BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY

CE 342

GEOTECHNICAL ENGINEERING LABORATORY

Experiment No: 01

Name of the Experiment: Field Identification Tests of Fine Grained Soils.

Date of Performance:	**Name: Moriom Akter**
09/06/2021	**Student No.: 1704015**
Date of Submission:	**Level-3 Term-1**
17/06/2021	**Section: A**
	Group: 1

Name of Experiment: Field Identification of soil.

Objective:

(1) classify soils on field.

(2) Identify and describe the subsoil condition on field.

(3) Comment on dry strength, Dilatancy, toughness of plastic thread, Dispersion.

Scope and Significance:

(1) ~~Ex~~ All tests are done by visual and physical means and without any specialized laboratory instrument.

(2) Fine grained (organic and inorganic) soil were tested.

(3) ~~A~~ To assess the nature of a problem that might be encountered in a project immediately, engineers need to perform field identification.

(4) field Identification initially gives an idea about soil before ~~an~~ extensive lab test.

Equipment:

- wash bottle
- Dish
- Wooden hammer
- Spatula
- Beaker
- stirring glass rod.
- 1/8" steel rod.

Data sheet :

Color : Grey
Odour : None.

Group No : A1

Name of Test	Reaction / Observation	Possible Soil Type	Soil type.
Dry Stren - gth	None	Sandy silt.	
Dilatancy on Shaking Test.	Rapid	Sandy silt	
		Silt	Sandy silt.
		clayey silt	
Plasticity	Low	Sandy silt	
		Silt	
		Organic Silt	
Dispersion	45 sec.	Sandy silt.	
		Sandy clay.	

Student ID : 1704015
Level : 3
Term : 1
Section : A
Department : Civil Eng.

IV Result: Sandy Silt.

V Discussion: From dry strength test observed reaction is none. Usually silty sand has very low or no dry strength. It was becoming powder with mere pressure of handling.

From Dilatancy or shaking test water came to the top surface of soil pat rapidly. sandy silt, silt and clayey silt gives this kind of reaction.

From Plasticity test, reaction found low as the thread can barely be rolled and lump cannot be formed when drier than plastic limit. Sandy Silt, silt and organic silt give this reaction usually.

Finally, in Dispersion test it took only 45 sec to be settled in soil water mixture. Sandy silt and Sandy clay depict this behaviour.

~~Anl~~ Analysing all criteria, it can be conclude that, the soil sample was a ~~sit~~ sandy silt sample.

P.T.O.

As Dry strength is none, Dilatancy is rapid and toughness or plasticity is low it's group symbol is ML or Low plastic silt. The color of the soil becoming grey ensure its inorganic origin and no odour ensures no organic presence. This sample is fair to good as subgrade soil.

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Experiment No: 02

Name of the Experiment: Determination of the specific gravity of soil solids by water pycnometer.

Date of Performance:	**Name: Moriom Akter**
10/03/2021	**Student No.: 1704015**
Date of Submission:	**Level-3 Term-1**
17/03/2021	**Section: A**
	Group: 1

□ Name of Experiemnt: Determine the Specific Gravity of soil solids by water Pycnometer.

□ Objective: (1) Find the specific gravity of sample soil solid at existing temperature.

(2) Convert the specific gravity into specific gravity of 20°C.

□ Scope and Significance:

(1) Through this test, specific gravity of soil solid's which particle size is not greater than 4.75 mm sieve (#4) can be determined.

(2) As water pycnometer is being used, if any soil solid is lighter than water or floats in water than that type of soil's G_s can be measured.

(3) From specific gravity different properties of soil like void ratio, degree of saturation, density of soil etc can be calulated.

⊞ Equipment :

1. Volumetric flask
2. Wash bottle
3. Funnel
4. Pippet
5. Can
6. Balance
7. Burner/gas stove.
8. Vaccum pump
9. Oven
10. Thermometer.

⊞ Data Table :

P.T.O.

Specific Gravity Test.

Group-1

Student No: 1704015

Section: A.

Data Table.

Weight of Bottle (gm)	100·1
Wt of Bottle+Dry Soil (gm)	152·3
Wt of Soil, W_s (gm)	52·2
Wt of Bottle+Water+Soil, W_1 (gm)	377.5
Wt ~~g~~ of Bottle+Water, W_2 (gm)	351.4
Room Temperature (°C)	30

From chart,

Specific gravity of water $(G_W)_{20°} = 0·9982$

Specific gravity of water $(G_W)_{30} = 0·9957$

G_s at 20°C = 1·99

Sample Calculation:

Weight of Soil, W_s = (Wt of Bottle + Dry Soil) − (Wt of Bottle)

$$= (152.3 - 100.1) \text{ gm}$$

$$= 52.2 \text{ gm.}$$

$$G_s \text{ at } 20^\circ C = \frac{W_s}{W_s - W_1 + W_2} \times \frac{(G_W)_{30}}{(G_W)_{20}}$$

$$= \frac{52.2}{52.2 - 377.5 + 351.4} \times \frac{0.9957}{0.9982}$$

$$= 1.99.$$

Result:

G_s at 20°C = 1.99.

Discussion:

From experimental result G specific gravity of test sample is 1.99 which is generally a lower value for soil's specific gravity. It is because usually soil that is

~~adun~~ abundant in nature, inorganic soil holds a range of 2.60 to 2.80. specific gravity falls under 2.60 when the soil contains ~~two~~ too much organic component of particles are porous in nature such as diatomaceous earth. It may fall up to 2.00. As, found G_w is 1.99, it is evident, experimental soil sample is containg either excessive organic matter or porous material.

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Experiment No: 03

Name of the Experiment: Determination of particle size distribution (gradation) of soil using sieve analysis.

Date of Performance:	**Name: Moriom Akter**
10/03/2021	**Student No.: 1704015**
Date of Submission:	**Level-3 Term-1**
17/03/2021	**Section: A**
	Group: 1

▣ Name of Experiment: Particle-Size Distribution (Gradation) of soils using Sieve Analysis.

▣ Objective: (1) Plot a gradation curve in semilog paper for the tested soil sample.

(2) Determine the particle percentage of 'clay', 'silt', and 'sand' using ASTM and MIT textural classification from gradation curve.

(3) Determine D_{10}, D_{30} and D_{60} from graph and calculate Coefficient of Uniformity, C_u and Coefficient of gradation, C_c.

▣ Scope and Significance.

(1) For gradation of particles larger than 0.075 mm this test method is used.

(2) From gradation C_u, C_c can be found and using this classification is made.

(3) With variation and different proportion of particles engineering property is determind so gradation is required.

☐ Equipment:

1. #4, #8, #16, #30, #50, # 100, # 200 sieve.
2. Pan
3. Brush
4. Container
5. Spoon
6. Bowl
7. Balance
8. Sieve shaker.

☐ Data Table:

P.T.O.

Sieve Anlysis of Soil

Group-1

Student No: 1704015.

Section: A.

Weight of sample: 499.99 gm

Data Table.

Sieve No	Wt of Container (gm)	Wt of Container + Soil (gm)	Wt of Soil Retained (gm)	Percent of Soil Retained	Cumulative Percent Retained	Percent Finer
4	55	111.04	56.04	11	11	89
8	56	148.28	92.28	18	29	71
16	57	132.90	75.9	15	44	56
30	54	90.63	36.63	7	51	49
50	55	57.08	2.08	1	52	48
100	56	110.31	54.31	11	63	37
200	57	156.31.	99.31	20	83	17
PAN			83.44	17	100	0

Sample Calculation:

For sieve #4,

Weight of container = 55 gm.

Wt of container + Soil = 111.04 gm

Wt of Soil Retained = (111.04 − 55) gm

= 56.04 gm.

similarly, calculation for #8, #16, #30, #50, #100 and #200 is done.

Total weight of sample = 499.99 gm.

$\therefore$ Percent retained in #4 = $\frac{56.04}{499.99} \times 100\%$

= 11%

similarly calcution for other sieves are done.

For any sieve,

cumulative percent retained = Sum of Percent of soil retained from #4 to that sieve.

i.e. cumulative percent retained at #100

= 11 + 18 + 15 + 7 + 1 + 11 = 63

Percent Finer = 100 − Cumulative Percent Retained.

for example, at #30, Percent finer = 100 − 51 = 49.

From Graph,

effective size, D_{10} = 0·066 mm.

(As the graph ended above (0·075 mm) 10% finer D_{10} is obtained by visual and mannual analysis).

D_{30} = 0·11 mm

D_{60} = 1·5 mm

Coefficient of uniformity, $C_u = \frac{D_{60}}{D_{10}} = \frac{01{\cdot}5}{0{\cdot}066}$

$= 22{\cdot}72$.

Coefficient of gradation, $C_c = \frac{D_{30}^2}{D_{60} \cdot D_{10}}$

$= \frac{0{\cdot}11^2}{1{\cdot}5 \times 0{\cdot}066}$

$= 0{\cdot}122$.

Graph : Attatched

Result:

D_{10} = 0·066 mm, 10% particle finer than D_{10}

D_{30} = 0·11 mm, 30% particle finer than D_{30}

D_{60} = 1·5 mm, 60% particle finer than D_{60}.

⊞ Graph :

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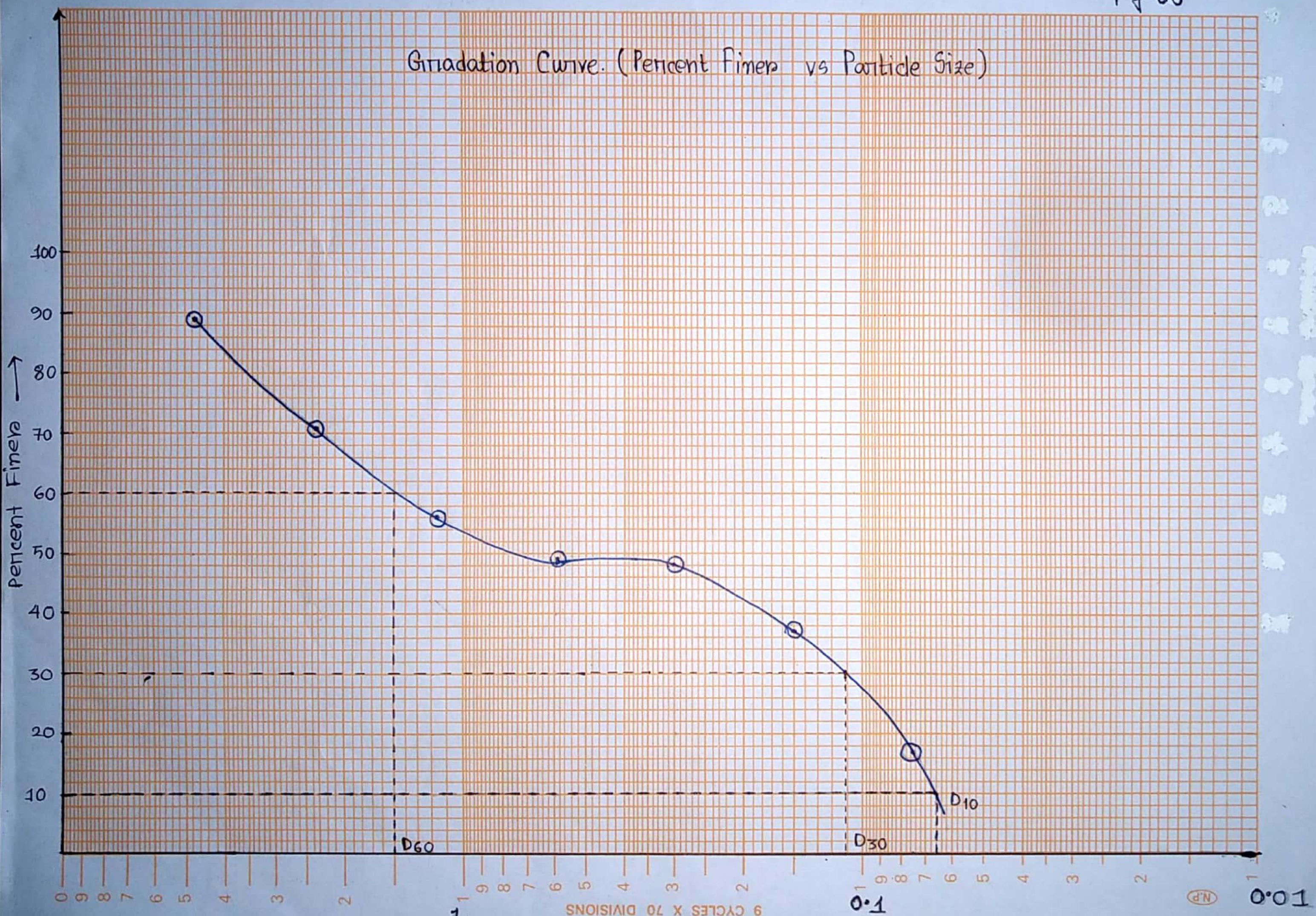
Pg-06



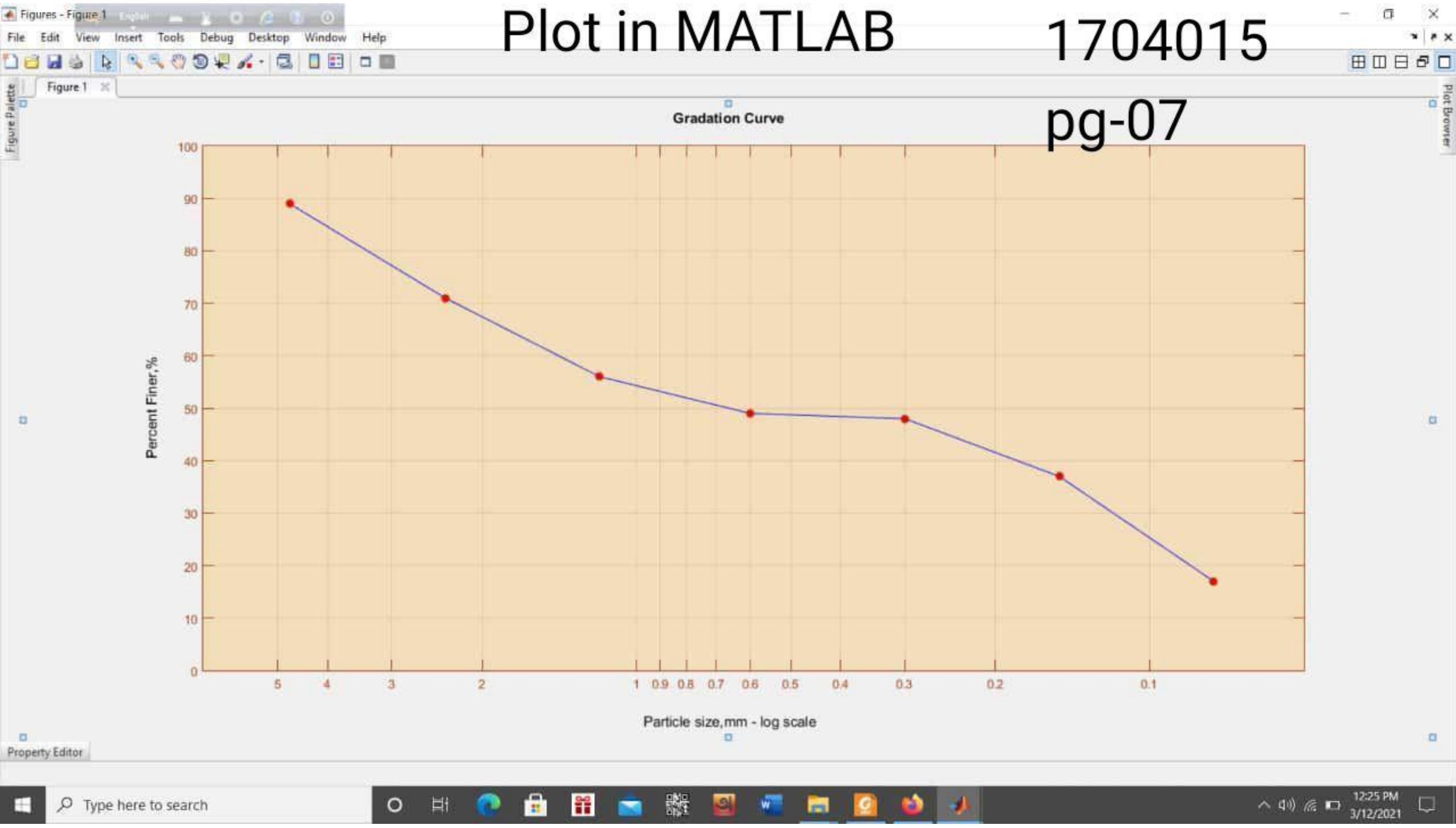
Roll No. 1704015

← particle size (mm) - log scale.

Plot in MATLAB

1704015

pg-07



Dissussion :

According to ASTM texural classification, (1967) particles coarser than 4.75 mm are considered as gravel and particles finer than 0.075 mm are considered as fines (silt and clay). Between this range particles are considered sand. Therefotie, as 11% particles are coarser than 4.75 mm and 17% particles are finer than 0.075 mm 72% of soil particle is sand. So, this is a sample of sand. Again, as more than 12% particles are finer, depending on the size of fine particles it can be called Silty Sand or clayey sand according to ASTM.

On the other hand, particle's size equal to 2mm or greater is considered as gravel and in between 2mm and 0.06 mm are considered sand according to MIT, 1931 texural classification. From gradtion curve, 44% particles are coarser than 2 mm and (100 - 44 - 8) or 48% particles are in between 2.0 mm and 0.06 mm. Only 8% soil is finer than 0·06mm ~~or~~ which is considered silt. As, the sample mainly contains sand along with a good proportion of gravel, it is gravelly sand according to soil classification by MIT, 1931.

In general, from this sand sample different soil parameters found as follows,

$D_{10} = 0{\cdot}066mm$, $C_u = 22{\cdot}72$ and $C_c = 0{\cdot}122$.

D_{10}, also known as effective parameter is not only important to calculate C_u, C_c but also significant for determining various soil properties such as liquid limit, plasticity index, unconfined compressive strength etc.

For, sand $C_u \geq 6$ implies that it is a well graded sand and $1 \leq C_c \leq 3$ indicated well gradation. But, from experemental data though $C_u > 6$, $C_c < 1$ means gradation is poor. So, the gradation is not well or very poor instead it's nearly well graded but few particles size is missing.

This become evident from gradation curve for the sample. Usually, well graded gradation curve extends over a large number of particle ~~zi~~ size and slope is moderate. But, for the samples gradtion curve, it is almost horizontal in between #30 and #50 sized particles. Also, from data sheet, percent retain in #50 sieve is only ~~or~~ 1% of total soil. Other than this, gradation curve is moderately sloped and extends over a wide range (0.075mm to 4.75mm). So, the sand is not perfectly well graded, the gap of indermediate sized particles made ~~is~~ it similar like gap gradation.

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GEOTECHNICAL ENGINEERING LABORATORY

Experiment No: 04

Name of the Experiment: Hydrometer Analysis of Soil.

Date of Performance:	**Name: Moriom Akter**
23/06/2021	**Student No.: 1704015**
Date of Submission:	**Level-3 Term-1**
01/07/2021	**Section: A**
	Group: 1

Name of the experiment: Hydrometer Analysis of soil.

Objective:

(1) Determine the grain size distribution of fine grained soil.

