SSM COLLEGE OF ENGINEERING

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DEPARTMENT OF CIVIL ENGINEERING

"GEOTECH ENGINEERING LAB MANUAL"

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CONTENTS:

EXPERIMENT NO : 1

DETERMINATION OF MOISTURE CONTENT (OVEN DRYING METHOD)

OBJECTIVE

Determine the Moisture content of the given soil sample by oven drying method as per IS: 2720 (Part II) – 1973

NEED AND SCOPE OF THE EXPERIMENT

In almost all soil tests natural moisture content of the soil is to be determined. The knowledge of the natural moisture content is essential in all studies of soil mechanics. To sight a few, natural moisture content is used in determining the bearing capacity and settlement. The natural moisture content will give an idea of the state of soil in the field.

DEFINITION

The natural water content also called the natural moisture content is the ratio of the weight of water to the weight of the solids in a given mass of soil. This ratio is usually expressed as percentage.

APPARATUS REQUIRED

1. Non-corrodible air-tight container.
2. Electric oven, maintain the temperature between 1050 C to 1100 C.
3. Desiccator.
4. Balance of sufficient sensitivity.

PROCEDURE

S.No.	Sample No.	1	2	3
1	Weight of container with lid W_1 gm			
2	Weight of container with lid +wet soil W_2 gm			
3	Weight of container with lid +dry soil W_3 gm			
4	Water/Moisture content $W = [(W_2-W_3)/(W_3-W_1)]$�100			

1. Clean the container with lid dry it and weigh it (W1).

2. Take a specimen of the sample in the container and weigh with lid (W2).

3. Keep the container in the oven with lid removed. Dry the specimen to constant weight maintaining the temperature between 1050 C to 1100 C for a period varying with the type of soil but usually 16 to 24 hours.

4. Record the final constant weight (W3) of the container with dried soil sample. Peat and other organic soils are to be dried at lower temperature (say 600) possibly for a longer period.

Certain soils contain gypsum which on heating loses its water if crystallization. If itb is suspected that gypsum is present in the soil sample used for moisture content determination it shall be dried at not more than 800 C and possibly for a longer time.

OBSERVATIONS AND RECORDING

Data and observation sheet for water content determination

INTERPRETATION AND REPORTING

RESULT

The natural moisture content of the soil sample is ________

GENERAL REMARKS

1. A container with out lid can be used, when moist sample is weighed immediately after placing the container and oven dried sample is weighed immediately after cooling in desiccator.

2. As dry soil absorbs moisture from wet soil, dried samples should be removed before placing wet samples in the ove

EXPERIMENT NO: 2

DETERMINATION OF SPECIFIC GRAVITY

OBJECTIVE

Determine the specific gravity of soil fraction passing 4.75 mm I.S sieve by density bottle.

NEED AND SCOPE

The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc.

DEFINITION

Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air.

APPARATUS REQUIRED

1. Density bottle of 50 ml with stopper having capillary hole.

2. Balance to weigh the materials (accuracy 10gm).

3. Wash bottle with distilled water.

4. Alcohol and ether.

PROCEDURE

1. Clean and dry the density bottle Wash the bottle with water and allow it to drain. Wash it with alcohol and drain it to remove water. Wash it with ether, to remove alcohol and drain ether.
2. Weigh the empty bottle with stopper (W1)

3. Take about 10 to 20 gm of oven soil sample which is cooled in a desiccator. Transfer it to the bottle. Find the weight of the bottle and soil (W2).

4. Put 10ml of distilled water in the bottle to allow the soil to soak completely. Leave it for about 2 hours.
5. Again fill the bottle completely with distilled water put the stopper and keep the bottle Under constant temperature water baths (Tx0).
6. Take the bottle outside and wipe it clean and dry note. Now determine the weight of the bottle and the contents (W3).
7. Now empty the bottle and thoroughly clean it. Fill the bottle with only disttiled water and weigh it. Let it be W4 at temperature (Tx0 C).
8. Repeat the same process for 2 to 3 times, to take the average reading of it.

