon = \frac{\Delta L}{L}$	Changed area, cm^2 $A_c = \frac{A_0}{1-\epsilon}$	P.R.R	load (kg) $P = PRR \times LC$	$\sigma_d = \frac{P}{A}$	$\sigma_1 = (\sigma_d + \sigma_3)$	$\frac{\sigma_1}{\sigma_3}$
	D.G.R	Displacement [DL = LC x DGR] cm							
1	0	0	0	11.34	0	0	0	1	1
2	50	0.05	5.81×10^{-3}	11.40	19	3.23	0.28	1.28	1.28
3	100	0.1	0.011	11.46	32	5.44	0.47	1.47	1.47
4	150	0.15	0.017	11.53	40	6.8	0.58	1.58	1.58
5	200	0.2	0.023	11.60	50	8.5	0.73	1.73	1.73
6	250	0.25	0.029	11.67	59	10.03	0.85	1.85	1.85
7	300	0.3	0.034	11.73	66	11.22	0.95	1.95	1.95
8	350	0.35	0.04	11.81	71	12.07	1.02	2.02	2.02
9	400	0.4	0.046	11.88	76	12.92	1.02	2.08	2.08
10	450	0.45	0.052	11.96	79	13.43	1.08	2.12	2.12
11	500	0.5	0.058	12.03	82	13.94	1.12	2.15	2.25
12	550	0.55	0.063	12.1	88	14.96	1.15	2.23	2.23
13	600	0.6	0.069	12.18	90	15.3	1.23	2.25	2.25
14	650	0.65	0.075	12.25	92	15.64	1.25	2.27	2.27
15	700	0.7	0.081	12.33	96	16.32	1.32	2.32	2.32
16	750	0.75	0.087	12.42	92	15.64	1.25	2.25	2.25
17	800	0.8	0.093	12.50	88	14.96	1.19	2.19	2.19

Name of Experiment :

Experiment No :

Date :

Experiment Result :

11. Assemble the cell and fill it with water
12. Note the initial reading of the burette
13. Apply the cell pressure equal to 5N/cm²
14. Note the reading of the burette.
15. Raise the loading platform of the compression machine to bring the ram in contact of the loading cap.
16. Set the dial gauge on the proving ring to read zero. This will compensate for the load due to cell pressure & piston friction.
17. The strain dial is adjusted to zero
18. Start the machine to apply the normal load take the readings of the proving ring & burette at intervals of 25 divisions (0.25 mm) till sample fails or 20% strain is applied.
19. make a sketch of failed specimen & measure final dimensions.
20. Repeat the test for higher cell pressure say 1kg/cm² 1.5, 2.0, 3.0 & 4kg/cm² at the same initial dry density.