(2) Determine the percentage of different grain sizes for soiling passing through #200.

Scope and Significance:

(1) particles which can't be graded in sieve analysis will be graded in this method.

(2) For classifying fine grained soil.

Equipment:

1. Balance
2. Measuring cylinder (100 mL)
3. Mixing pot
4. Dish
5. Spoon
6. 152H Hydrometer
7. Mixer
8. Control Cylinder (1000mL)
9. Sedimentation Cylinder (1000mL)
10. Stop watch
11. Wash bottle
11. Rubber stopper
12. Dispersing agent (Sodium hexametaphosphate)

Data table:

Exp: 3 Hydrometer Analysis of Soil

Wt of Sample (gm) (Ws)	Specific Gravity (Gs)	zero Correction (CR)	Miniscus correction (cm)	Elapsed Time (min)	Room Temp. (°C)	Hydrometer Reading (Ra)	Correction factor for different Sp. Gravity	Temp. Correction	Reading after miniscus correction (RL)	corrected reading	Value of K	Effective depth	Particle size, D (mm)	Percent finer (P)
				0·25	30	53		+3·80	54	53·8	0·01256	7·498	0·0687	100
				0·5	30	51		+3·80	52	51·8	0·01256	7·824	0·0496	96
				1	30	47		+3·80	48	47·8	0·01256	8·476	0·0365	89
55	2·55	4	1	2	30	43	1·02	+3·80	44	43·8	0·01256	9·128	0·0268	81
				4	30	38		+3·80	39	38·8	0·01256	9·943	0·0198	72
				8	30	32		+3·80	33	32·8	0·01256	10·921	0·0146	61
				15	31	28		+4·65	29	29·65	0·01243	11·573	0·0109	55
				30	31	24		+4·65	25	25·65	0·01243	12·225	0·0079	48
				60	31	21		+4·65	22	22·65	0·01243	12·714	0·0057	42
				120	31	19		+4·65	20	20·65	0·01243	13·04	0·0041	38
				24 hr	29	13		+3·05	14	13·05	0·01269	14·018	0·0012	24
				48 hr	32	11		+5·6	12	13·6	0·01231	14·394	0·0008	25
				72 hr	33	10		+6·65	10	13·65	0·01219	14·67	0·0007	25

Sample calculation :

Correction factor, $a = 1.65\,Gs / 2.65\,(G_s - 1)$
for Sp. Gravity

$= 1.65 \times 2.55 / \{2.65\,(2.55-1)\}$

$= 1.02$

Corrected reading, $R_c = R_a + C_m - C_R \pm C_T$

for example, $R_c = 53 + 1 - 4 + 3.80$

$= 53.8$.

$$K = \sqrt{\frac{30 \times \eta}{980\,(G - G_L)}}$$ (values obtained from table)

effective Depth $= 16.3 - 0.163\,R_L$ -

for example, $L_1 = 16.3 - 0.163 \times 54 = 7.498$

particle size, $D(mm) = K \times \sqrt{\frac{L\,(cm)}{T\,(min)}}$

$= 0.01256 \times \sqrt{\frac{7.498}{0.25}}$

$= 0.0687$ mm .

$$\text{Percent finer } (P) = \frac{R_c\,a}{W} \times 100$$

$$= \frac{53.8 \times 1.02}{55} \times 100$$

$= 99.77\% \approx 100\%$

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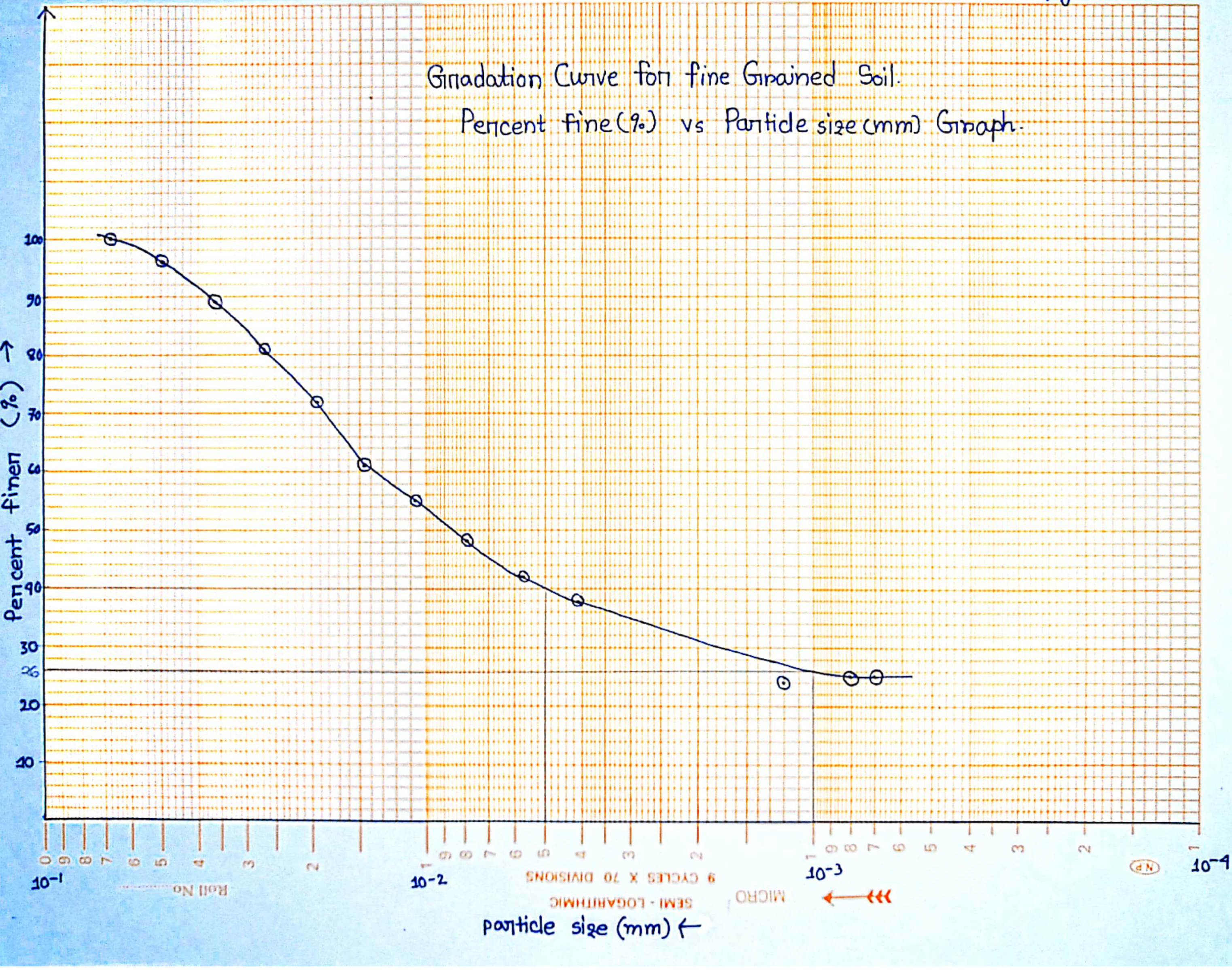
Pg-04



■ Result: Well graded.

■ Discussion: From experimental data, Percent finer (%) vs particle size (mm) graph has been plotted on a semi-log graph paper. Thus a 'S' shaped curve has been found. This shape implies the gradation is well.

According to ASTM Classification, ranges for sand, silt, clay and colloids are 0.075mm to 4.75mm, 0.005mm to 0.075mm, 0.001mm to 0.005mm and smaller than 0.001 mm respectively. From experimental data 100% is finer than 0.075mm so no soil sand particle is present. Around 40% is finer than 0.005 mm (from graph). Therefore, 60% particles are in between 0.005 mm to 0.075 mm, i.e. 60% silt is present.

Also, from graph, 26% soil particle is finer than 0.001 mm. So, (100 − 26 − 60) or, 14% particles are clay as they fall in between 0.001 mm to 0.005.

P.T.O.

And finally (100-60-14) or. 26% particles of the soil sample are colloids.

Though the soil sample has higher percentage of silt than clay, the classification can't be made right away as classification of fine grained soil depends on other parameters like liquid limit, plasticity index and some others. But, a rough estimation about soil nature will be found from the gradation curve which will help to assess it for the purpose.

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GEOTECHNICAL ENGINEERING LABORATORY

Experiment No: 04

Name of the Experiment: Atterberg Limit Test.

Date of Performance:	**Name: Moriom Akter**
07/07/2021	**Student No.: 1704015**
Date of Submission:	**Level-3 Term-1**
13/07/2021	**Section: A**
	Group: 1

Name of Experiment: Atterberg Limit test.

Objective:

(1) Determine Liquid limit of sample soil.
(2) Determine Plastic limit of sample soil.
(3) Determine shrinkage limit of sample soil.
(4) Determine plasticity index of sample soil.
(5) Determine flow index of sample soil.
(6) Determine toughness index of sample soil.

Scope and significance:

(1) Atterberg limit test is conducted ~~par~~ for partide passing through #40 sieve.

(2) As soil behaviour changes with the change of water content these limits are important to assess the soil quality.

Equipments:

(1) Casagrande's Apparatus
(2) Grooving tool
(3) Glass plate
(4) 1/8" dia rod
(5) mercury
(6) Shrinkage dish.

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02

Data Table :

Liquid Limit.

No. of Blows	17	20	24	31	35
Wt. Container (gm)	7.3	7	7.4	11.3	7.5.
Wt of Container + Wet soil (gm)	24.11	26.1	26.2	34.9	19.4.
Wt of Container + Dry soil (gm)	18.9	20.3	20.6	28.1	16.1.
Wt of water (gm)	5.21	5.8	5.6	6.8	3.3
Wt of Dry soil (gm)	11.6	13.3	13.2	16.8	8.6.
Water content. (%)	45	44	42	40	38

Plastic Limit.

Wt. container (gm)	6.9	7.3
Wt container + Wet soil (gm)	16.6	19.6
Wt of container + Dry soil (gm)	14	16.4.
Wt of water (gm)	2.6	3.2
Wt of Dry soil (gm)	7.1	9.1.
Water content (%)	37	35.

Shrimkage limit.

Wt of Dish (gm)	28.2
Wt of Dish + wet soil (gm)	54
Wt of Dish + dry soil (gm)	45.8
wt of Dry soil pat (gm)	176
Wt of displaced mercury (gm)	167.1
Vol of displaced mercury (cc)	12.29
Vol of Dish (cc)	15.00
Vol of dry soil pat (cc)	12.3
shrinkage limit (%)	32

Deliverables	
Liquid Limit (%)	42
Plastic Limit (%)	36
Shrinkage Limit (%)	32
Plasticity Index.	6
Flow Index	22.5
Toughness Index.	0.31.

☐ Sample calculation:

from graph,

water content at 25 blows = 42%

Flow index, $I_f = -\dfrac{W_1 - W_2}{\log_{10}\left(\frac{N_1}{N_2}\right)}$

$= \dfrac{-(42-39)}{\log\left(\frac{25}{34}\right)}$

$= 22.5$

Plastic limit $= \dfrac{37+35}{2} = 36.$

initial water content $w = \dfrac{54-45.8}{17.6} \times 100$

$= 46.59$

$\approx 47\%$

initial volume $= \dfrac{204}{13.6} = 15cc. = V$

volume of dry soil pat $= \dfrac{167.1}{13.6} = 12.3\ cc = V_0$

shrinkage limit $= w - \dfrac{(V - V_0)}{M_0} \rho_w \times 100$

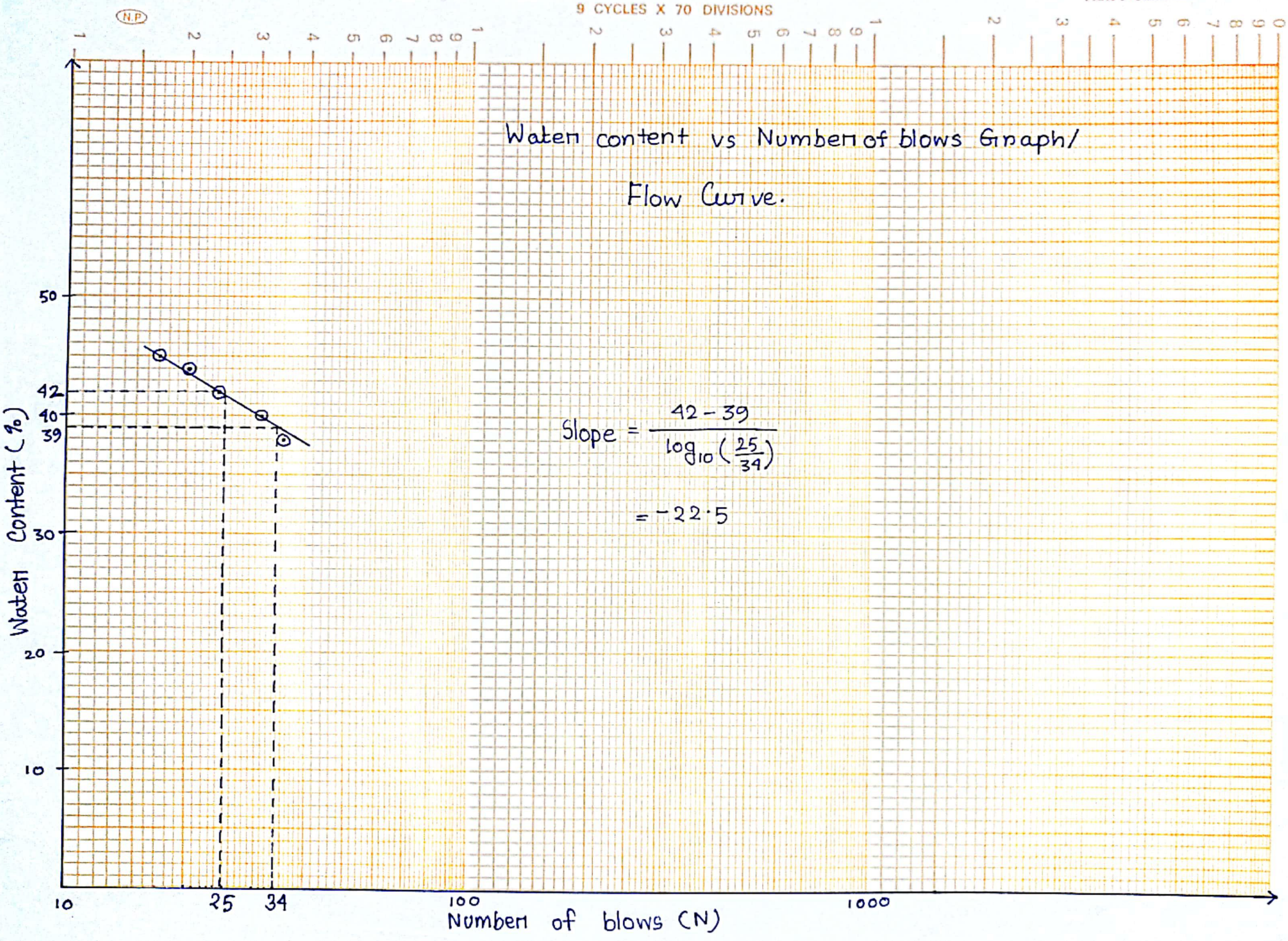
$= 47 - \dfrac{(15-12.3)}{17.6} \times 1 \times 100$

$= 31.66 \approx 32$

Toughness ~~nen~~ index, $I_t = \dfrac{PI}{I_f} = \dfrac{42-36}{22.5} = 0.311$

MICRO SEMI - LOGARITHMIC
9 CYCLES X 70 DIVISIONS

Roll No. 1704016



Water content vs Number of blows Graph/ Flow Curve.

$$\text{Slope} = \frac{42 - 39}{\log_{10}\left(\frac{25}{34}\right)}$$

$$= -22.5$$

Result :

LL = 42 , PL = 35, SL = 32, PI = 7,
FI = 22.5 , TI = 31.

Disscussion: From experimental data of Liquid Limit, a water percentage vs number of blows graph known as flow curve is plotted. As water content decreases, soil become stiffer and require more blow to close of minimum length 12mm. Therefor the semi-log plot is a downward going straight line.

From graph, ~~number of blows~~ water content corresspording to 25 blows is 42 and therefore is the liquid limit of soil sample according to Cassagrande's method.

Plastic limit found 35 as 1/8" soil thread starts to crumble at 35% moisture content.

from LL = 42 and PL = 35 Plasticity index found 42−35 = 6

As Liquid limit is less than 50, the soil sample is low plastic soil. From plastic chart, putting the value of LL in eqn of 'A' line, $PI = 0.73(LL - 20) = 16.06$ But, PI for experimental sample found 6 implies that it is below a line. There-fore, soil is Low plastic silt.

Also, from graph the negetive slope of flow curve is 22.5 which is flow index. from flow index and plasticity index toughness index found 0.31 which is less than 1. This value implies that the soil is friable that means can easily be crushed at plastic limit.

As the plasticity index is very low, it implies the soil sample have very low plasticity and quickly shift from semisolid state to Liquid state. As the sample found to be silt, it is low plastic silt.

The shrimkage limit found to be 32 implies that at 32% water content the soil is fully saturated and have minimum volume. After that if the soil is dried only the ~~water~~ weight will be reduced by the volume will be filled by air. As the shrinkage limit is high the degree of shrinkage will be, $\frac{2.71}{15.00} \times 100\%$ or 18% is high also. High degree of shrinkage implies that the soil sample is very poor.

BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY

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GEOTECHNICAL ENGINEERING LABORATORY

Experiment No: 05

Name of the Experiment: Determination of relative density of soil sample.

Date of Performance: **24/03/2021** **Date of Submission:** **31/03/2021**	**Name: Moriom Akter** **Student No.: 1704015** **Level-3 Term-1** **Section: A** **Group: 1**

Name of Experiment: Determination of relative density using a vibrating table.

Objective: (1) Determine the relative density of field. soil sample.

(2) Also determine minimum and maximum index density at Lab.

Scope and Significance:

(1) In ~~s~~this experiment, ~~de~~ relative density cohesionless, free draining soils are determined using vibratory table.

(2) Relative density is required to assess the compactness of a ~~s~~ soil of given mass.

(3) Different engineering property like strength, compressibility, and permeability varies with different relative density.

Equipment: Vibrating Table, Mold Assembly consisting of standard mold, collar, surcharge base plate, surcharge weights, surcharge base plate handle, Balance, scoop, straightedge.

4] Data Table:

Height of Mold : 6 inch = 15.24 cm

Diameter of Mold : 6 inch = 15.24 cm.

Volume of Mold : 2780 cm^3

Date : 24/03/2021.

Performed by : A1 - Group 1.

Loosest State

No of Obs	Wt of mold+ soil (gm)	Wt of mold (gm)	Wt of soil (gm)	Density (gm/cc)	Avg. Density (gm/cc)
1	9910	5910	4000	1.43	
2	9900	5910	3990	1.43	1.43.
3	9920	5910	4010	1.44	

Densest State.

No of Obs	Wt of mold+ soil (gm)	Wt of mold (gm)	Wt of soil (gm)	Density (gm/cc)	Avg Density (gm/cc)
1	10530	5910	4620	1.66	1.66.