OBSERVATIONS

S.No.	Sample No.	1	2	3
1	Weight of container with lid W_1 gm			
2	Weight of container with lid +wet soil W_2 gm			
3	Weight of container with lid +dry soil W_3 gm			
4	Water/Moisture content $W = [(W_2-W_3)/(W_3-W_1)]$�100			

CALCULATIONS

$$Specific\ gravity\ of\ soil = \frac{\text{Density of water at 27 C}}{\text{Weight of water of equal volume}}$$

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

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

INTERPRETATION AND REPORTING

Unless or otherwise specified specific gravity values reported shall be based on water at 270C. So the specific gravity at 270C = K× Sp. Gravity at Tx0C.

$$where \quad K = \frac{\text{Density of water at temperature } T_x^0 C}{\text{Density of water at temperature } T_x^0 C}$$

The specific gravity of the soil particles lie with in the range of 2.65 to 2.85. Soils containing organic matter and porous particles may have specific gravity values below 2.0. Soils having heavy substances may have values above 3.0.

EXPERIMENT NO : 03

Soil gradation by sieve analysis

SIEVE ANALYSIS:

OBJECTIVE

(a). Select sieves as per I.S specifications and perform sieving.

(b). Obtain percentage of soil retained on each sieve.

(c). Draw graph between log grain size of soil and % finer.

NEED AND SCOPE OF EXPERIMENT

The grain size analysis is widely used in classification of soils. The data obtained from grain size distribution curves is used in the design of filters for earth dams and to determine suitability of soil for road construction, air field etc. Information obtained from grain size analysis can be used to predict soil water movement although permeability tests are more generally used.

PLANNING AND ORGANISATION

Apparatus

1.Balance

2.I.S sieves

3.Rubber pestle and mortar.

4.mechanical Sieve Shaker

KNOWLEDGE OF EQUIPMENT:

1.The balance to be used must be sensitive to the extent of 0.1% of total weight of sample taken.

2.I.S 460-1962 are to used. The sieves for soil tests: 4.75 mm to 75 microns.

PROCEDURE

For soil samples of soil retained on 75 micron I.S sieve

(a) The proportion of soil sample retained on 75 micron I.S sieve is weighed and recorded weight of soil sample is as per I.S 2720.

(b) I.S sieves are selected and arranged in the order as shown in the table.

(c) The soil sample is separated into various fractions by sieving through above sieves placed in the above mentioned order.

(d) The weight of soil retained on each sieve is recorded.

The moisture content of soil if above 5% it is to be measured and recorded.

No particle of soil sample shall be pushed through the sieves.

OBSERVATIONS AND RECORDING

Weight of soil sample:

Moisture content:

I.S sieve number or size in mm	Wt. Retained in each sieve (gm)	Percentage on each sieve	Cumulative %age retained on each sieve	% finer	Remarks
4.75					
4.00					
3.36					
2.40					
1.46					
1.20					
0.60					
0.30					
0.15					
0.075					

GRAPH

Draw graph between log sieve size vs % finer. The graph is known as grading curve. Corresponding to 10%, 30% and 60% finer, obtain diameters from graph are designated as D10, D30, D60.

CALCULATION

The percentage of soil retained on each sieve shall be calculated on the basis of total weight of soil sample taken.

Cumulative percentage of soil retained on successive sieve is found.

HYDROMETER ANALYSIS

OBJECTIVE:

Grain size analysis of soils by hydrometer analysis test.

SPECIFIC OBJECTIVE:

1. To determine the grain size distribution of soil sample containing appreciable amount of fines.
2. To draw a grain size distribution curve.

NEED AND SCOPE OF THE EXPERIMENT

For determining the grain size distribution of soil sample, usually mechanical analysis (sieve analysis) is carried out in which the finer sieve used is 63 micron or the nearer opening. If a soil contains appreciable quantities of fine fractions in (less than 63 micron) wet analysis is done. One form of the analysis is hydrometer analysis. It is very much helpful to classify the soil as per ISI classification. The properties of the soil are very much influenced by the amount of clay and other fractions.

APPARATUS

(a) Hydrometer
(b) Glass measuring cylinder-Two of 1000 ml capacity with ground glass or rubber stoppers about 7 cm diameter and 33 cm high marked at 1000 ml volume.
(c) Thermometer- To cover the range 0 to 50o C with an accuracy of 0.5° C .
(d) Water bath.