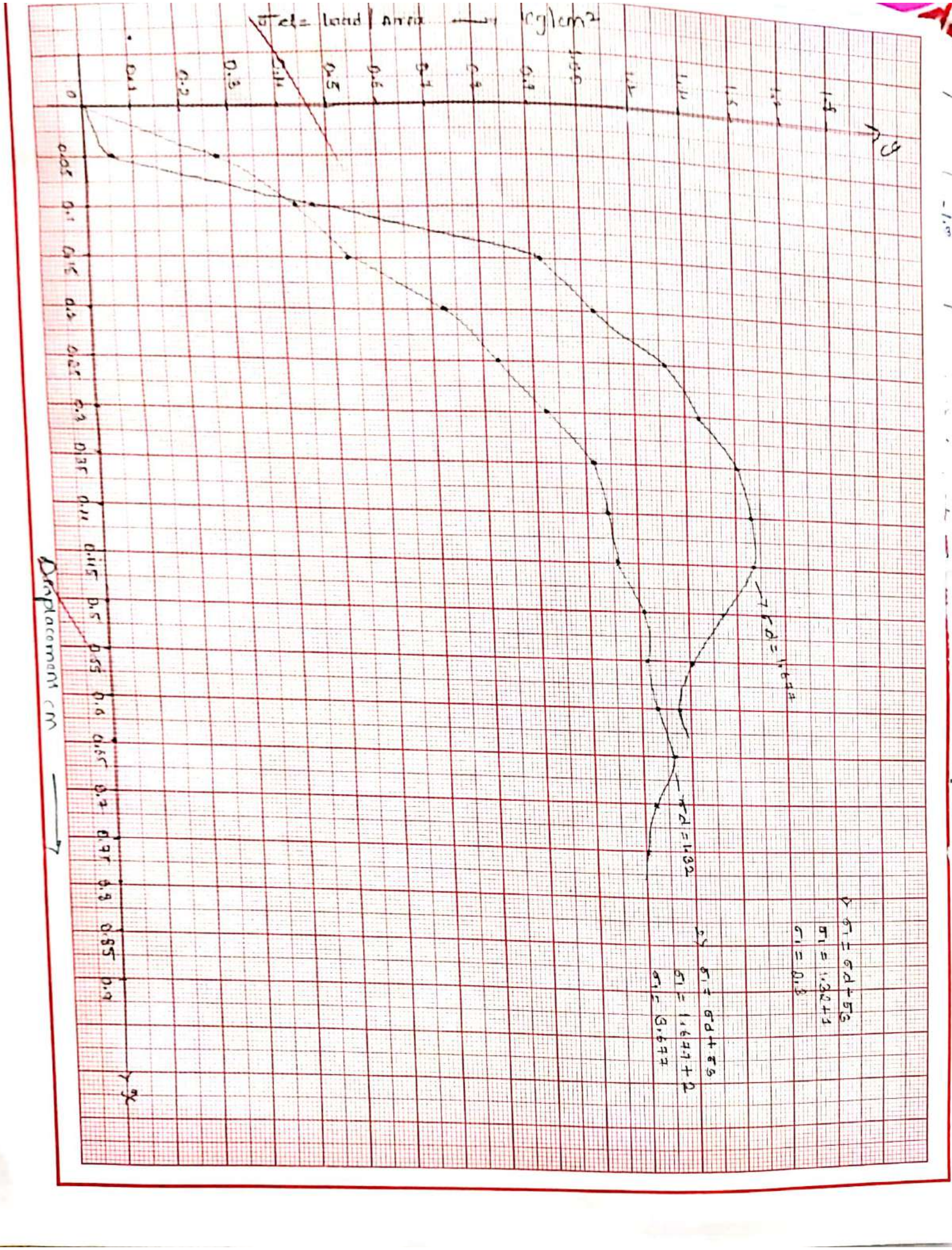
Graph

1. For I II & III samples draw on a shear stress vs normal stress axes, three mohr circles for all round pressure σ_3 & total vertical stress σ. Draw a common tangent to the three circles & obtain c & ϕ for any one of mohr circle mark the pole. plane of failure major & minor principles planes
2. Also draw a graph of Deviator stress vs axial deformation.

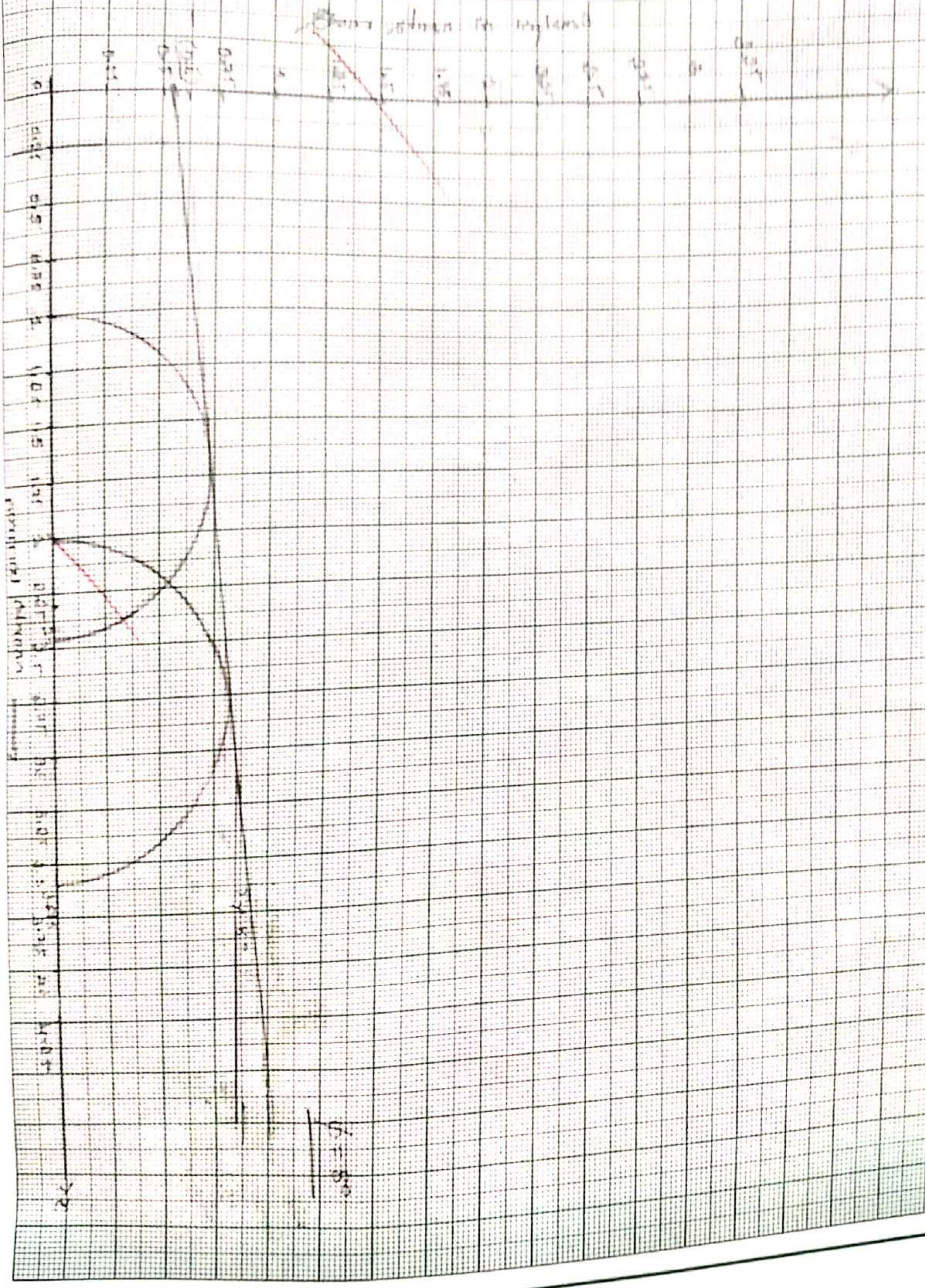
Teacher's Signature :