Sample calculation:

For loosest state, Obs 1,

weight of mold + soil (gm) = 9910

weight of mold (gm) = 5910

$\therefore$ Wt of soil = 9910 − 5910 = 4000 gm.

$\therefore$ Density = 4000 ÷ 2780 = 1.43 gm/cc.

similarly. density for other observations are found.

Finally. Avg density = $\frac{1.43+1.43+1.44}{3}$ = 1.43 gm/cc.

similarly density for densest state is calculated.

Now, minimum index density, $\rho_{d.min}$ = 1.43 gm/cc.

maximum index density, ρ_{dmax} = 1.66 gm/cc.

Specific gravity. $G_s = 2.65$ ρ_w = 1 gm/cc.

$\therefore$ minimum index void ratio,

$$e_{min} = \frac{\rho_w G_s}{\rho_{d max}} - 1$$

$$= \frac{1 \times 2.65}{1.66} - 1 = 0.596$$

and, maximum index void ratio,

$$e_{max} = \frac{\rho_w G_s}{\rho_{dmin}} - 1 = \frac{1 \times 2.65}{1.43} - 1 = 0.853$$

∴ Relative density,

$$D_d = \frac{e_{max} - e}{e_{max} - e_{min}}.$$

where, e = void ratio of natural state of soil.

$$e = \frac{\rho_s}{\rho_d} - 1$$

ρ_d = density of soil at field condition = 1.53 gm/cc.

$$\therefore e = \frac{\rho_w G_s}{\rho_d} - 1 = \frac{1 \times 2.65}{1.53} - 1 = 0.732$$

$$\therefore D_d = \frac{0.853 - 0.732}{0.853 - 0.596} \times 100\%$$

$$= 47\%$$

Result: Relative density D_d = 47%.

P.T.O

Dissussion:

From experimental data, minimum index void ratio found in Laboratory is 0.596. That implies amount of void volume is 59.6% of solid volume. As laboratory follows some standard weight and vibratory method to reduce void. this minimum value of void ratiot may vary from procedure to procedure. Infact in field condition it may be less than that found in laboratory and as a result relative density may become more than 100%

Maximum void ratio found in laboratory is 0.853 that implies 85.3% of ~~ve~~ solid volume is eaual to void volume. To find this sand was poured as loosely as posible. So, technically in field void ratio can't be more than this. So, maximum field roid ratio will be eaual to that at laboratory and thus relative density can be minimum 0%.

Relative dencity found for field soil is 47%. As it's with in 35-65% range. it is a medium dense soil sample. That's why it can be densed further implies that it's compressibility is moderate. Also, it has been moderately compacted.

BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY

CE 342

GEOTECHNICAL ENGINEERING LABORATORY

Experiment No: 06

Name of the Experiment: Soil Compaction Test.

Date of Performance:	**Name: Moriom Akter**
02/06/2021	**Student No.: 1704015**
Date of Submission:	**Level-3 Term-1**
09/06/2021	**Section: A**
	Group: 1

Name of the experiment: Soil compaction Test.

Objective:

(1) Plot a dry density vs water content or moisture content graph in plain graph paper.

(2) Determine the optimum moisture content from graph.

(3) Plot a zero air void curve in the same graph.

Scope and Significance:

(1) The test will be carried out in standard proctor test method.

(2) From this experiment the optimum moisture content to be maintained in field can be determined for a specified compactive effort.

(3) compaction is required to maintain stability of the soil for structure to be made on that.

(4) To meet the design specification, the field soil needs to be compacted to a desired degree.

四 Equipment :

(1) Molds

(2) Manual hammer.

(3) Extruder

(4) Balance

(5) Drying oven.

(6) Mixing pan

(7) ~~two~~ trowel

(8) Moisture cans.

(9) Graduated ~~s~~ cylinder.

(10) straight edge.

四 Data Table.

Volume of mold $= \pi \times \left(\frac{10.16}{2}\right)^2 \times 11.64$ cc

$= 943.7$ cc.

P.T.O.

Group	1		2		3		4		5		6	
Wt of can (gm)	8·2	8·6	8·4	8·7	9·1	7·7	9·3	9·5	7·4	7·9	8·3	8·1
Wt of can + wet soil (gm)	43·8	43·5	43·7	44	44·2	43·5	41·5	42·7	45·7	44·1	44·2	43·6
Wt of can + dry soil (gm)	40·7	40·6	40	40·1	39·6	38·8	36·5	37·4	38·9	37·9	37·1	36·8
Moisture content	9·54	9·06	11·71	12·42	15·08	15·11	18·38	18·99	21·59	20·67	24·65	23·70
Avg. moisture content	9·30		12·07		15·10		18·69		21·13		24·18	
Wt of mold (gm)	4160		4160		4160		4160		4160		4160	
Wt of mold + compacted soil (gm)	5840		5970		6050		5900		5770		5700	
Wt of compacted soil (gm)	1680		1810		1890		1740		1610		1540	
Wet density (gm/cc)	1·78		1·92		2·00		1·84		1·71		1·63.	
Dry density (gm/cc)	1·63		1·71		1·74		1·55		1·41		1·31	
Specific gravity	2·7		2·7		2·7		2·7		2·7		2·7.	
Dry density at zero air void (gm/cc)	2·16		2·04		1·92		1·79		1·72		1·63	
Std Max dry density gm/cc	1·75		1·75		1·75		1·75		1·75		1·75	
field dry density (gm/cc)	1·68		1·68		1·68		1·68		1·68		1·68	
percent compaction	96 [illegible]		96 [illegible]		96 [illegible]		96 [illegible]		96 [illegible]		96 [illegible]	

Sample calculation:

$$\text{moisture content} = \frac{44.2-39.6}{39.6-9.1} \times 100\%$$

$$= 15.08\%$$

similarly other mc is calculated.

$$\text{Wet densidity (gm/cc)} = \frac{\text{wet mass}}{\text{volume of moldused}}$$

$$= \frac{1890}{943.7} = 2.00 \text{ gm/cc}$$

$$\text{Dry density}. \rho_d = \frac{\rho}{1+W}$$

$$= \frac{2.00}{1+0.151} = 1.74 \text{ gm/cc}.$$

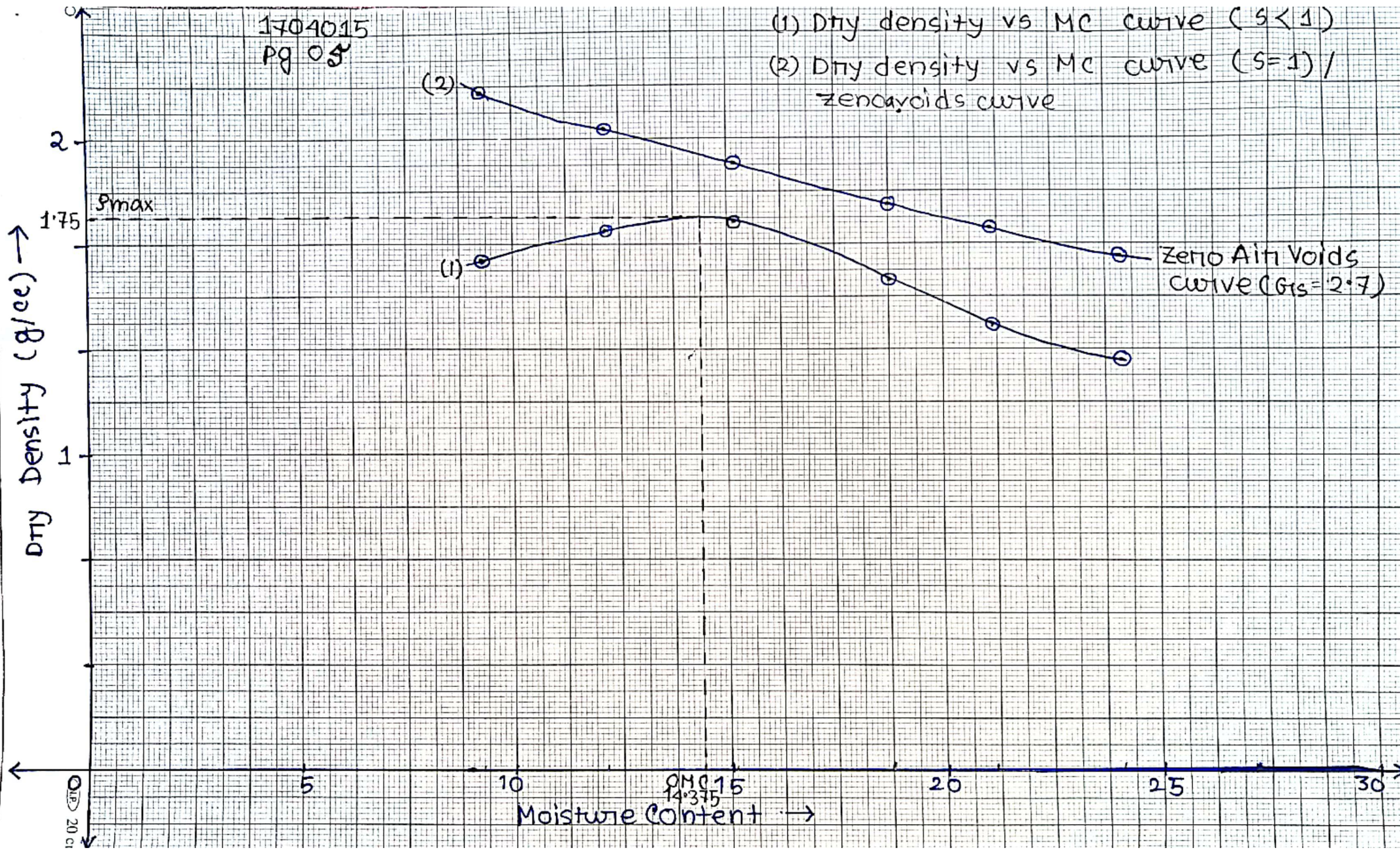
$$\text{Dry density at zero air void}. \rho_{d(zav)} = \frac{\rho_w}{\left(\frac{W}{100} + \frac{1}{G_s}\right)}$$

$$= \frac{1}{\left(\frac{15.1}{100} + \frac{1}{2.7}\right)}$$

$$= 1.92 \text{ gm/cc}.$$

$$\text{percent compation} = \frac{1.68}{1.74} \times 100\%$$

$$= 96.55\%.$$



1704015
Pg 05
(1) Dry density vs MC curve (S<1)
(2) Dry density vs MC curve (S=1) / zeroairvoids curve
(2)
(1)
ρmax
1·75
2
1
Zero Air Voids curve (Gs = 2·7)
Dry Density (g/cc) →
Moisture Content →
0
5
10
OMC 14·375
15
20
25
30

Result :

Optimum moisture content = 14·375 %

at that MC ρ_{max} = 1·75 gm/cc.

Degree of compation at field = 96 %

Discussion:

From experiental data optimum moisture content is 14·375. Implies that went water content to dry soil ratio is 14·375 the dry density of the soil is maximum and found 1.75 gm/cc. The value for ρ_{dry} can't be greater than this.

The graph for dry density vs mc data for not 100% saturated soil is a upward convex curve and the peak gave OMC and ρ_{max} respectively.

The left side of this ~~cry~~ curve is dry side of OMC and here addition of water content acts as lubricant's and thus help soil particle to be more compact. After sertain water content the sample reaches OMC.

When water content is added below omc the ρ_{dry} ~~drer~~ decreases. As ρ_{dry} can't be greater than $\rho_{dry(max)}$ ~~to~~ the addtional water takes the spaces of soil and thus increasing void content decrease the dry density.

From graphical representation ~~t~~ on left of OMC ρ_{dry} is 1.63 gm/cc at 9.30% w.c. but beyond OMC it even dereases to 1.31 at 24.18% w.c.

The typical values of maximum dry density are around 1.6 to 2.0 gm/cc and value found from experiment 1.75 is within this range. Also, typical water content for ρ_{max} is 10-20% whereas from experiment ~~is~~ found 14.375 also ~~get~~ satisfies the range.

The zero air voids curve lies above the first graph as Dry density is maximum in zero air void ~~e~~ curve. ~~a~~ Therefore, it can be concluded say the carried out experiment is satisfactory.

P.T.O.

But the ~~max~~ fields dry density found 1·68 gm/cc which is 96% of laboratory's ρ_{max}. Usually, laboratory's ρ_{max} is not achieveable in field but 5% deviation is allowed. Therefore, the field compaction is satisfactory if requirement allows 5% deviation.

This test was conducted for constant energy. If energy was increased the whole graph would shift left-up and if decreased than the movement would be right-down. But this is beyond the scope of this experiment

BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY

CE 342

GEOTECHNICAL ENGINEERING LABORATORY

Experiment No: 06

Name of the Experiment: Falling Head Permeability Test.

Date of Performance:	**Name: Moriom Akter**
31/03/2021	**Student No.: 1704015**
Date of Submission:	**Level-3 Term-1**
07/04/2021	**Section: A**
	Group: 1

Name of experiment: Falling head permeability test.

Objective:

(1) Determine hydraulic conductivity or coefficient of permeability for soil sample at experiment temperature.

(2) Report coefficient of permeability (k) at 20° c. Temperature.

(3) Plot K vs $\frac{e^3}{1+e}$, K vs $\frac{e^2}{1+e}$ and K vs e^2 in normal scale in the same graph paper, where, e = void ~~rat~~ ratio.

(4) Plot e vs log k in semilog graph paper.

Scope and Significance:

(1) Falling head permeability test is conducted for fine grained soil usually. But for demonstation purpose coarse grained soil is used in this experiment.

(2) To estimate seepage ~~water~~ ~~flow~~ under dam, retaining wall etc 'K' is required.

(3) To approximate ground water flow 'k' is also required.

(4) Rate of consolidation depends on permeability of soil.

(5) To calculate uplift pressure and piping coefficient of permeability is necessary.

Equipment and Apperatus:

(1) Dry and clean sand

(2) Wash bottle

(3) Measuring cylinder

(4) Spoon

(5) Filter papers

(6) A permeameter

(7) stop watch.

P.T.O

Data Table:

Permeability test.

Group: 1.

Specific Gravity, G_s : 2.7.

h_0 = 100 h_1 = 50

Weight of Dry Soil used, W_s in g = 455.

Permeameter:

Diameter, D = 6.35 cm Area, A = 31.67 cm^2

standpipe:

Diameter, d = 0.8 cm Area, a = 0.503 cm^2

No	Sample Length L (cm)	Temp. T (°C)	Elapsed time in sec for Flow from		Permeability at T° C k in cm/sec	Permeability at 20°C, k_{20} μ/s	Void Ratio e	e^2	$\frac{e^2}{1+e}$	$\frac{e^3}{1+e}$
			h_0 to $\sqrt{h_0h_1}$	h_0 to h_1						
1	9.0	25°	5.36	9.75	0.0185	164	0.863	0.745	0.4	0.345
2	9.0	25°	5.36	9.75	0.00924	82	0.863	0.745	0.400	0.345
3	9.0	25°	5.36	9.75	0.0113	100	0.863	0.745	0.400	0.345
4	9.4	25°	6.5	13.15	0.00787	70	0.788	0.621	0.347	0.274
5	9.4	25°	6.5	13.15	0.00796	71	0.788	0.621	0.347	0.274
6	9.4	25°	6.5	13.15	0.00778	69	0.788	0.621	0.347	0.274
7	10.5	25°	9.25	17.01	0.0068	60	0.512	0.262	0.173	0.089
8	10.5	25°	9.25	17.01	0.00625	55	0.512	0.262	0.173	0.089
9	10.5.	25°	9.25	17.01	0.00745	66	0.512	0.262	0.173	0.089

Sample calculation:

$h_0 = 100$ $h_1 = 50$ $a = 0.503\ cm^2$

$A = 31.67\ cm^2$

$\therefore \sqrt{h_1 h_0} = 70.71.$

time to reach h_0 to $\sqrt{h_1 h_0}$, t_1 =

for 1, 2, 3 $t_1 = 5.36\ s$; 4,5, 6 $t_1 = 6.5s$; 7,8,9 $t_1 = 9.25s$

time to reach $\sqrt{h_1 h_0}$ to h_1, t_2.

for 1, 2, 3. $t_2 = 9.75 - 5.36 = 4.39s.$

4, 5, 6 $t_2 = 13.15 - 6.5 = 6.65.s$

7, 8, 9. $t_2 = 17.01 - 9.25 = 7.76s$

time to reach h_0 to h_1, t

for 1, 2, 3 $t = 9.75s$; 4,5, 6 $t = 13.15s$; 7, 8, 9 $t = 17.01s$

$$\therefore k_1 = \frac{aL_1}{At} \ln\left(\frac{h_0}{h_1}\right) = \frac{0.503 \times 9}{31.67 \times 9.75} \ln\left(\frac{100}{50}\right) = 0.0185\ cm/s$$

$$k_2 = \frac{aL_1}{At_1} \ln\left(\frac{h_0}{\sqrt{h_0 h_1}}\right) = \frac{0.503 \times 9}{31.67 \times 5.36} \ln\left(\frac{100}{70.71}\right) = 0.00924\ cm/s$$

$$k_3 = \frac{aL_1}{At_2} \ln\left(\frac{\sqrt{h_0 h_1}}{h_1}\right) = \frac{0.503 \times 9}{31.67 \times 4.39} \ln\left(\frac{70.71}{50}\right) = 0.0113\ cm/s$$

$$k_4 = \frac{aL_2}{At} \ln\left(\frac{h_0}{h_1}\right) = \frac{0.503 \times 9.4}{31.67 \times 9.75} \ln\left(\frac{100}{50}\right) = 0.00787\ cm/s$$

$$k_5 = \frac{aL_2}{At_1} \ln\left(\frac{h_0}{\sqrt{h_1 h_0}}\right) = \frac{0.503 \times 9.4}{31.67 \times 6.5} \ln\left(\frac{100}{70.71}\right) = 0.00796\ cm/s$$

$$k_6 = \frac{aL_2}{At_2} \ln\left(\frac{\sqrt{h_0 h_1}}{h_1}\right) = \frac{0.503 \times 9.4}{31.67 \times 6.65} \ln\left(\frac{70.71}{50}\right) = 0.00778\ cm/s.$$

$$k_7 = \frac{aL_3}{At}\ln\left(\frac{h_0}{h_1}\right) = \frac{0.503\times10.5}{31.67\times17.01}\ln\left(\frac{100}{50}\right) = 0.00680\,cm/s$$

$$k_8 = \frac{aL_3}{At_1}\ln\left(\frac{h_0}{\sqrt{h_1h_0}}\right) = \frac{0.503\times10.5}{31.67\times9.25}\ln\left(\frac{100}{70.71}\right) = 0.00625\,cm/s$$

$$k_9 = \frac{aL_3}{At_2}\ln\left(\frac{\sqrt{h_0h_1}}{h_1}\right) = \frac{0.503\times10.5}{31.67\times7.76}\ln\left(\frac{70.71}{50}\right) = 0.00745\,cm/s.$$

Now,

$$K_{20} = K \times \frac{\mu_T}{\mu_{20}}$$

at $25°C$ $\mu_{25} = 8.95$ milipoise

at $20°C$ $\mu_{20} = 10.09$ milipoise.