(e) Stirring apparatus.
(f) I.S sieves apparatus.
(g) Balance-accurate to 0.01 gm.
(h) Oven-105 to 110.
(i) Stop watch.
(j) Desiccators
(k) Centimeter scale.
(l) Porcelain evaporating dish.
(m) Wide mouth conical flask or conical beaker of 1000 ml capacity.
(n) Thick funnel-about 10 cm in diameter.
(o) Filter flask-to take the funnel.
(p) Measuring cylinder-100 ml capacity.
(q) Wash bottle-containing distilled water.
(r) Filter papers.
(s) Glass rod-about 15 to 20 cm long and 4 to 5 mm in diameter.
(t) Hydrogen peroxide-20 volume solution.
(u) Hydrochloric acid N solution-89 ml of concentrated hydrochloric acid.(specific gravity 1.18) diluted with distilled water one litre of solution.
(v) Sodium hexametaphosphate solution-dissolve 33 g of sodium hexametaphosphate and 7 gms of sodium carbonate in distilled water to make one litre of solution.

CALIBRATION OF HYDROMETER

Volume

(a) Volume of water displaced: Approximately 800 ml of water shall be poured in the 1000 ml measuring cylinder. The reading of the water level shall be observed and recorded.

The hydrometer shall be immersed in the water and the level shall again be observed and recorded as the volume of the hydrometer bulb in ml plus volume of that part of the stem that is submerged. For practical purposes the error to the inclusion of this stem volume may be neglected.

(b) From the weight of the hydrometer: The hydrometer shall be weighed to the nearest 0.1 gm.

The weight in gm shall be recorded as the volume of the bulb plus the volume of the stem below the 1000 ml graduation mark. For practical purposes the error due to the inclusion of this stem may be neglected.

Calibration

- The sectional area of the 1000 ml measuring cylinder in which the hydrometer is to used shall be determined by measuring the distance between the graduations. The sectional area is equal to the volume include between the two graduations divided by the measured distance between them.
- Place the hydrometer on the paper and sketch it. On the sketch note the lowest and highest readings which are on the hydrometer and also mark the neck of the bulb. Mark the center of the bulb which is half of the distance between neck of the bulb and tip of the bulb.
- The distance from the lowest reading to the center of the bulb is (Rh) shall be recorded (Rh =HL + L/2).
- The distance from the highest hydrometer reading to the center of the bulb shall be measured and recorded.
- Draw a graph hydrometer readings vs HH and RH. A straight line is obtained. This calibration curve is used to calibrate the hydrometer readings which are taken with in 2 minutes.
- From 4 minutes onwards the readings are to be taken by immersing the hydrometer each time. This makes the soil solution to rise, there by rising distance of free fall of the particle. So correction is applied to the hydrometer readings.

$$\frac{R_h - V_h}{A} = \frac{H_L + h/2 - V_h}{2A}$$

- Correction applied to the Rh and HH

Vh= Volume of hydrometer bulb in ml.

A =Area of measuring cylinder in cm2.

From these two corrected readings draw graph (straight line)

Grain Size Distribution in Soil-Data and Calculation Chart

Date:

Sample No:

Total weight of dry soil taken, W =

Specific Gravity of soil, G =

Hydrometer No.______________ Wt. Of soil gone into solution ,Ws =

Meniscus correction, Cn Dispersion agent correction =

Reading in water RW =

Temperature correction =

% finer for wt. Of soil Ws gone into solution N=[(100G)/{Ws x (G 1)}] x

Date	Time	Elapsed Time in Sec	Hydrometer reading upper Meniscus R_h � 1000	Corrected hydrometer Reading (1- lower meniscus C_m)	Z_r or Z^1r	Velocity Cms/sec V=Z�r/K or Z^1r/t	Equivalent dia. Of Particle D�mm	R	N(% finer Than for soil)	REMARKS

EXPERIMENT NO: 04

DETERMINATION OF CONSISTENCY LIMITS

LIQUID LIMIT TEST

OBJECTIVE:

1.Prepare soil specimen as per specification.
2.Find the relationship between water content and number of blows.
3.Draw flow curve.
4.Find out liquid limit.

NEED AND SCOPE

Liquid limit is significant to know the stress history and general properties of the soil met with construction. From the results of liquid limit the compression index may be estimated. The compression index value will help us in settlement analysis. If the natural moisture content of soil is closer to liquid limit, the soil can be considered as soft if the moisture content is lesser than liquids limit, the soil can be considered as soft if the moisture content is lesser than liquid limit. The soil is brittle and stiffer.

THEORY

The liquid limit is the moisture content at which the groove, formed by a standard tool into the sample of soil taken in the standard cup, closes for 10 mm on being given 25 blows in a standard manner. At this limit the soil possess low shear strength.

APPARATUS REQUIRED

1. Balance 2. Liquid limit device (Casagrendes) 3. Grooving tool 4. Mixing dishes 5. Spatula 6. Electrical Oven

PROCEDURE

1. About 120 gm of air-dried soil from thoroughly mixed portion of material passing 425 micron I.S sieve is to be obtained.