Trial - 2 :- $\sigma_3 = 2\ kg/cm^2$

Sl No.	Deformation		Axial strain $\epsilon = \frac{\Delta L}{L}$	Changed area in cm^2 $A_c = \frac{A_0}{1-\epsilon}$	P.R.R	Load (kg) $P = PRR \times LC$	$\sigma_d = \frac{P}{A}$	$\sigma_1 = \sigma_d + \sigma_3$	$\frac{\sigma_1}{\sigma_3}$
	DGR	Displacement ($\Delta L = L.C \times DGR$) in cm							
1	0	0	0	11.34	0	0	0	2	1
2	50	0.05	6.81×10^{-3}	11.4	4	0.68	0.05	2.05	1.02
3	100	0.1	0.011	11.46	35	5.95	0.519	2.519	1.25
4	160	0.15	0.017	11.53	62	10.54	0.91	2.91	1.45
5	200	0.2	0.023	11.60	77	13.09	1.12	3.12	1.56
6	260	0.25	0.029	11.67	90	15.3	1.31	3.31	1.65
7	300	0.3	0.034	11.73	101	17.17	1.46	3.46	1.73
8	350	0.35	0.04	11.81	113	19.21	1.62	3.62	1.81
9	400	0.4	0.046	11.88	116	19.72	1.66	3.65	1.82
10	450	0.45	0.052	11.96	118	20.06	1.677	3.67	1.83
11	500	0.5	0.058	12.03	110	18.7	1.55	3.55	1.77
12	560	0.56	0.063	12.1	100	17	1.4	2.4	1.7
13	600	0.6	0.069	12.18	95	16.15	1.32	3.32	1.66



σd = load / area → kg/cm²
Displacement cm
σd = 1.677
σd = 1.32
1) σ1 = σd + σ3
σ1 = 1.32 + 1
σ1 = 2.3
2) σ1 = σd + σ3
σ1 = 1.677 + 2
σ1 = 3.677



Name of Experiment : ....

Experiment No : ....

Date : ....

Experiment Result : ....

Result:

Angle of internal friction $\phi = 8°$

cohesion = 0.6

APPLICATIONS:

1) Triaxial testing is used in the oil and gas industry to determine the properties of shale cores. & predict how soil responds during natural gas extraction.

2) Triaxial shear tests are used for building dams & embankments.

3) Triaxial tests are often used to determine the behavior & strength characteristics of soils.

30/1/22 24/24

Teacher's Signature : ____________