$\therefore (K_{20})_1 = 0.0164\ cm/s = 164\,\mu/s.$

$(K_{20})_2 = 0.0082\ cm/s = 82\,\mu/s$

$(K_{20})_3 = 0.0100\ cm/s = 100\,\mu/s$

$(K_{20})_4 = 0.0070\ cm/s = 70\,\mu/s$

$(K_{20})_5 = 0.0071\ cm/s = 71\,\mu/s$

$(K_{20})_6 = 0.0069\ cm/s = 69\,\mu/s$

$(K_{20})_7 = 0.0060\ cm/s = 60\,\mu/s$

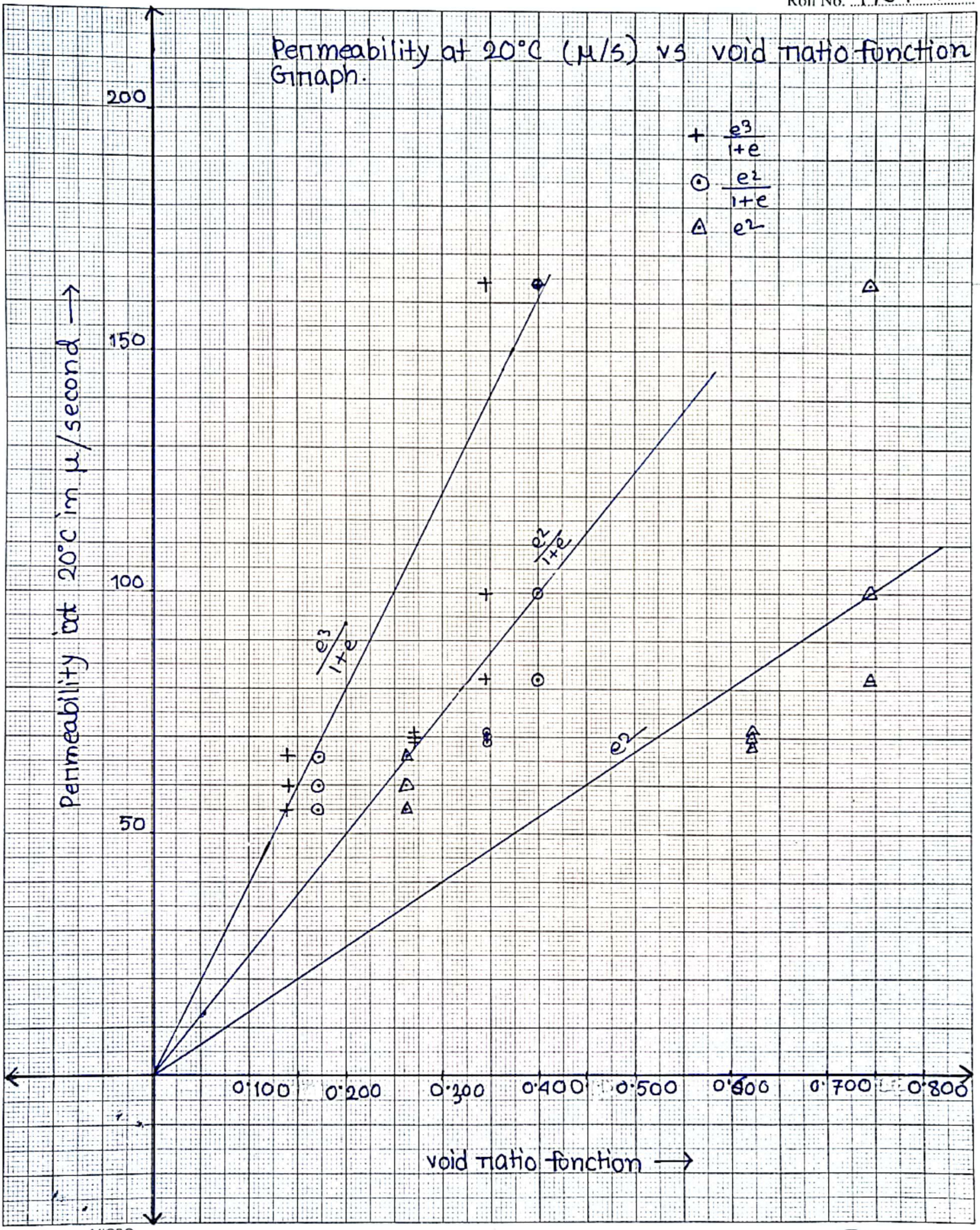
$(K_{20})_8 = 0.0055\ cm/s = 55\,\mu/s$

$(K_{20})_9 = 0.0066\ cm/s = 66\,\mu/s.$

Graph: (Attached)

•Graph 1

Roll No. 1704015



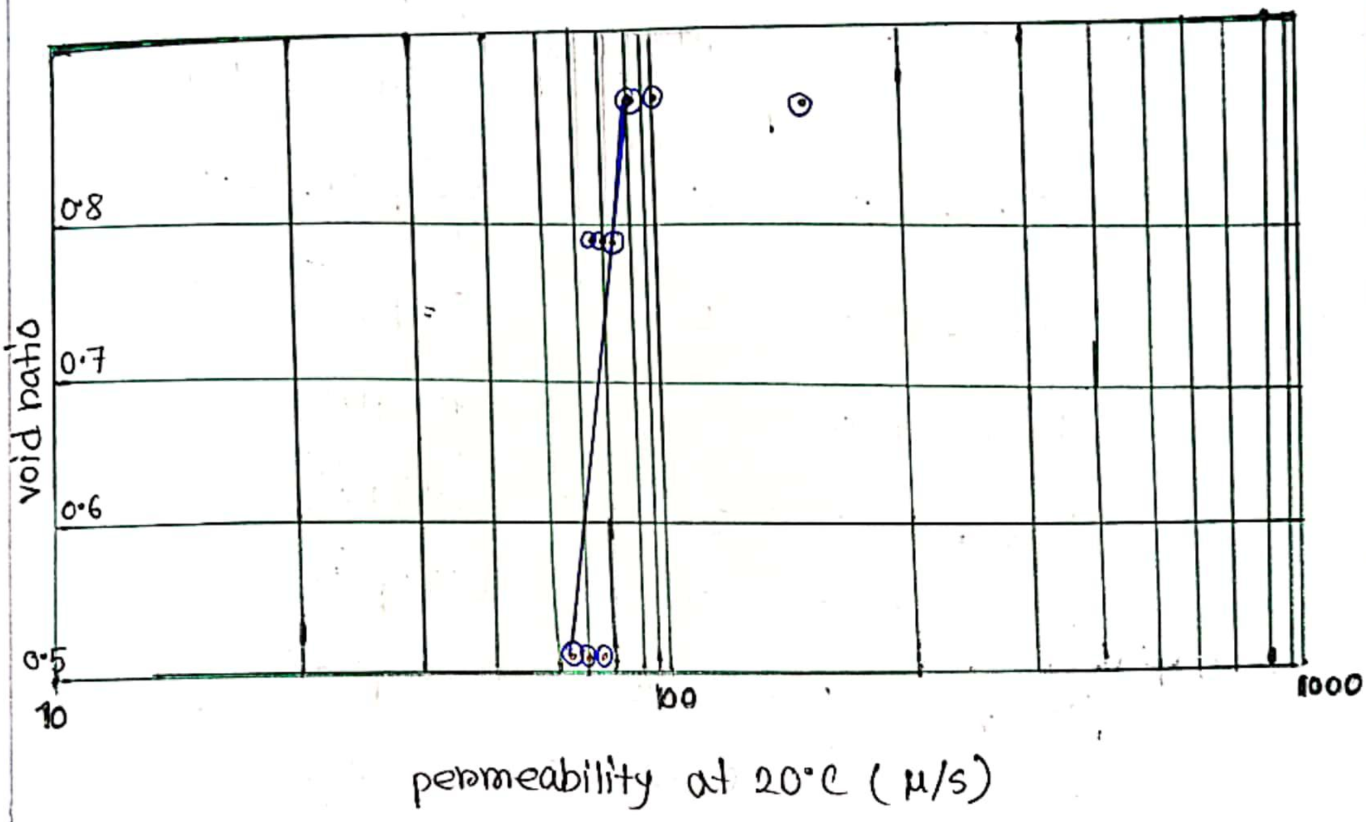
MICRO

20 cm x 25 cm

- Graph 2

[Due to unavailability of semilog graph papers during lock down void ratio vs permeability graph is drawn below in a hand drawn semilog scale]

Void ratio vs permeability at 20°C (μ/s) graph.



P.T.O.

Discussion:

From experiment coefficient of permeability obtained for different void ration. For fixed length of soil sample and same void ratio permeability. ~~diffe~~ coefficient difference is insignificant. For example, for $L = 9.4$ and $e = 0.788$ $K_{20} = 70, 71$ and 69 for 3 observation.

The values obtained from experiment used to plot K vs $\frac{e^3}{1+e}$, K vs $\frac{e^2}{1+e}$ and k vs e^2 graph in the same plain graph paper. Three graphs are straight line passing through origin implies that at zero void ratio permeability is zero. And value of permeability valies with void ratio. So, there is a dependency of permeability of void ratio in a proportional nature.

The second graph, coefficient of permeabity - void ratio or, e vs K graph is also a straight line. and. permeability is confined with in $10\,\mu/s$ - $1000\,\mu/s$ zone or 10^{-3} cm/s - 10^{-1} cm/s. Therefore, it can be said that soil sample has medium degree of permeability. Also, as all values of $k > 1 \mu/s$, the soil sample can be leveled as pervious soil and can be used for a dam-shell or pervious backfill.

BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY

CE 342

GEOTECHNICAL ENGINEERING LABORATORY

Experiment No: 09

Name of the Experiment: Direct shear Test.

Date of Performance:	Name: Moriom Akter
07/04/2021	Student No.: 1704015
Date of Submission:	Level-3 Term-1
03/06/2021	Section: A
	Group: 1

Name of Experiment: Direct Shear Test.

Objective:

(1) Plot a shear stress vs the horizontal displacement graph

(2) Plot maximum shear stress vs the vertical (normal) confining stresses for each of the tests is produced.

(3) Find the internal friction angle φ, from graph 2

Scope and significance:

1. This test is performed to determine the consolidated shear strength of a sandy to silty soil.

2. Shear strength is required whenever a structure is dependent ~~of~~ on the soil's shearing resistance.

3. The determine the stability of slopes or cuts, to find the bearing capacity of a foundation or to calculate pressure exerted by a soil on retained wall, shear strength is required.

Equipment:

Direct shear Device, Load and deformation dial gages. Balance.

CE 342 Experiment : Direct Shear Test

Data Sheet.

Diameter of sample : 2.5 inch

Height of the sample: 1 inch.

Shear and normal displacement factor = 0.001 in.

Load calibration equation : $y = 0.3014x + 0.2156$

Normal load = 10kg.

Initial Normal Dial reading before placing vertical load: 517.

Elapsed time (min)	Shear Displacement (div)	Shear Displacement (inch)	Normal Dial (div)	Normal displacem-ent (in)	Load reading (div)	Shear force (lbs)	Shear stress (psi)
0	0	0	518	0.001	0	0.2156	0.0439
0.25	10	0.01	520	0.003	64	19.5	3.97
0.5	26	0.026	521	0.004	85	25.8	5.25
0.75	45	0.045	522	0.005	96	29.2	5.95
1	63	0.063	522	0.005	101	30.7	6.25
1.25	80	0.080	524	0.007	100	30.4	6.19
1.50	98	0.098	525	0.008	98	29.8	6.070
1.75	118	0.118	526	0.009	95	28.8	5.87
2	135	0.135	527	0.010	94	28.5	5.80
2.25	155	0.155.	528	0.011.	92	27.9	5.68.

Sample calculation:

Area = $\pi r^2 = \pi(\frac{d}{2})^2 = \pi \times (\frac{2.5}{2})^2 = 4.91 in^2$

at 0.5 min,

Shear Dispacement (in) = 0.001 × Shear displacement (div).

$= 0.001 \times 26 = 0.026$ in.

Normal displacement (in) = 0.001 × Normal dial div,

$= 0.001 \times (521-57)$

$= 0.004$ in.

shear force (lbs) = 0.3014 × load reading + 0.2156.

$= 0.3014 \times 85 + 0.2156$

$= 25.8$ lbs.

$\therefore$ shear stress = $\frac{\text{shear force}}{\text{Area}}$

$= \frac{25.8}{4.91} = 5.25$ psi

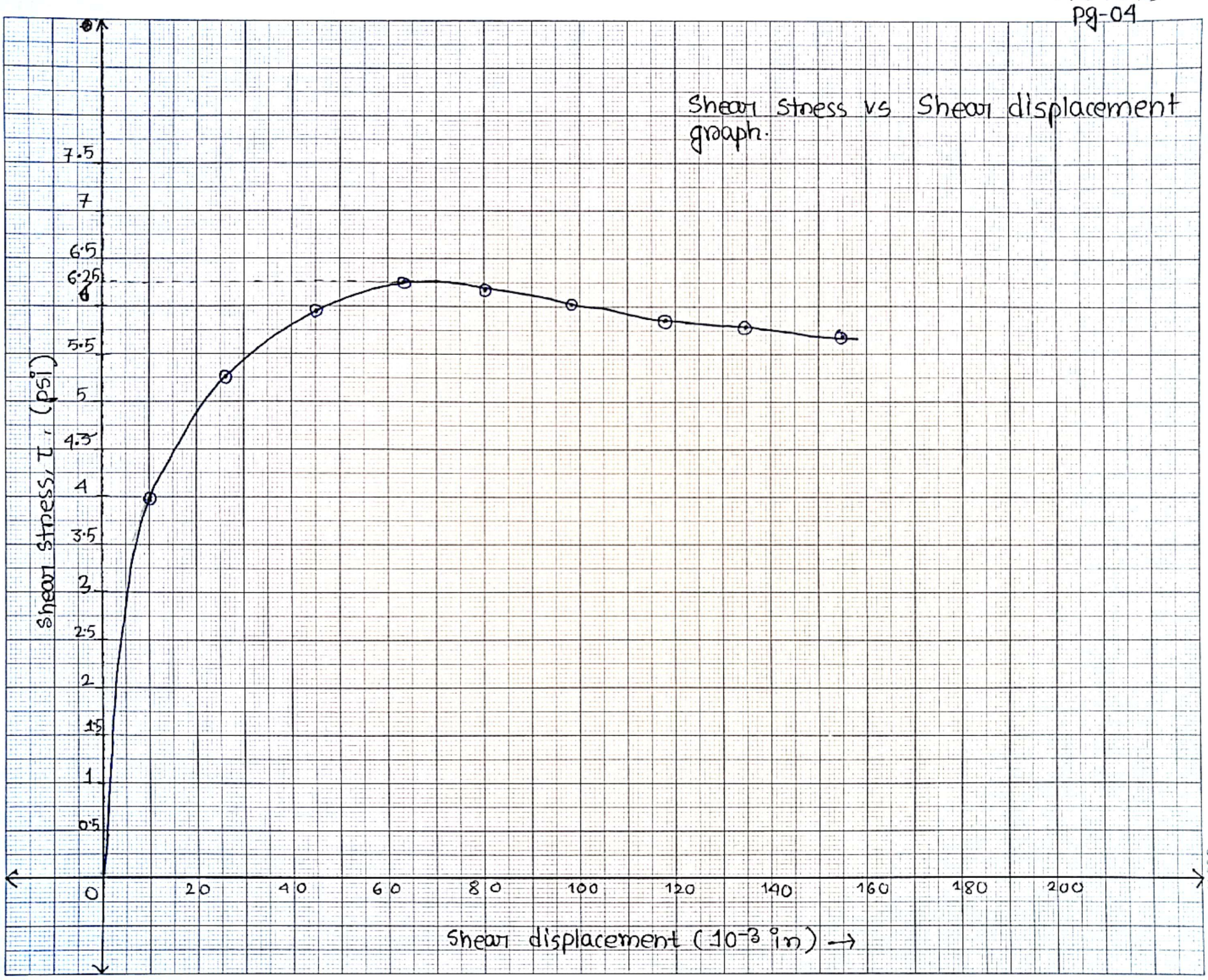
Similarly other calculations are done.

Graph:

for graph 2, data set,

τ (psi)	6.25	8.94	10.9
σ (psi)	4.49	13.5	8.98

1704015
Pg-04



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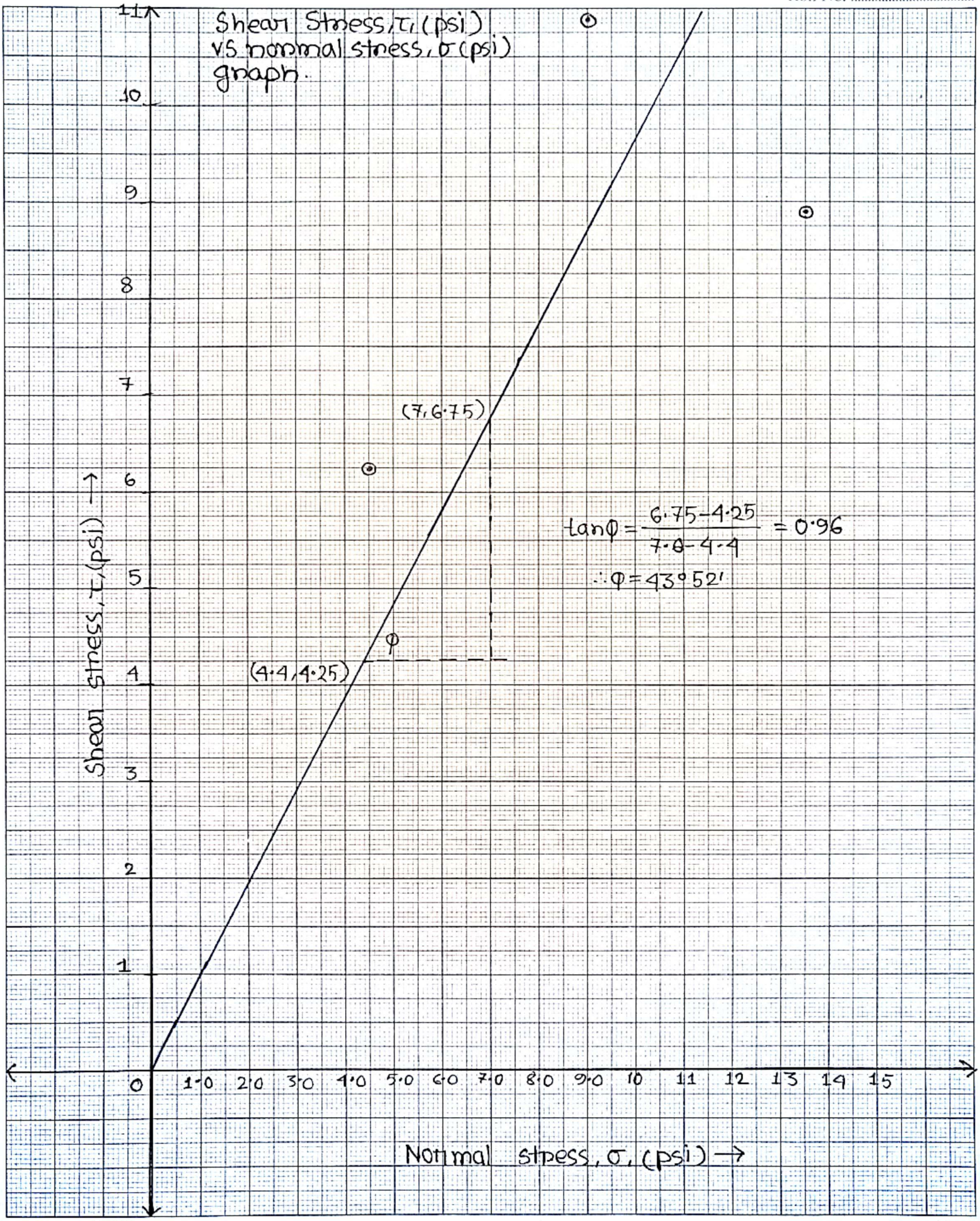


Discussion:

From experimental data two graphs are plotted in normal scale seperately.