2. Distilled water is mixed to the soil thus obtained in a mixing disc to form uniform paste. The paste shall have a consistency that would require 30 to 35 drops of cup to cause closer of standard groove for sufficient length.

3. A portion of the paste is placed in the cup of LIQUID LIMIT device and spread into portion with few strokes of spatula.

4. Trim it to a depth of 1cm at the point of maximum thickness and return excess of soil to the dish.

5. The soil in the cup shall be divided by the firm strokes of the grooving tool along the diameter through the centre line of the follower so that clean sharp groove of proper dimension is formed.

6. Lift and drop the cup by turning crank at the rate of two revolutions per second until the two halves of soil cake come in contact with each other for a length of about 1 cm by flow only.

7. The number of blows required to cause the groove close for about 1 cm shall be recorded.

8. A representative portion of soil is taken from the cup for water content determination.

9. Repeat the test with different moisture contents at least three more times for blows between 10 and 40.

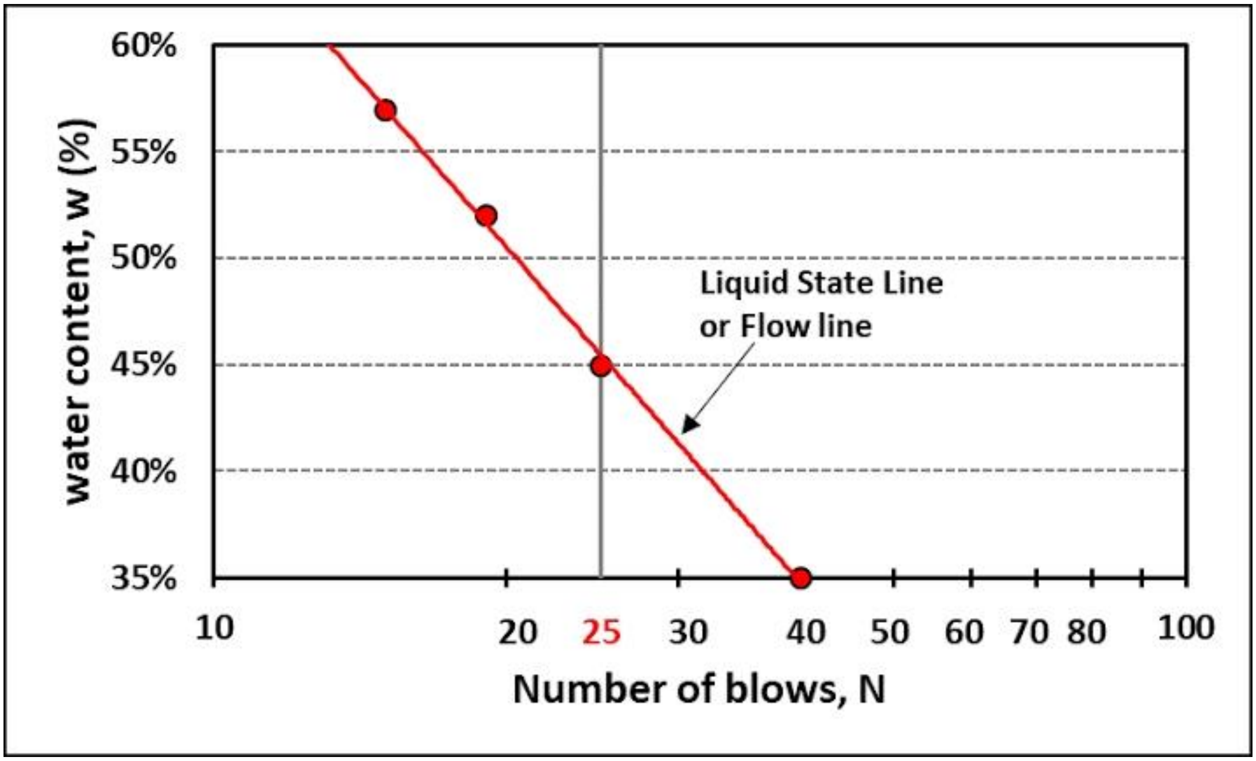
OBSERVATIONS

1) Details of the sample:.......
2) Natural moisture content:........ Room temperature:..............

Determination Number	1	2	3	4
Container number				
Weight of container				
Weight of container + wet soil				
Weight of container + dry soil				
Weight of water				
Weight of dry soil				
Moisture content (%)				
No. of blows				

COMPUTATION / CALCULATION

Draw a graph showing the relationship between water content (on y-axis) and number of blows (on x-axis) on semi-log graph. The curve obtained is called flow curve. The moisture content corresponding to 25 drops (blows) as read from the



represents liquid limit. It is usually expressed to the nearest whole number.

INTERPRETATION AND RECORDING

Flow index If = (W2-W1)/(logN1/N2) = slope of the flow curve.

Plasticity Index = wl-wp =

Toughness Index = Ip/If =

PLASTIC LIMIT TEST

NEED AND SCOPE:

Soil is used for making bricks , tiles , soil cement blocks in addition to its use as foundation for structures.

APPARATUS REQUIRED

- Porcelain dish.
- 2.Glass plate for rolling the specimen.
- 3.Air tight containers to determine the moisture content.
- 4.Balance of capacity 200gm and sensitive to 0.01gm
- 5.Oven thermostatically controlled with interior of non-corroding material to maintain the temperature around 1050 and 1100C.

PROCEDURE

(a) Take about 20gm of thoroughly mixed portion of the material passing through 425 micron I.S. sieve obtained in accordance with I.S. 2720 (part 1).

(b) Mix it thoroughly with distilled water in the evaporating dish till the soil mass becomes plastic enough to be easily molded with fingers.

(c) Allow it to season for sufficient time (for 24 hrs) to allow water to permeate throughout the soil mass

(d) Take about 10gms of this plastic soil mass and roll it between fingers and glass plate with just sufficient pressure to roll the mass into a threaded of uniform diameter throughout its length. The rate of rolling shall be between 60 and 90 strokes per minute.

(e) Continue rolling till you get a threaded of 3 mm diameter.

(f) Kneed the soil together to a uniform mass and re-roll.

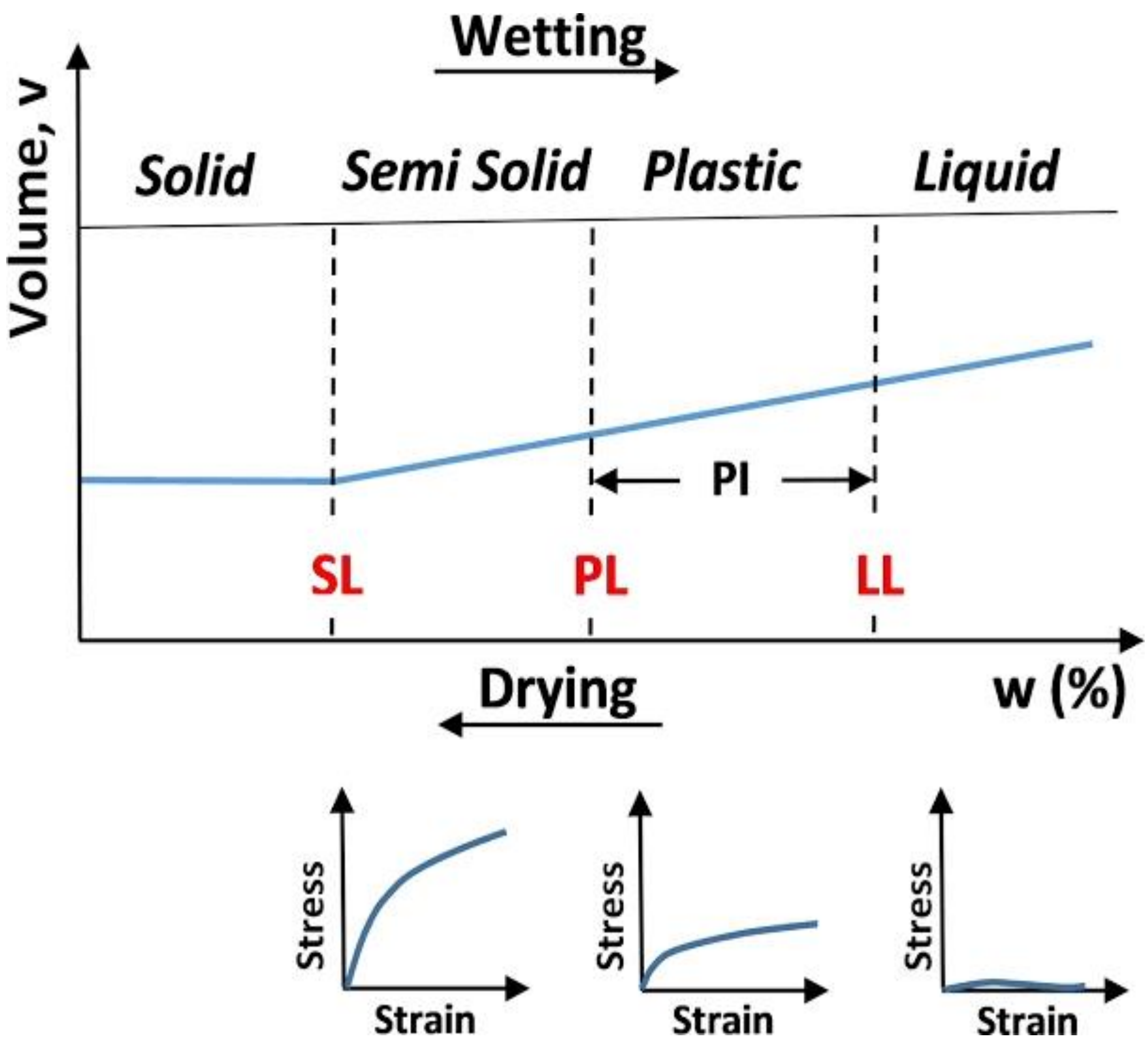
(g) Continue the process until the thread crumbles when the diameter is 3 mm.