Graph-1 Shear stress vs shear displacement shows that the value of shear stress increases initially with the increment of shear displacement ~~but~~ upto 6.25 psi at 7×10^{-3} in shear displacement and after that it decrease. That's why the curve is a upward convex curve. And the peak ~~repes~~ represents the peak strength of soil and the final stress of 5.68 psi represents the residual strength. The peak of the curve is neither so sharp nor so flat, so, its medium dense soil. As it is medium dense, void ratio will increase during experiment as void volume increases.

Graph-2 Shear stress vs normal stress graph is a best fitted straight line that passes through origin. As the soil sample was sand there is no cohesion and cut and y axis is zero. Thus, the angle of interlocking found, $\phi = 43°52'$ with is a moderate value indicates that the soil sample was moderately dense and soil particles are angular in nature. Therefore, It can be said that the sample has good enough shear strength and stability of structure will be secured.

BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY

CE 342

<u>GEOTECHNICAL ENGINEERING LABORATORY</u>

Experiment No: 07

Name of the Experiment: Unconfined Compressive Strength Test.

Date of Performance:	**Name: Moriom Akter**
28/07/2021	**Student No.: 1704015**
Date of Submission:	**Level-3 Term-1**
01/08/2021	**Section: A**
	Group: 1

Name of Experiment : Unconfined Compressive strength Test.

Objective:

(1) Determine the unconfined compressive strength of soil.

(2) Plot a unconfined compressive strength vs axial strain graph in plain graph paper.

Scope and significance:

(1) It is done for cohesive soil.

(2) For this test, fully saturated soil sample is required.

(3) In this test unconfined soil sample was used.

(4) To measure bearing capacity of soil is quite expensive, hence unconfined compressive strength test is done to assess the property of soil.

(5) It is a cheap and quick experiment. so, it's efficient.

Equipment:

unconfined compression machine, shelby tube, extruder, trimmer, split mold.

Data Sheet:

CE 342: Unconfined Compressive Strength
Test Data sheet.

Deformation constant = 0.001", Load Calibration eqn = 0.3154x+0.1458

Deformation Dial Reading	Load Dial Reading	sample deformation (in)	Strain (%)	Corrected Area (in^2)	Load (lb)	Stress (psi)
0	0	0	0	1.767	0.1458	0.08
20	4	0.02	0.67	1.779	1.407	0.79
40	9	0.04	1.33	1.791	2.984	1.67
60	12	0.06	2	1.803	3.931	2.18
80	19	0.08	2.67	1.815	6.138	3.38
100	21	0.1	3.33	1.828	6.769	3.70
120	24	0.12	4	1.841	7.715	4.19
140	26	0.14	4.67	1.854	8.346	4.50
160	29	0.16	5.33	1.866	9.292	4.98
180	33	0.18	6	1.880	10.554	5.61
200	36	0.2	6.67	1.893	11.50	6.08
220	45	0.22	7.33	1.907	14.339	7.52
240	54	0.24	8	1.9210	17.177	8.94

1704015

Pg-03

Deformation Dial Reading	Load Dial Reading	Sample Deformation (in)	Strain (%)	Corrected Area (in²)	Load (lb)	Stress (psi)
260	64	0·26	8·67	1·935	20·331	10·51
280	74	0·28	9·33	1·949	23·485	12·05
300	84	0·3	10	1·963	26·639	13·57
350	93	0·35	11·67	2·00	29·478	14·739
400	102	0·4	13·33	2·039	32·317	15·85
500	112	0·5	16·67	2·120	35·471	16·73
550	120	0·55	18·33	2·164	37·994	17·56
600	129	0·6	20	2·209	40·832	18·48
650	138	0·65	21·67	2·256	43·671	19·36
700	144	0·7	23·33	2·305	45·563	19·77
750	152	0·75	25	2·356	48·087	20·41
800	160	0·8	26·67	2·410	50·609	21·00
850	156	0·85	28·33	2·465	49·348	20·02
900	151	0·9	30	2·524	47·771	18·93
950	132	0·95.	31·67.	2·586	41·7786	16·16.

Sample calculation:

Initial Height of specimen = 3.0 in.

Initial Dia. of specimen = 1.5 in.

Initial Vol. of specimen = $\pi \times \frac{1.5^2}{4} \times 3$

$= 5.301 in^3$

Dry unit wt (lb/cft) = 103.87.

Initial area, $A_0 = \pi \frac{1.5^2}{4}$

$= 1.767 in^2$

at 0 dial reading of load,

Load = 0.3154 × 0 + 0.1458

= 0.1458 lb. $\therefore \sigma_c = \frac{0.1458}{1.767} = 0.08$ psi

for 2nd row,

Deformation Dial Reading = 20

∴ sample deformation, $\Delta L = 20 \times 0.001''$

$= 0.02''$

∴ Strain in % $\epsilon_1 = \frac{\Delta L}{L} \times 100 = \frac{0.02}{3} \times 100\% = 0.67$.

Corrected area, $A_c = \frac{A_0}{1 - \epsilon_1}$

$= \frac{1.767}{1 - 0.0067}$

$= 1.779 in^2$

Load Dial Reading = 20

$\therefore$ Load = $0.3154 \times 4.0 + 0.1458$

= 1.407 lb.

$\therefore$ compressive stress, $\sigma_c = \dfrac{6.454 \text{ lb}}{1.779 \text{ in}^2}$

= 3.628 psi

similarly calculation of other rows are done.

⊞ Graph: Attatched.

⊞ Result:

From Graph,

maximum compressive stress, σ_{max} = 21 psi = 145 kPa

strain at that stress, ϵ (%) = 26.67

failure compressive stress, σ_f = 16.16.

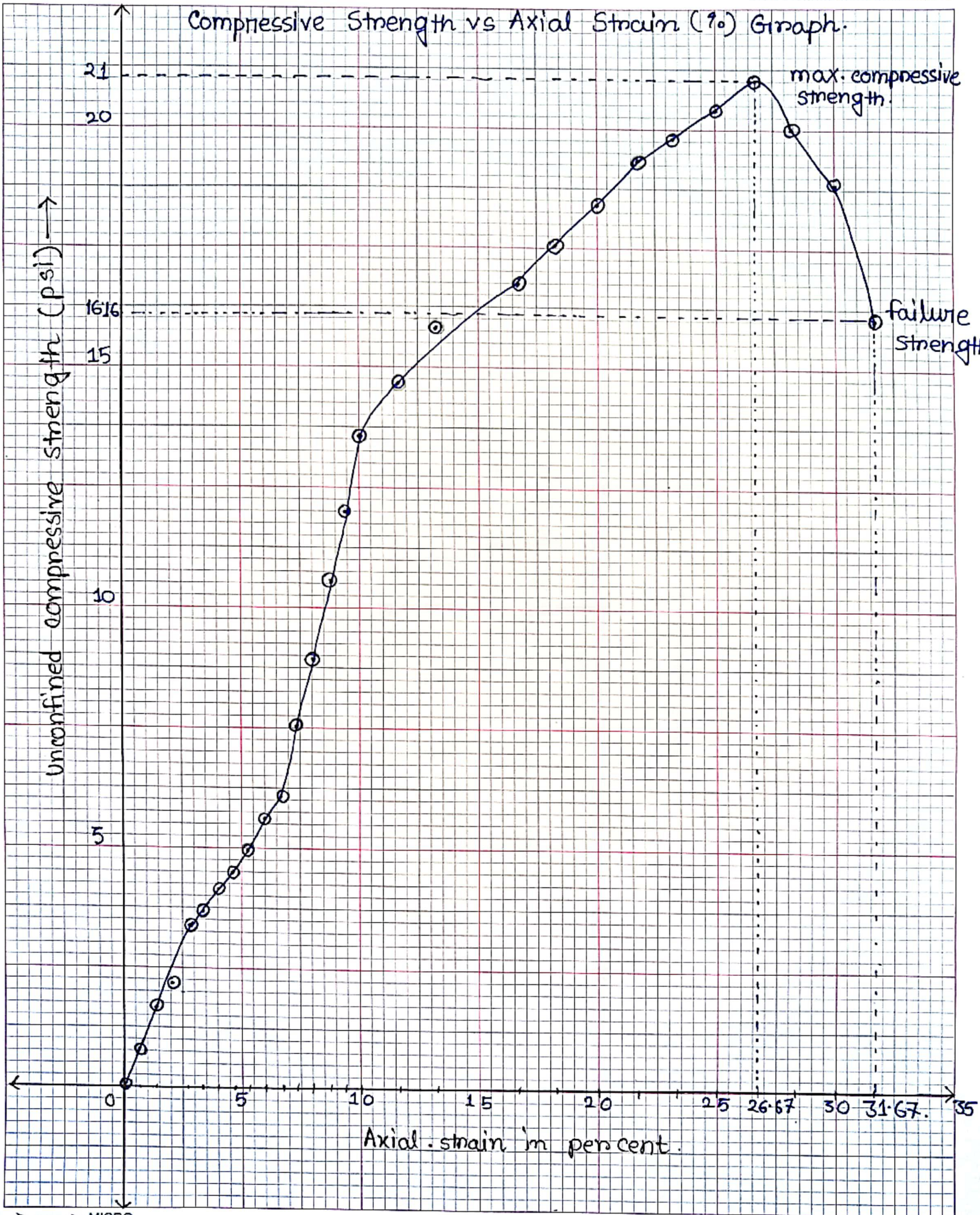
strain at that stress, ϵ (%) = 31.67.

failure type: Bulging failure.

⊞ Discussion:

From experimental data, a compressive strength vs strain (%) graph was plotted on plain graph paper. At first, the stress and strain increased linearly

Roll No. 1704015



for a while. Then, stress increased with increasing strain in a curvilinear path and kept increasing upto stress = 21 psi or 145 kPa with corresponding strain 0.2667.

After that it dreased in a faster rate and failed at 16.16 psi or 111kPa stress and corresponding strain 0.3167.

Therefore, maximum compressive strength of the soil is 145 kPa and 111 kPa is its residual strength. Usually, soil with 100 to 200 kPa compressive strength is stiff in nature. So, it can be said, the tested soil sample was siff in nature.

Relating maximum compressive strength with Mohr circle, the $\sigma_3 = 0$ as its unconfined and $\sigma_1 = 145$ kPa and thus, the shear strength will be $\sigma_1/2 = 77.5$ kPa. As, the soil is clay, the frictional angle is zero and thus, conesion of the soil will also be 77·5.

The failure parttern of the soil sample was buldge failure. It eoccured as the soil was not hard i.e. hadn't high stoength.

BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY

CE 342

GEOTECHNICAL ENGINEERING LABORATORY

Experiment No: 10

Name of the Experiment: Consolidation Test.

Date of Performance: **14/07/2021** **Date of Submission:** **30/07/2021**	**Name: Moriom Akter** **Student No.: 1704015** **Level-3 Term-1** **Section: A** **Group: 1**

☐ Name of Experiment: consolidation Test.

☐ Objective:

(1) Plot a dial reading vs log(t) graph for each load increments.

(2) Plot a Dial reading vs $\sqrt{t}$ graph for each load increments.

(3) Plot an e-log(P) curve showing preconsolidation pressure, Cc and Cr.

(4) Plot an e vs cv graph.

☐ Scope and significance:

(1) In this experiment two way draining were occured.

(2) During foundation design settlement of Soil is an important factor thus consolidation Test is required.

☐ Equipments:

consolidation testing machine, ring, Displacement Dial Gauge, Filter paper, porous stone, etc.

Consolidation Test.

Data sheet.

SURVEY 2000

SAMPLE TICKET

Project: Elevated Expressway / Road from Mithamain.
Sadar to Karimganj Upazilla.

Client: BBA.

Soil type: Brownish silty clay.

Bore hole No: 07.

sample type: UD-1.

Depth : 2.43 - 2.93 m.

Ring No = 4.

Wt of ring = 158.1 gm.

Wt of ring + Soil : 309.7 gm. (1)
308.3 gm (2)

∴ avg wt of ring + soil = 309 gm.

Tare = 13.5 lbs.

Datasheet

Consolidation Test

Date	Time	Load(kPa)	Elapsed Time	Dail reading
17/5	9:45	0		406
		5		435
18/5	9:02			427
		12.5	0	460
			0.1	468
			0.25	471
			0.5	474
			1	481
			2	485
			4	486
			8	490
			15	491
			30	492
	10:14		60	494
	11:14		120	498
	1:14		240	501
	5:14		480	503
19/5	8:59			507
		25	0	540
			0.1	550
			0.25	555
			0.5	561
			1	568
			2	571
			4	577
			8	580
			15	582
			30	585
	10:05		60	587
	11:05		120	589
	1:05		240	590
	5:05		480	592
20/5	8:58			600
		50	0	640

			0.1	656
			0.25	663
			0.5	669
			1	675
			2	679
			4	682
			8	684
			15	686
			30	690
	10:05		60	693
	11:05		120	695
	1:05		240	699
	5:16		480	703
21/5	9:23			707
22/5	8:55			711
		100	0	762
			0.1	782
			0.25	791
			0.5	798
			1	804
			2	810
			4	813
			8	817
			15	819
			30	825
	10:03		60	827
	11:03		120	831
	1:03		240	835
	5:03		480	840
23/5	9:00			847
23/5		200	0	918
			0.1	943
			0.25	955
			0.5	963
			1	970
			2	976
			4	980
			8	984
			15	987
			30	992
	10:13		60	996

	11:13		120	1000
	1:13		240	1005
	5:13		480	1010
24/5	9:02			1016
		400	0	1130
			0.1	1162
			0.25	1178
			0.5	1187
			1	1193
			2	1200
			4	1206
			8	1211
			15	1216
			30	1221
	10:11		60	1228
	11:11		120	1234
	1:11		240	1240
	5:11		480	1246
25/5	8:57			1254
25/5		800	0	1420
			0.1	1454
			0.25	1472
			0.5	1488
			1	1495
			2	1504
			4	1511
			8	1520
			15	1527
			30	1536
	10:07		60	1545
	11:07		120	1551
	1:07		240	1560
	5:07		480	1570
26/5	9:08			1585
	9:16	400	0	1547
	10:16		1h	1538
	1:16		4h	1534
27/5	9:00			1532
	9:07	200	0	1487

	10:07		1h		1472
	1:07		4h		1469
28/5	9:01				1461
29/5	9:02				1460
	9:08	50		0	1365
	10:08		1h		1316
	1:08		4h		1309
30/5	8:57				1300
	9:02	10		0	1220
	10:02		1h		1100
	1:02		4h		1123
31/5	9:04				1109

#Table for e log p curve

Pressure(kPa)	Final Dial reading	Dial change(inch)	Sample height 2H (inch)	void height (2H-2Ho)(inch)	Void Ratio,e
0	406	0	1	0.2326	0.303101381
5	427	0.0021	0.9979	0.2305	0.300364868
12.5	507	0.008	0.9899	0.2225	0.289940057
25	600	0.0093	0.9806	0.2132	0.277821214
50	711	0.0111	0.9695	0.2021	0.263356789
100	847	0.0136	0.9559	0.1885	0.24563461
200	1016	0.0169	0.939	0.1716	0.223612197
400	1254	0.0238	0.9152	0.1478	0.192598384
800	1585	0.0331	0.8821	0.1147	0.149465728
400	1532	-0.0053	0.8874	0.12	0.156372166
200	1461	-0.0071	0.8945	0.1271	0.165624186
50	1300	-0.0161	0.9106	0.1432	0.186604118
10	1109	-0.0191	0.9297	0.1623	0.211493354

2Ho cm	1.949320243
Wt of dry soil g	166.6
Area of the ring in^2	4.91
Area of the ring cm^2	31.67
2Ho in	0.7674

#Table for determination of specific gravity

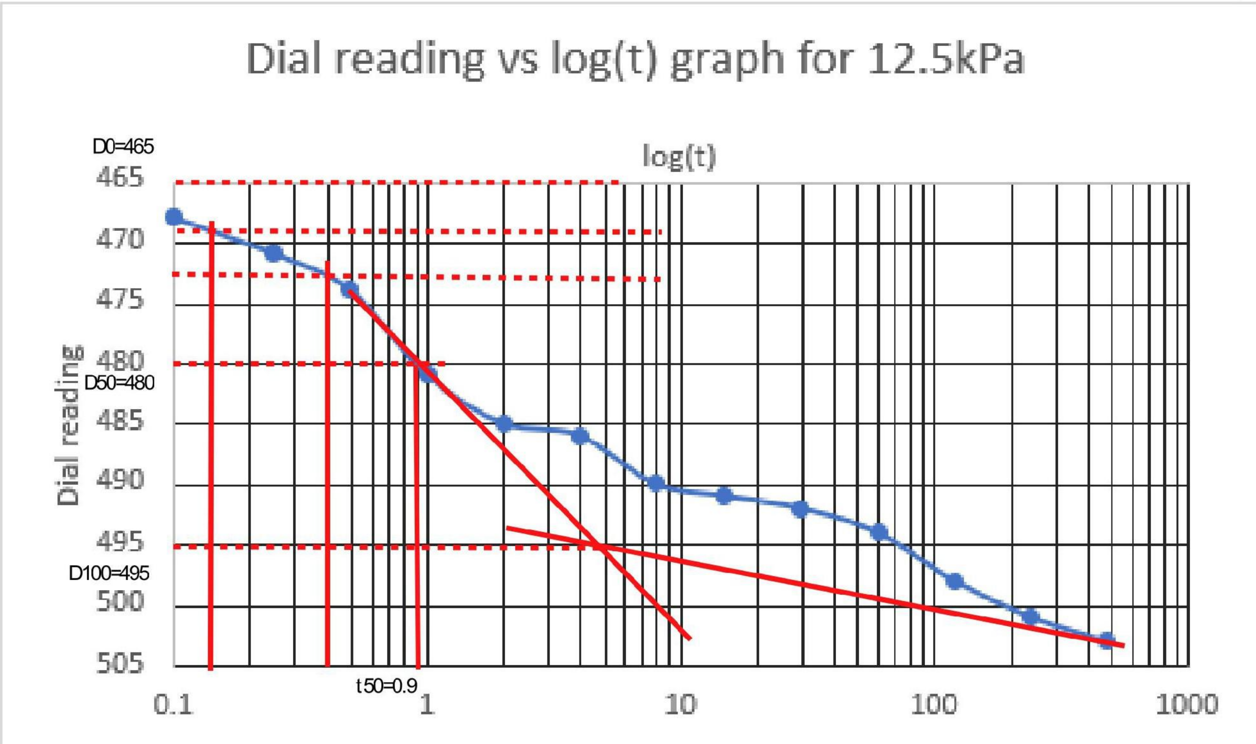
Bottle No.	11
Wt. of bottle + Water+ soil W1 in g	373.5
Temperature T in C	32
Wt. of bottle + Water W2 in g	342.1
Evaporating dish, No	25
Wt. of dish g	283.4
Wt. of dish + dry soil g	333
Wt. of bottle + Dry soil in g	
Wt. of bottle in g	93.6
Wt. of Soil (dry) Ws (g)	49.6
Specific Gravity of water Gt at T C	0.9951
Specific Gravity of Soil Gs	2.711920879

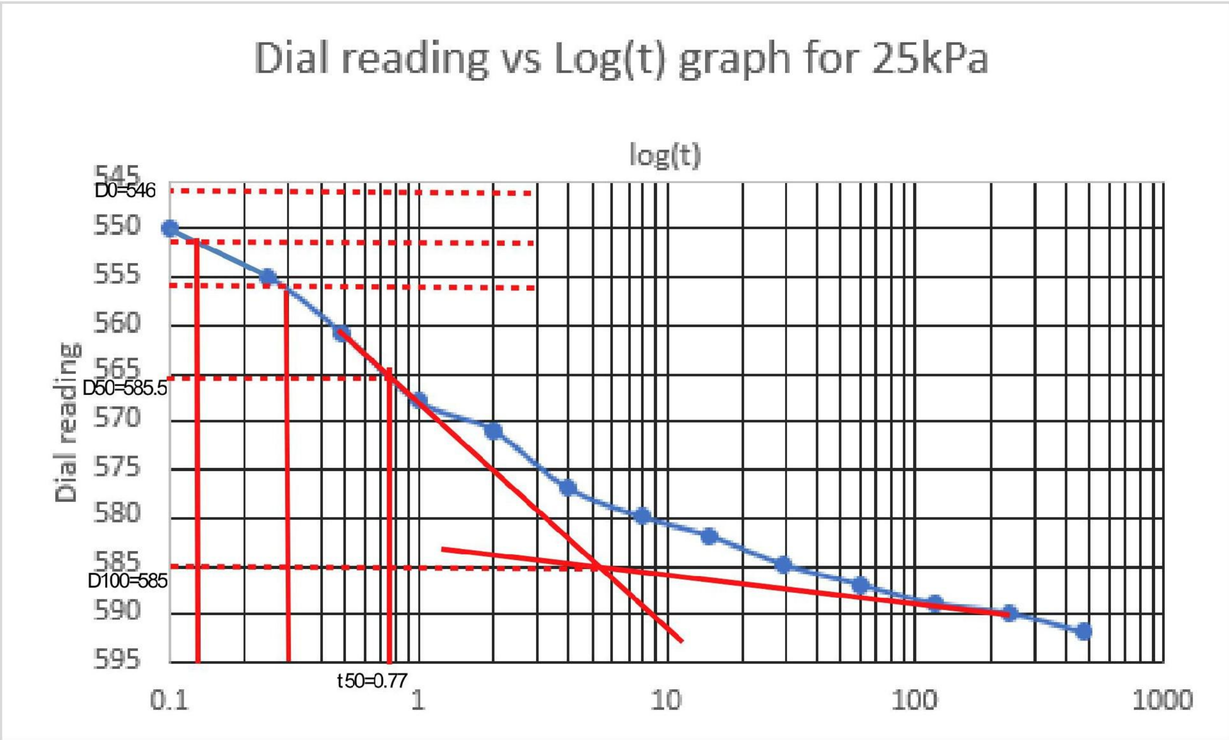
#Table for Cv vs Avg pressure graph

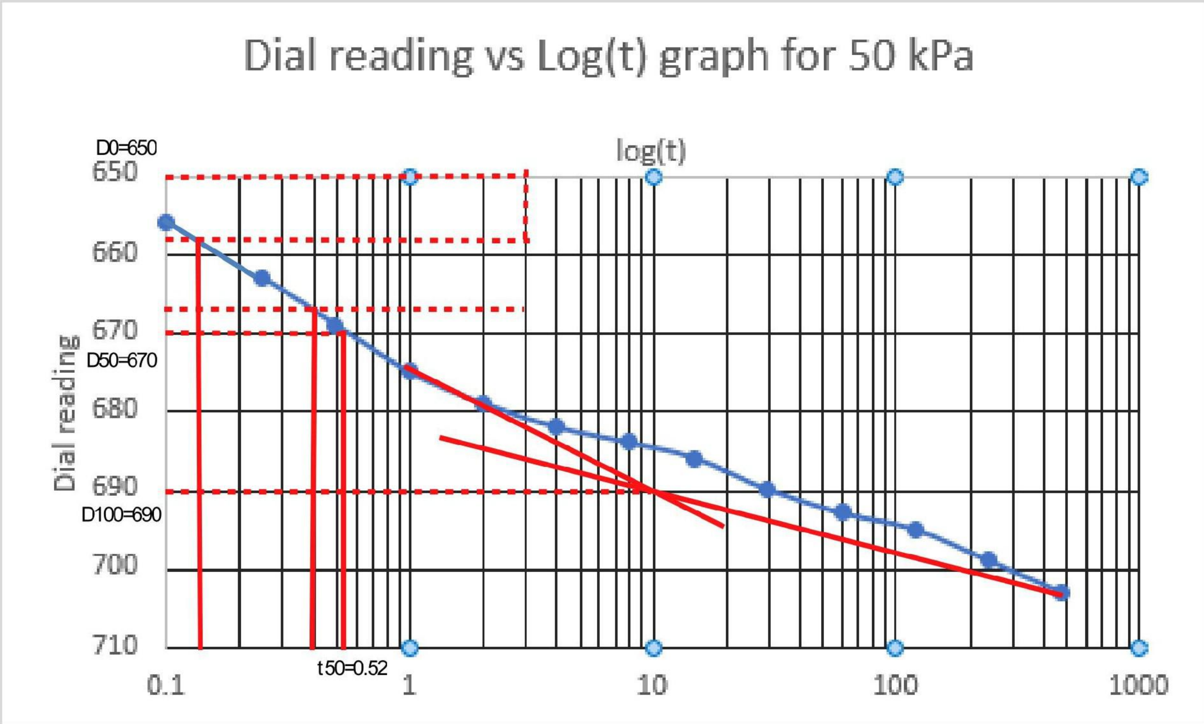
H=(H1+H2)/2 (inch)	H (mm)	t90(min)	t50 (min)	Cv from t90(m2/yr)	Cv from t50 (m2/year)
0.99895	25.453246				
0.9939	25.324572	7.29	0.9	39.21099916	73.78418793
0.98525	25.10417	1.69	0.77	166.2096514	84.74666019
0.97505	24.844274	1	0.52	275.1083863	122.9053703
0.9627	24.529596	1	0.35	268.1834663	178.0058722
0.94745	24.141026	1	0.25	259.7542466	241.3754084
0.9271	23.622508	0.81	0.22	307.0564322	262.6339777
0.89865	22.897602	0.64	0.2	365.1331295	271.4385906

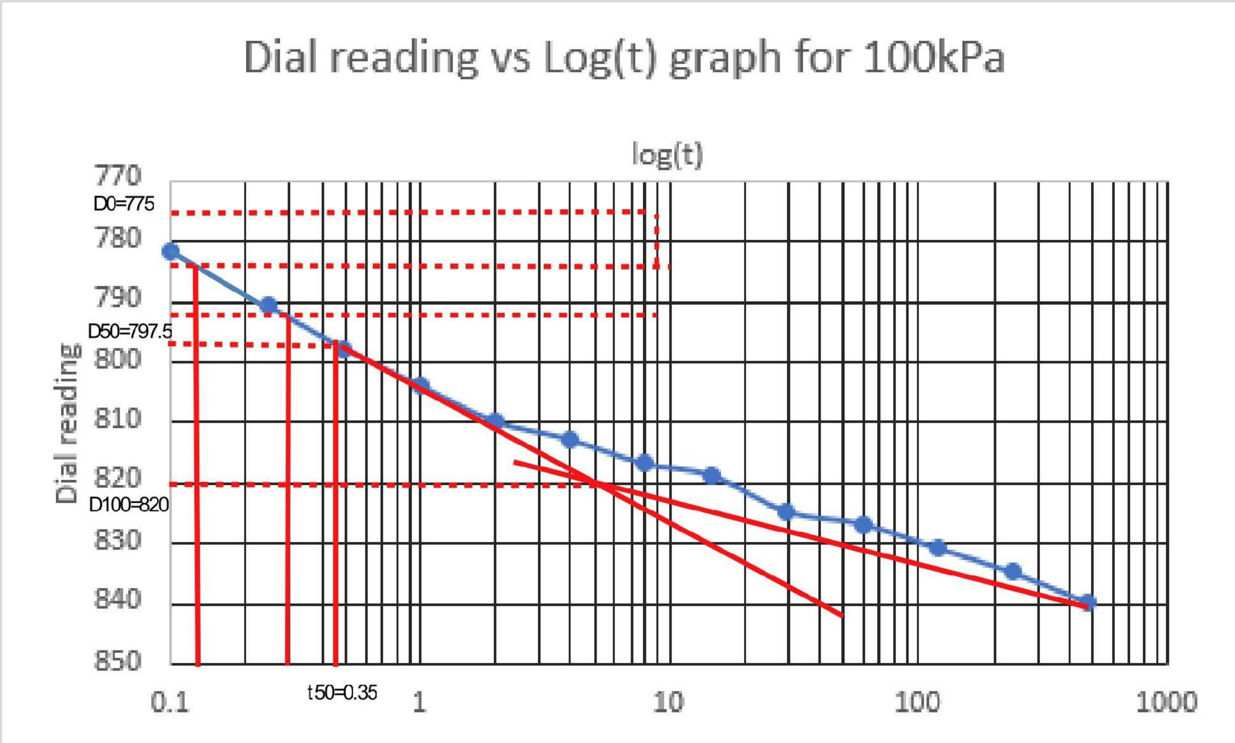
#Table for kv vs Cv and e vs Cv graphs

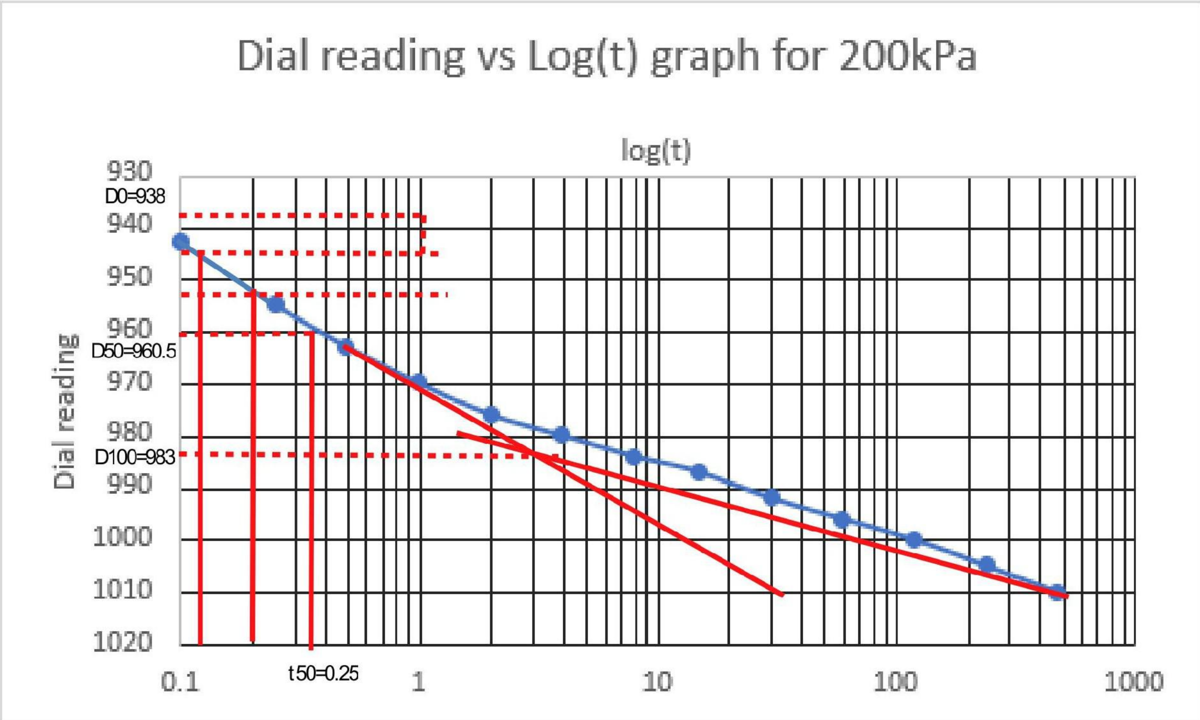
Pressure (kPa)	Av. Pressure (kPa)	Void Ration e	av(m2/kn)	mv(m2/kN)	cv(m2/year(from t50)	γw(kN/m3)	kv 10^-7(cm/sec)
0		0.303101381				9.761931	
5	2.5	0.300364868	0.000547303	0.00042		9.761931	
12.5	8.75	0.289940057	0.001389975	0.001068911	73.78418793	9.761931	0.769911375
25	18.75	0.277821214	0.000969507	0.000751591	84.74666019	9.761931	0.621784565
50	37.5	0.263356789	0.000578577	0.000452784	122.9053703	9.761931	0.543247423
100	75	0.24563461	0.000354444	0.000280557	178.0058722	9.761931	0.487518559
200	150	0.223612197	0.000220224	0.000176797	241.3754084	9.761931	0.416584396
400	300	0.192598384	0.000155069	0.000126731	262.6339777	9.761931	0.324913693
800	600	0.149465728	0.000107832	9.04174E-05	271.4385906	9.761931	0.23958483

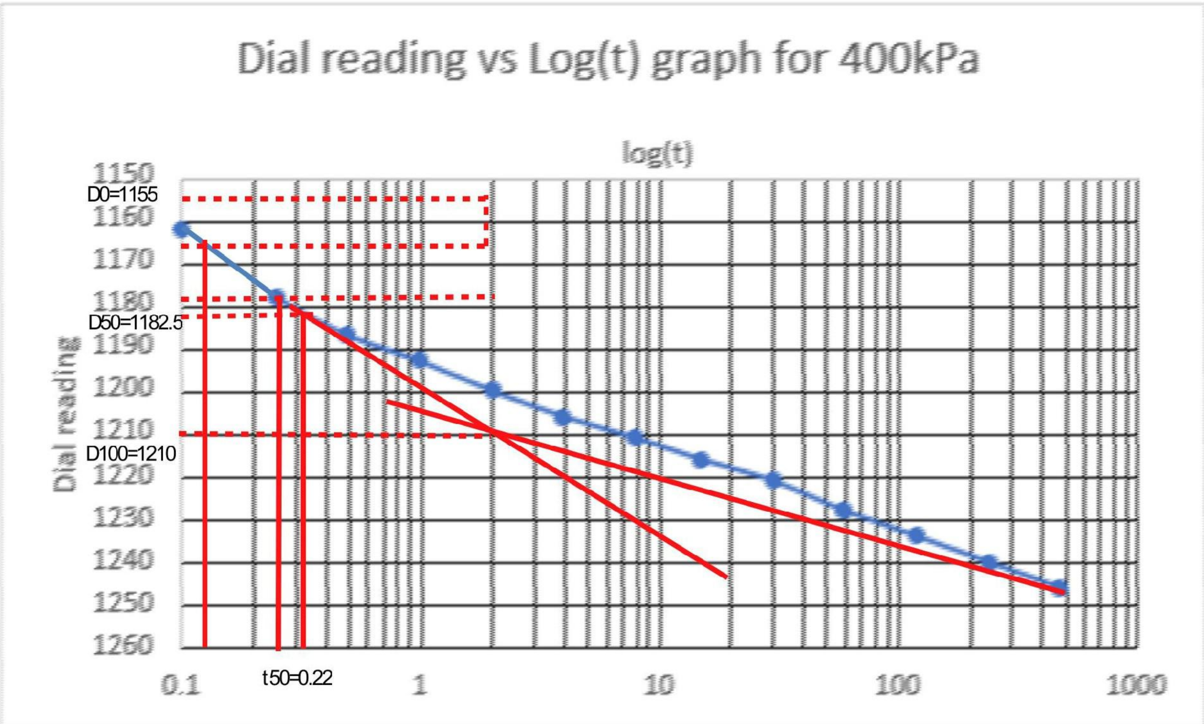

Dial reading vs log(t) graph for 12.5kPa
log(t)
Dial reading
D0=465
D50=480
D100=495
t50=0.9
465
470
475
480
485
490
495
500
505
0.1
1
10
100
1000

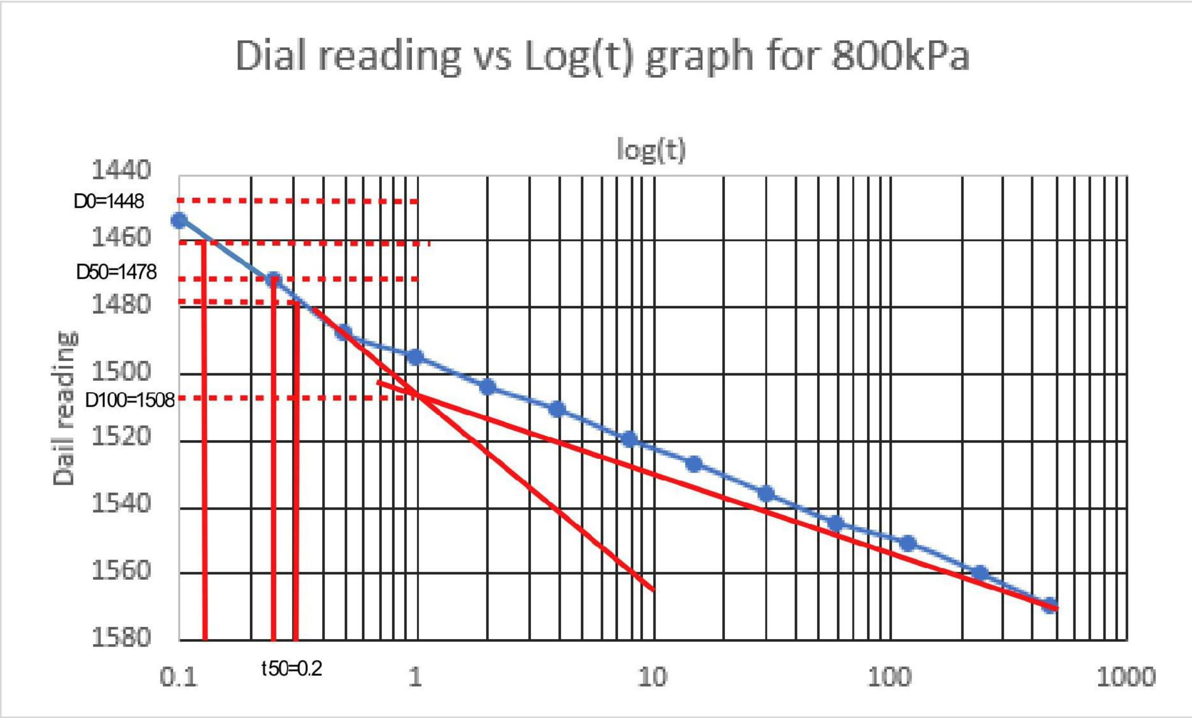

Dial reading vs Log(t) graph for 25kPa
log(t)
Dial reading
545
550
555
560
565
570
575
580
585
590
595
D0=546
D50=585.5
D100=585
t50=0.77
0.1
1
10
100
1000