(h) Collect the pieces of the crumbled thread in air tight container for moisture content determination.

(i) Repeat the test to atleast 3 times and take the average of the results calculated to the nearest whole number.

OBSERVATION AND REPORTING

Compare the diameter of thread at intervals with the rod. When the diameter reduces to 3 mm, note the surface of the thread for cracks.



PRESENTATION OF DATA:

Container No.		
Wt. of container + lid, W_1		
Wt. of container + lid + wet sample, W_2		
Wt. of container + lid + dry sample, W_3		
Wt. of dry sample = W_3 � W_1		
Wt. of water in the soil = W_3� � W_2		
Water content (%) = (W_3� � W_2) / (W_3 � W_1) � 100		

Average Plastic Limit=……………

Plasticity Index(Ip) = (LL – PL)=………..

Toughness Index =Ip/IF

SHRINKAGE LIMIT TEST

OBJECTIVE

To determine the shrinkage limit and calculate the shrinkage ratio for the given soil.

THEORY

As the soil loses moisture, either in its natural environment, or by artificial means in laboratory it changes from liquid state to plastic state, from plastic state to semi-solid state and then to solid state. Volume changes also occur with changes in water content. But there is particular limit at which any moisture change does not cause soil any volume change.

NEED AND SCOPE

Soils which undergo large volume changes with change in water content may be troublesome. Volume changes may not and usually will not be equal.

shrinkage limit test should be performed on a soil.

- To obtain a quantitative indication of how much change in moisture can occur before any appreciable volume changes occurs
- To obtain an indication of change in volume.
- The shrinkage limit is useful in areas where soils undergo large volume changes when going through wet and dry cycles (as in case of earth dams)

APPARATUS

(a) Evaporating Dish. Porcelain, about 12cm diameter with flat bottom.
(b) Spatula
(c) Shrinkage Dish. Circular, porcelain or non-corroding metal dish (3 nos) having a flat bottom and 45 mm in diameter and 15 mm in height internally.
(d) Straight Edge. Steel, 15 cm in length.
(e) Glass cup. 50 to 55 mm in diameter and 25 mm in height , the top rim of which is ground smooth and level.
(f) Glass plates. Two, each 75 ×75 mm one plate shall be of plain glass and the other shall have prongs.
(g) Sieves. 2mm and 425- micron IS sieves.
(h) Oven-thermostatically controlled.
(i) Graduate-Glass, having a capacity of 25 ml and graduated to 0.2 ml and 100 cc one mark flask.
(j) Balance-Sensitive to 0.01 g minimum.
(k) Mercury. Clean, sufficient to fill the glass cup to over flowing.
(l) Wash bottle containing distilled water.

PROCEDURE

Preparation of soil paste

1. Take about 100 gm of soil sample from a thoroughly mixed portion of the material passing through 425-micron I.S. sieve.
2. Place about 30 gm the above soil sample in the evaporating dish and thoroughly mixed with distilled water and make a creamy paste.
3. Use water content some where around the liquid limit.
4. Filling the shrinkage dish
5. Coat the inside of the shrinkage dish with a thin layer of Vaseline to prevent the soil sticking to the dish.
6. Fill the dish in three layers by placing approximately 1/3 rd of the amount of wet soil with the help of spatula. Tap the dish gently on a firm base until the soil flows over the edges and no apparent air bubbles exist. Repeat this process for 2^{nd} and 3^{rd} layers also till the dish is completely filled with the wet soil. Strike off the excess soil and make the top of the dish smooth. Wipe off all the soil adhering to the outside of the dish.
7. Weigh immediately, the dish with wet soil and record the weight.
8. Air- dry the wet soil cake for 6 to 8hrs, until the colour of the pat turns from dark to light. Then oven-dry the to constant weight at 1050C to 1100C say about 12 to 16 hrs.
9. Remove the dried disk of the soil from oven. Cool it in a desiccator. Then obtain the weight of the dish with dry sample.
10. Determine the weight of the empty dish and record.
11. Determine the volume of shrinkage dish which is evidently equal to volume of the wet soil as follows. Place the shrinkage dish in an evaporating dish and fill the dish with mercury till it overflows slightly. Press it with plain glass plate firmly on its top to remove excess mercury. Pour the mercury from the shrinkage dish into a measuring jar and find the volume of the shrinkage dish directly. Record this volume as the volume of the wet soil pat.

Volume of the Dry Soil Pat

i. Determine the volume of dry soil pat by removing the pat from the shrinkage dish and immersing it in the glass cup full of mercury in the following manner.

ii. Place the glass cup in a larger one and fill the glass cup to overflowing with mercury. Remove the excess mercury by covering the cup with glass plate with prongs and pressing it. See that no air bubbles are entrapped. Wipe out the outside of the glass cup to remove the adhering mercury. Then, place it in another larger dish, which is, clean and empty carefully.

iii. Place the dry soil pat on the mercury. It floats submerge it with the pronged glass plate which is again made flush with top of the cup. The mercury spills over into the larger plate. Pour the mercury that is displayed by the soil pat into the measuring jar and find the volume of the soil pat directly.

First determine the moisture content

Shrinkage limit $(WS) = \left(W - (V - V_0) \times \gamma_W / W_0\right) \times 100$

Where, W = Moisture content of wet soil pat (%)

V = Volume of wet soil pat in cm3

$V0$ = Volume of dry soil pat in cm3

$W0$ = Weight of oven dry soil pat in gm.