Dial reading vs Log(t) graph for 50 kPa
log(t)
Dial reading
D0=650
D50=670
D100=690
t50=0.52
650
660
670
680
690
700
710
0.1
1
10
100
1000


Dial reading vs Log(t) graph for 100kPa
log(t)
Dial reading
770
780
790
800
810
820
830
840
850
D0=775
D50=797.5
D100=820
t50=0.35
0.1
1
10
100
1000


Dial reading vs Log(t) graph for 200kPa
log(t)
Dial reading
930
D0=938
940
950
960
D50=960.5
970
980
D100=983
990
1000
1010
1020
0.1
t50=0.25
1
10
100
1000


Dial reading vs Log(t) graph for 400kPa
log(t)
Dial reading
D0=1155
D50=1182.5
D100=1210
t50=0.22
1150
1160
1170
1180
1190
1200
1210
1220
1230
1240
1250
1260
0.1
1
10
100
1000


Dial reading vs Log(t) graph for 800kPa
log(t)
Dail reading
1440
1460
1480
1500
1520
1540
1560
1580
D0=1448
D50=1478
D100=1508
t50=0.2
0.1
1
10
100
1000

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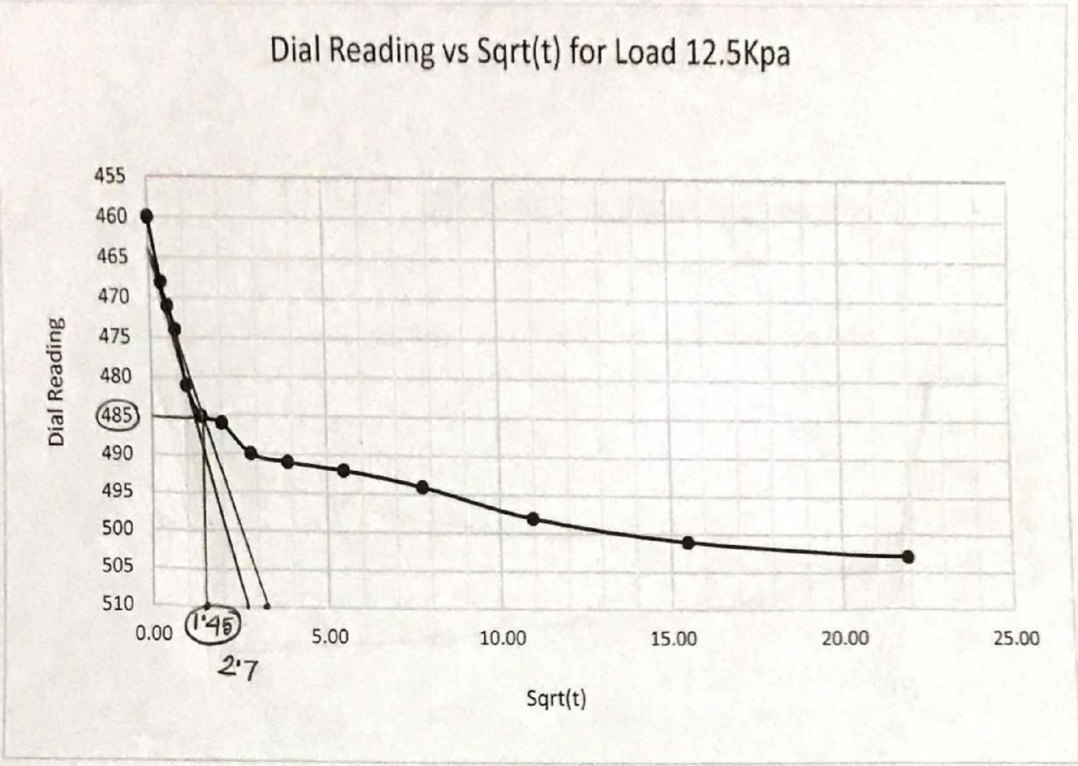

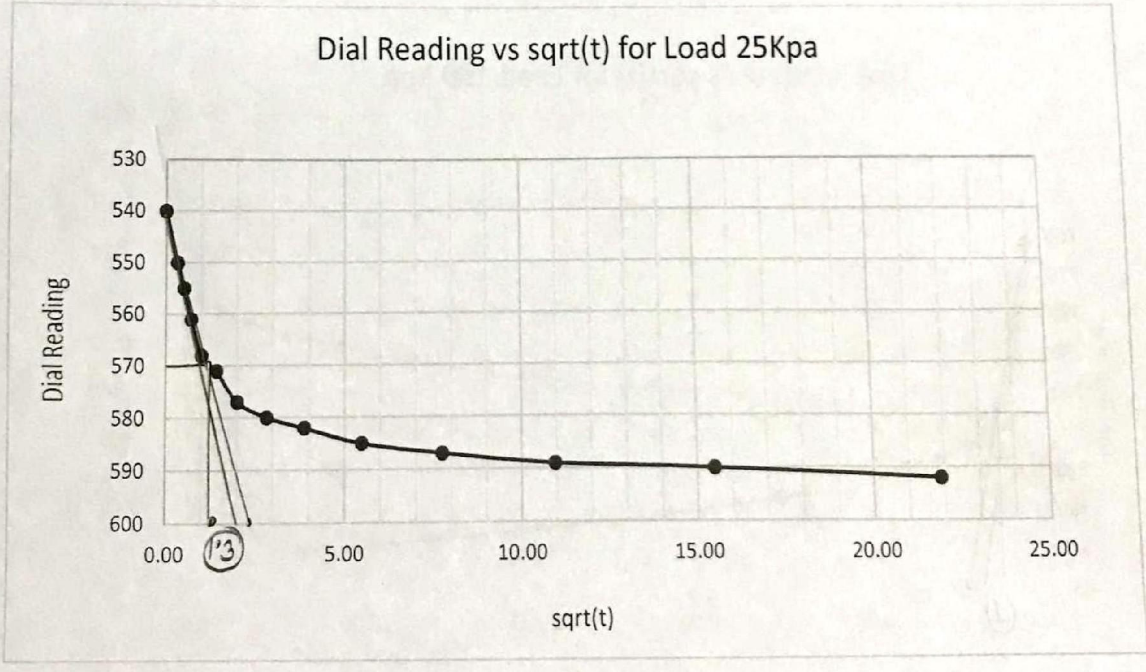

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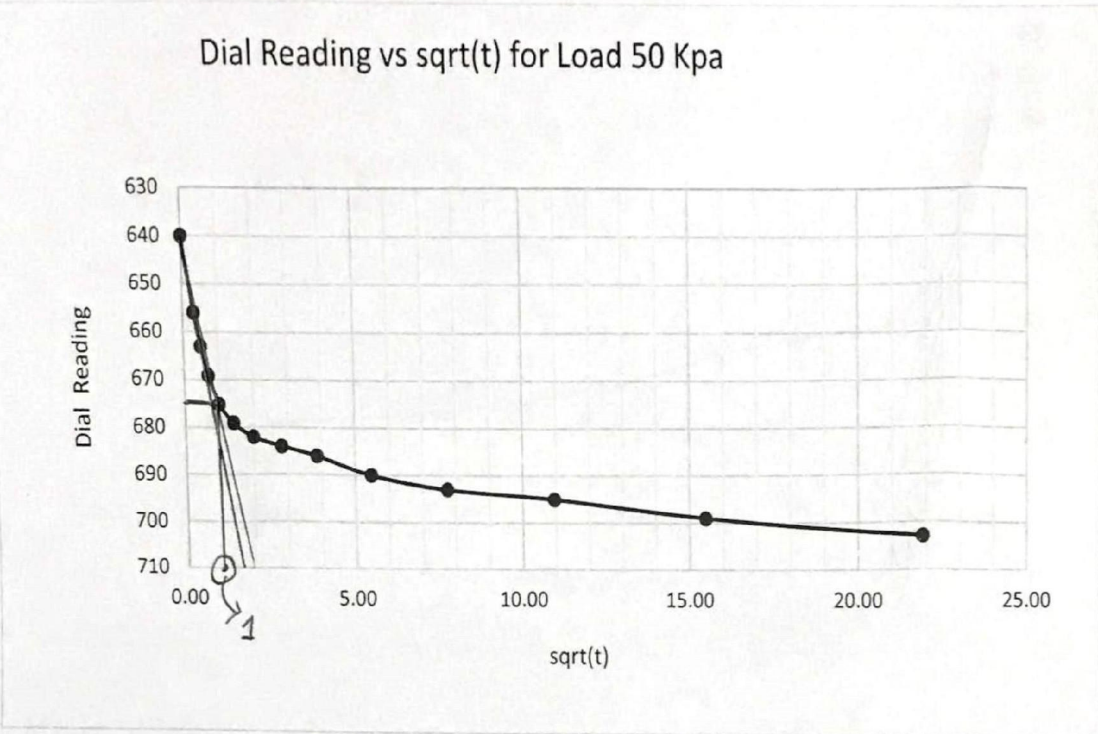
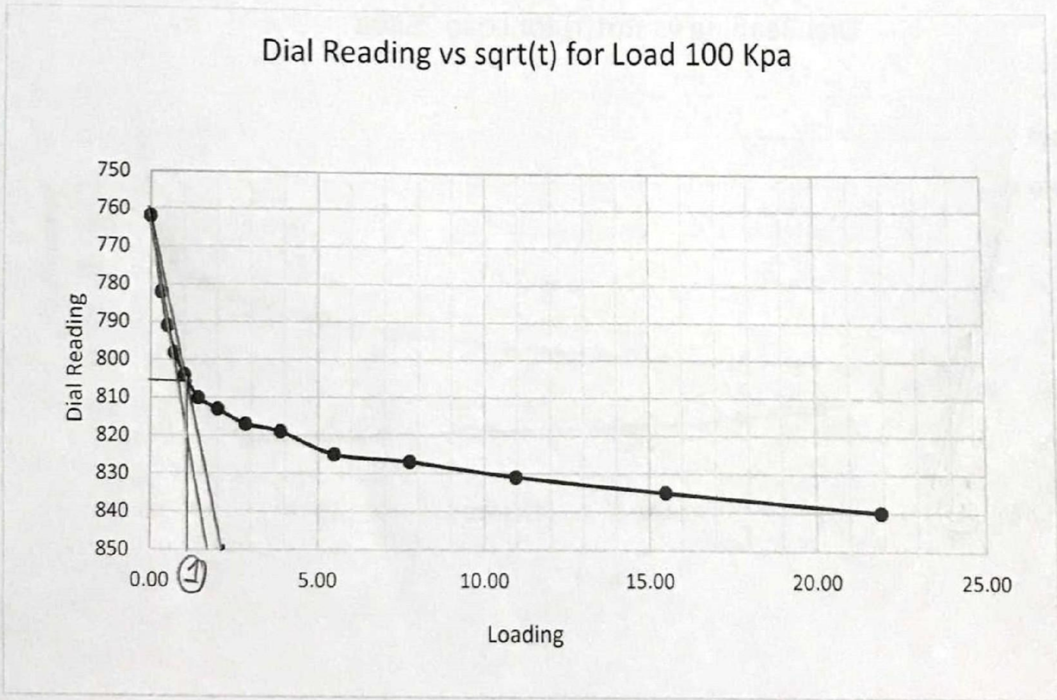
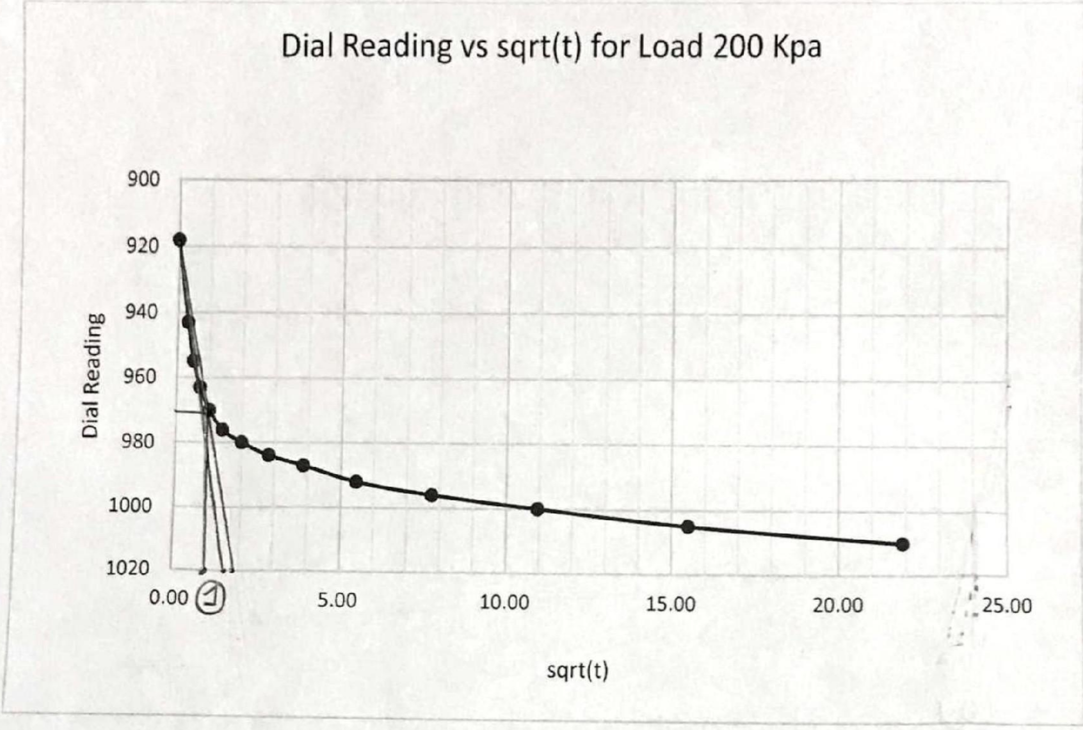
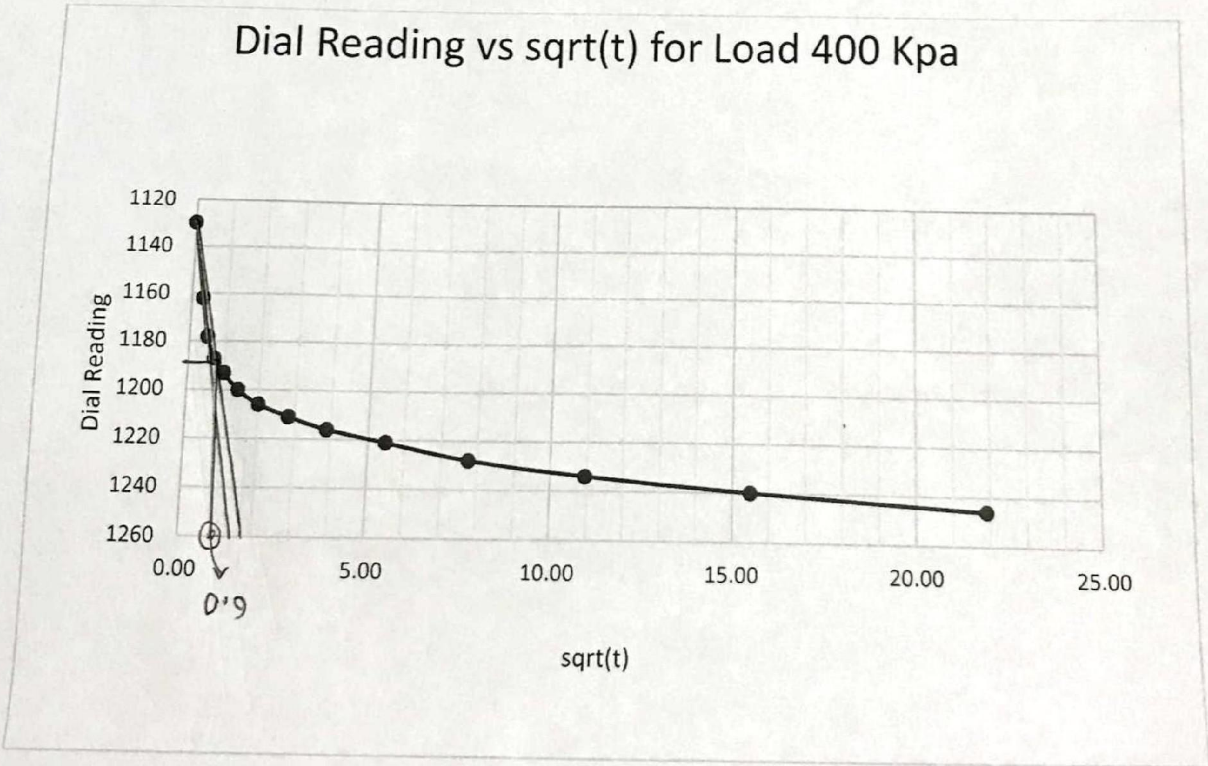
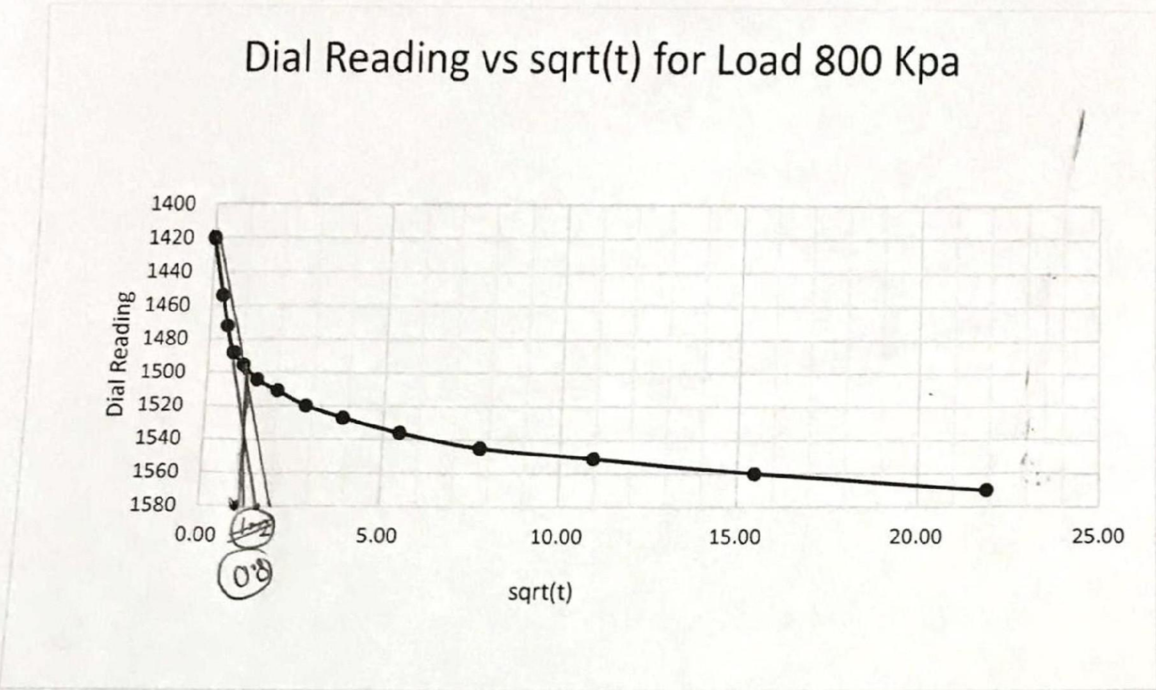
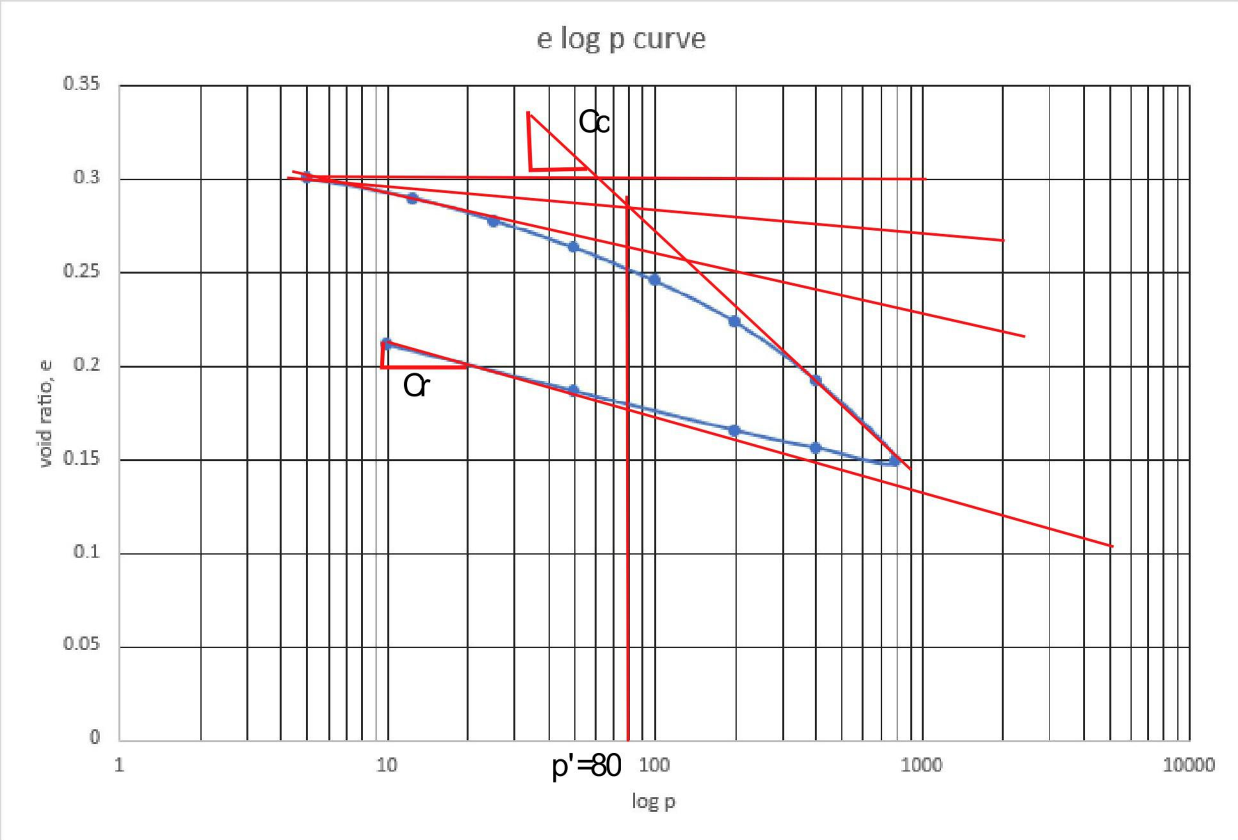


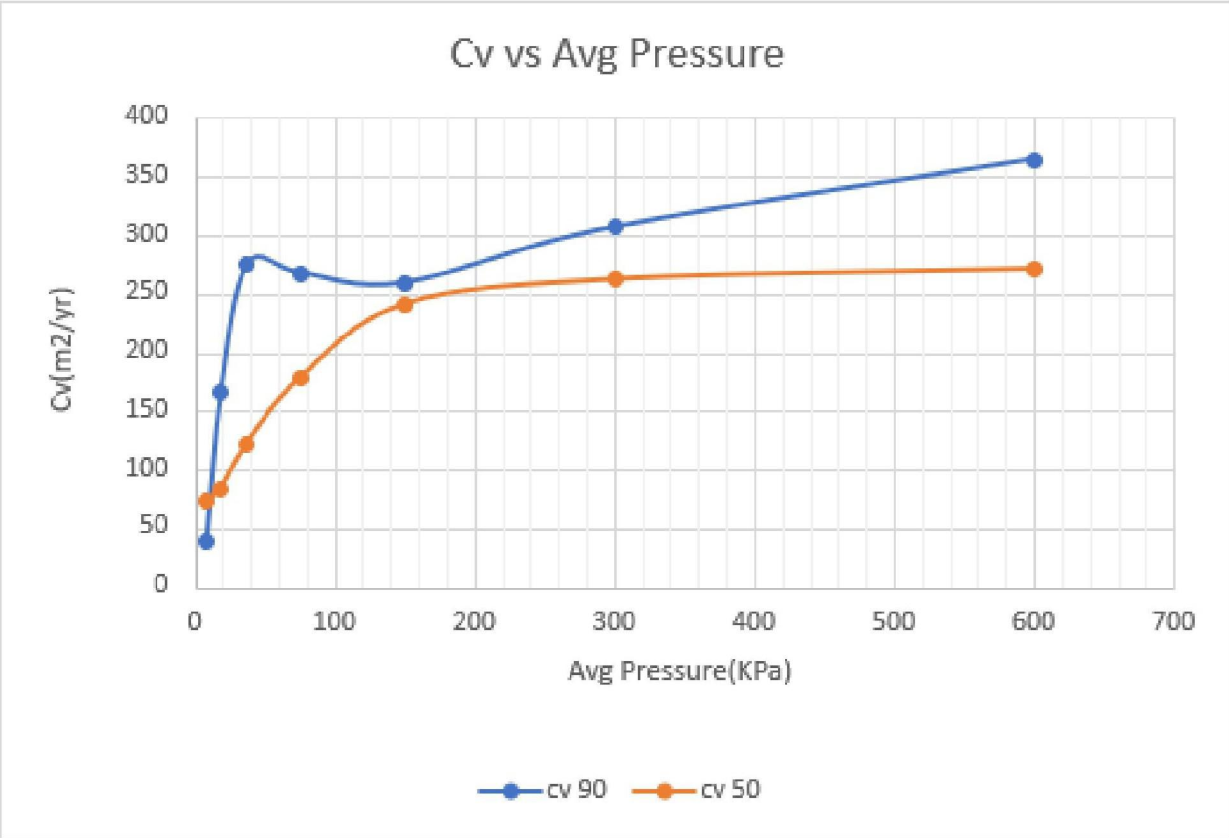


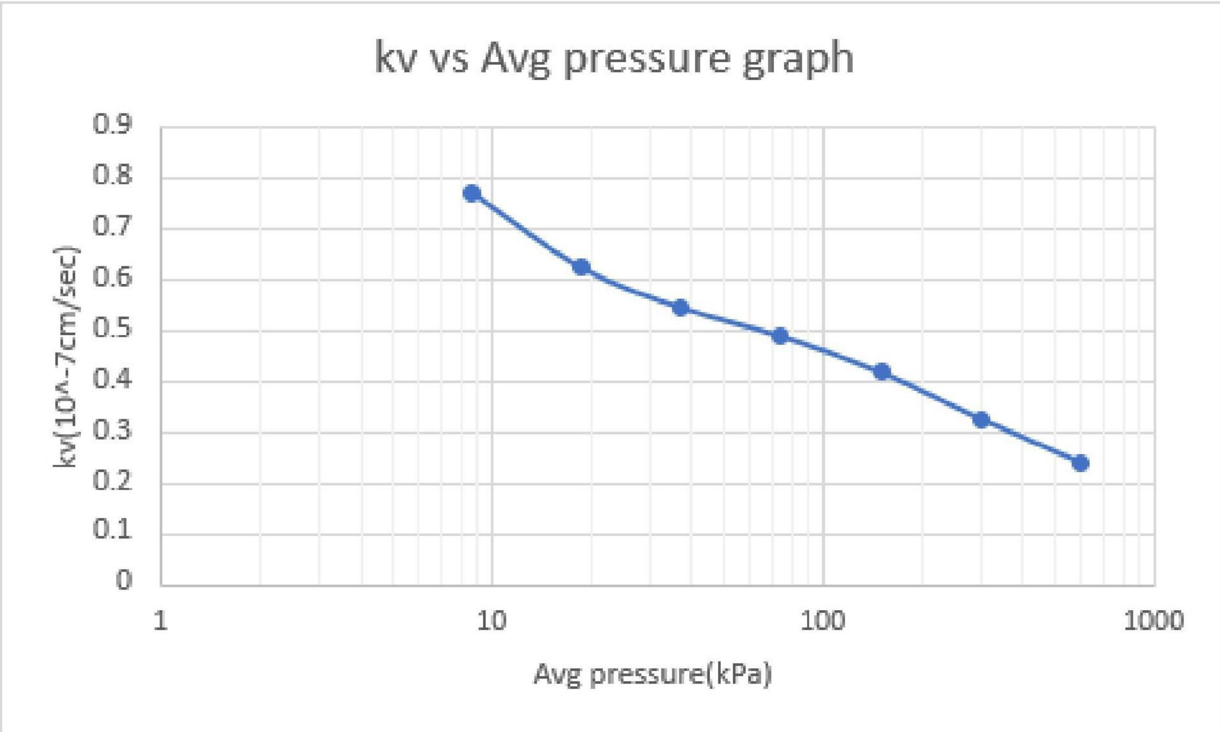

Dial Reading vs sqrt(t) for Load 200 Kpa
Dial Reading
900
920
940
960
980
1000
1020
0.00
1
5.00
10.00
15.00
20.00
25.00
sqrt(t)

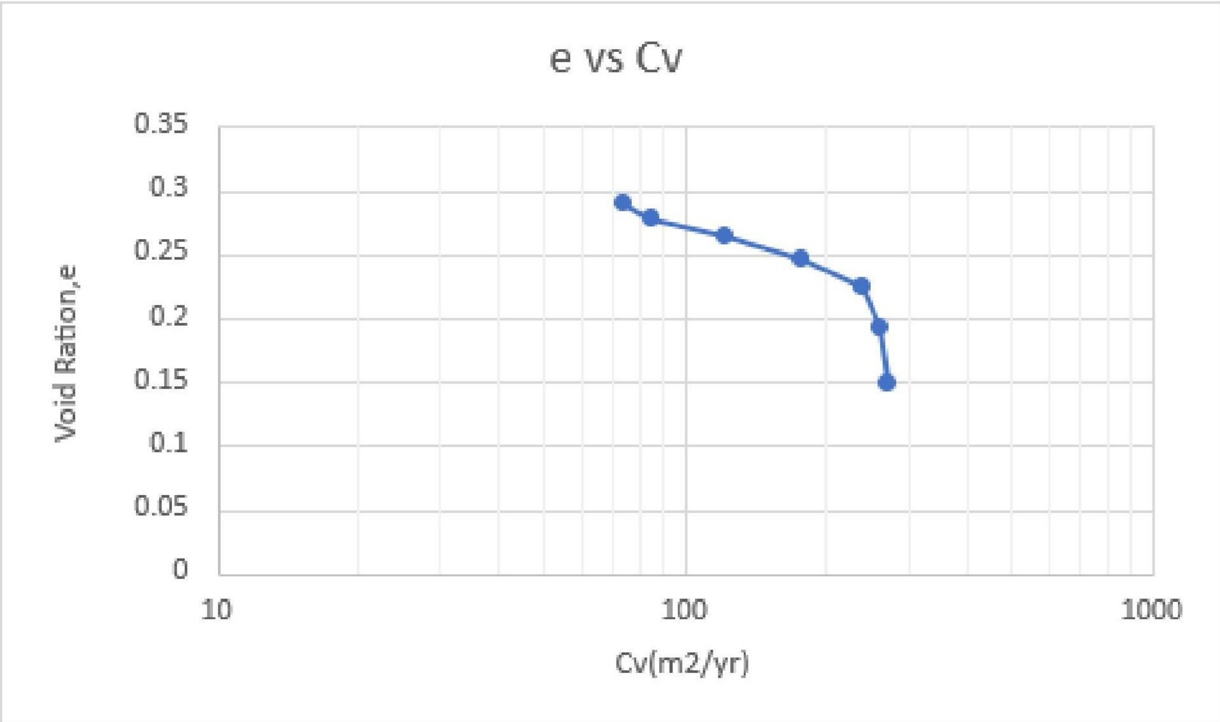

Dial Reading vs sqrt(t) for Load 400 Kpa
Dial Reading
1120
1140
1160
1180
1200
1220
1240
1260
0.00
0.9
5.00
10.00
15.00
20.00
25.00
sqrt(t)


Dial Reading vs sqrt(t) for Load 800 Kpa
Dial Reading
1400
1420
1440
1460
1480
1500
1520
1540
1560
1580
0.00
5.00
10.00
15.00
20.00
25.00
sqrt(t)
0.8


e log p curve
void ratio, e
log p
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
10
100
1000
10000
Cc
Cr
p'=80


Cv vs Avg Pressure
400
350
300
250
200
150
100
50
0
Cv(m2/yr)
0
100
200
300
400
500
600
700
Avg Pressure(KPa)
cv 90
cv 50


kv vs Avg pressure graph
kv(10^-7cm/sec)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
10
100
1000
Avg pressure(kPa)


e vs Cv
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Void Ration,e
10
100
1000
Cv(m2/yr)

Sample calculation:

For Dial reading vs log (t) graph,

load 12.5kPa,

$t_1 = 0.15$ min

$t_2 = 0.4$ min.

$D_0 = 465$

$D_{100} = 495$

$$D_{50} = \frac{D_0 + D_{100}}{2} = 480.$$

$t_{50} = 0.9.$

similarly other calculations are done for these graph.

For Dial reading vs $\sqrt{t}$ graph,

Load, 12.5kPa

$d_{90} = 485$ $\quad t_{90} = 7.29$ min.

In table of elog P curve.

dial change at 12.5kPa. $= (507 - 427) \times 0.0001''$

$= 0.008''$

sample Height $2H = (0.9979 - 0.008)''$

$= 0.9899.$

$$\text{Solid height} = \frac{W_s}{A\, G_s\, \gamma_w}$$

$$2H_0 = \frac{166.6}{31.67 \times 2.71 \times 0.9951}$$

$= 1.95$ cm

$= 0.7674''$

void height $= 2H - 2H_o$

$= 0.9899 - 0.7674$

$= 0.2225$.

$\therefore$ void ratio, $e = \dfrac{2H-2H_o}{2H_o}$

$= \dfrac{0.2225}{0.7674} = 0.29$.

similarly other calculations are done.

From table of Gs determination,

$G_s = \dfrac{G_T W_s}{W_s - W_1 + W_2} = \dfrac{0.9951 \times 49.6}{49.6 - 373.5 + 342.1}$

$= 2.71$.

From table for c_v vs Avg pressure graph.
for 12.5 kPa.

$H = \dfrac{H_1 + H_2}{2}$ in

$= \dfrac{0.9979 + 0.9899}{2}$ in

$= 0.9939"$

$= 25.45$ mm

$t_{90} = 7.29$ min

$t_{50} = 0.9$ min.

for t50,

$$C_v = \frac{TH^2}{t_{50}} = \frac{0.197 \times 25.32^2 \times 60 \times 24 \times 365}{0.9 \times 1000^2}$$

$$= 73.78 \text{ m}^2/\text{year.}$$

for t_{90}

$$C_v = \frac{TH^2}{t_{90}} = \frac{0.848 \times 25.32^2 \times 60 \times 24 \times 365}{7.29 \times 1000^2}$$

$$= 39.21 \text{ m}^2/\text{year.}$$

from table for k_v vs C_v and e vs C_v graphs,

$$a_v = \frac{\Delta e}{\Delta p'} = \frac{0.303 - 0.300}{5 - 0} = 0.000547 \text{ m}^2/\text{kN.}$$

$$m_v = \frac{a_v}{1+e} = \frac{0.000547}{1 + 0.3} = 0.00042 \text{ m}^2/\text{kN.}$$

$$k = C_v m_v \gamma_w = 73.78 \times 0.00042 \times \cancel{0.000547}\ 9.76$$

$$= 0.7699 \times 10^{-7} \text{ cm/sec.}$$

similarly other values were obtained.

from e log p curve,

$$C_c = -\frac{(0.3 - 0.15)}{\log\left(\frac{60}{800}\right)} = 0.133$$

$$C_s = -\frac{0.15 - 0.2}{\log\left(\frac{350}{20}\right)} = 0.0402$$

4. Soil condition:

Initial water content of specimen,

$$= \frac{249.7 - 198.7}{198.7 - 32.1} \times 100 = 30.6\%$$

Final water content of specimen.

$$= \frac{169.5 - 134.5}{134.5 - 19.4} \times 100 = 30.4\%$$

avg water content of trimmings = 30.5%.

Initial dry wt of specimen = 166.6 g

final " " " " = 115.1 g.

Initial void ratio of specimen = 0.303

final void ratio of specimen = 0.211

Initial dry unit wt = $\frac{166.6}{31.67 \times 2.54}$ g/cm3

$= 2.1$ g/cm3

final dry unit wt = $\frac{115.1}{31.67 \times 2.36}$ g/cm3

$= 1.54$ g/m3

Initial degree of saturation = $\frac{Gw}{e}$ = 2.7%

final degree of saturation = $\frac{Gw}{e}$ = 3.9%

Result:

Pre-consolidation pressure = 80kPa

Consolidation Index $C_c = 0.133$.

Swelling index, $C_r = 0.0402$

Coefficient of consolidation, C_v = 271.4 (m^2/year)
(for 800kpa and t_{50})

Coefficint of compressibility, $a_v = 0.000108\ m^2/kN$
(for 800kpa)

Coefficient of volume compressibility,

$m_v = 9.04 \times 10^{-5}\ m^2/kN$ (for 800 kPa)

Coefficient of permeability:

$K = 0.239 \times 10^{-7}$ cm/sec for (800 kPa)

Discussion:

From experimental data, pre consolidation pressure found 80 kPa, i.e. the soil sample had a history of max 80 kPa during it's deposition life time. Consolidation index $c_c = 0.133$. It's used for the settlement calculation of NC soil. Swelling index found 0.0402 which is almost 1/4 of c_c is used for settlement calculation of OC clay.

P.T.O

coefficient of consolidation found 271.4 (m^2/year) indicates the rate of ~~of~~ ~~co~~ set consolidation for the soil sample at 800 kPa. The coefficient of compressibility ~~and~~ $a_v = 0.000108\ m^2/kN$ implies it's not easily compressible. Coefficient of volume compressibility also implies same.

From graph of e vs log p its observed void ratio decreases with load ~~inch~~ increment and after removal of load void ratio increases but at a slower rate. As the result ~~or~~ loading path and unloading path become different.

from c_v vs Avg pressure graph, it's observed c_v increases with increasing pressure. From, k_v vs avg pressure graph k_v decreases as pressure increases as ~~compos~~ consolidation remove pore or void space and thus permeability coefficient from, e vs c_v graph, rate of consolidation represented c_v decreases as ~~void~~ void ratio e decrease as soil is already dense thats why consolidation is slow.