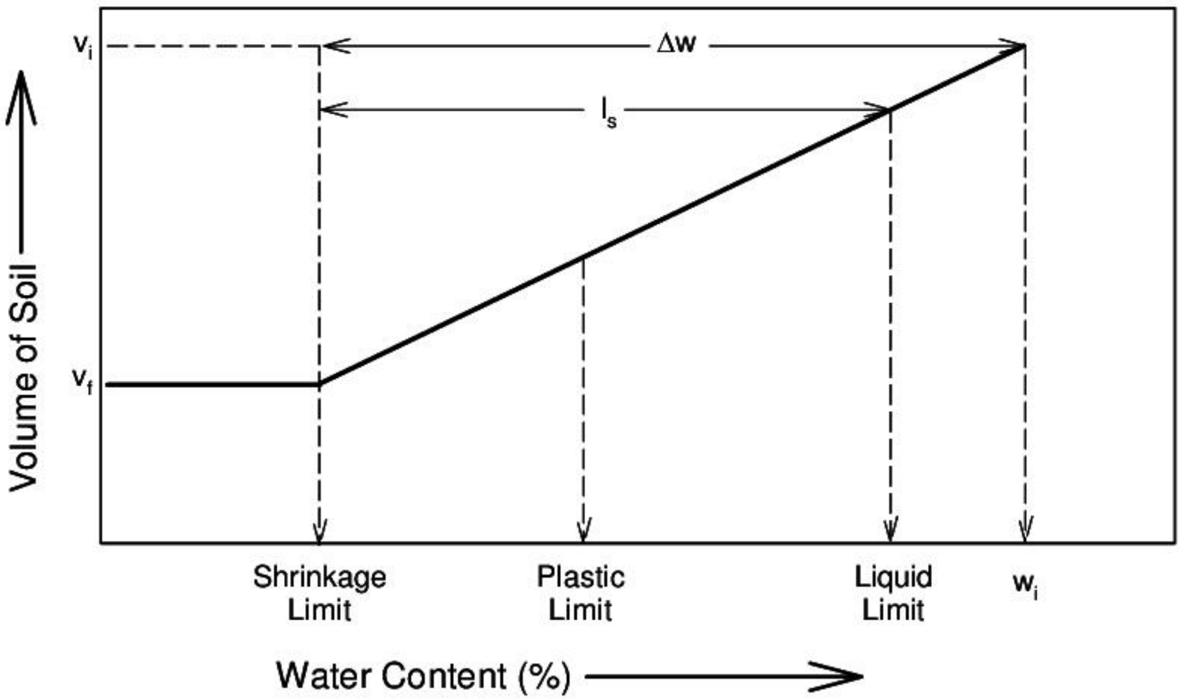
CALCULATION

CAUTION

Do not touch the mercury with gold rings.

TABULATION AND RESULTS

S.No	Determination No.	1	2	3
1	Wt. of container in gm, W_1			
2	Wt. of container + wet soil pat in gm, W_2			
3	Wt. of container + dry soil pat in gm, W_3			
4	Wt. of oven dry soil pat, W_0 in gm			
5	Wt. of water in gm			
6	Moisture content (%), W			
7	Volume of wet soil pat (V), in cm			
8	Volume of dry soil pat (V_0) in cm^3			
	By mercury displacement method			
	a. Weight of displaced mercury			
	b. Specific gravity of the mercury			
9	Shrinkage limit (W_S)			
10	Shrinkage ratio (R)			



EXPERIMENT NO: 05

PERMEABILITY TEST(CONSTAN HEAD)

OBJECTIVE

To determine the coefficient of permeability of a soil using constant head method.

NEED AND SCOPE

The knowledge of this property is much useful in solving problems involving yield of water bearing strata, seepage through earthen dams, stability of earthen dams, and embankments of canal bank affected by seepage, settlement etc.

PLANNING AND ORGANIZATION

A. Preparation of the soil sample for the test
B. Finding the discharge through the specimen under a particular head of water.

DEFINITION OF COEFFICIENT OF PERMEABILITY

The rate of flow under laminar flow conditions through a unit cross sectional are of porous medium under unit hydraulic gradient is defined as coefficient of permeability.

EQUIPMENT

1.Permeameter mould of non-corrodible material having a capacity of 1000 ml, with an internal diameter of 100 0.1 mm and internal effective height of 127.3,, 0.1 mm.

2.The mould shall be fitted with a detachable base plate and removable extension counter.

3.Compacting equipment: 50 mm diameter circular face, weight 2.76 kg and height of fall 310 mm as specified in I.S 2720 part VII 1965.

4.Drainage bade: A bade with a porous disc, 12 mm thick which has the permeability 10 times the expected permeability of soil.

5.Drainage cap: A porous disc of 12 mm thick having a fitting for connection to water inlet or outlet.

6.Constant head tank: A suitable water reservoir capable of supplying water to the permeameter under constant head.

7. Graduated glass cylinder to receive the discharge. Stop watch to note the time.

8. A meter scale to measure the head differences and length of specimen

PREPARATION OF SPECIMEN FOR TESTING

UNDISTURBED SOIL SAMPLE

1.Note down the sample number, bore hole number and its depth at which the sample was taken.

2.Remove the protective cover (paraffin wax) from the sampling tube.

3.Place the sampling tube in the sample extraction frame, and push the plunger to get a cylindrical form sample not longer than 35 mm in diameter and having height equal to that of mould.

4.The specimen shall be placed centrally over the porous disc to the drainage base.

5.The angular space shall be filled with an impervious material such as cement slurry or wax, to provide sealing between the soil specimen and the mould against leakage from the sides.

6.The drainage cap shall then be fixed over the top of the mould.

7.Now the specimen is ready for the test.

DISTURBED SOIL SAMPLE.

1.A 2.5 kg sample shall be taken from a thoroughly mixed air dried or oven dried material.

2.The initial moisture content of the 2.5 kg sample shall be determined. Then the soil shall be placed in the air tight container.

3.Add required quantity of water to get the desired moisture content.

4.Mix the soil thoroughly.

5.Weigh the empty permeameter mould.

6.After greasing the inside slightly, clamp it between the compaction base plate and extension collar.

7.Place the assembly on a solid base and fill it with sample and compact it.

8.After completion of a compaction the collar and excess soil are removed.

9.Find the weight of mould with sample.

10.Place the mould with sample in the permeameter, with drainage base and cap having discs that are properly saturated.

TEST PROCEDURE

1.For the constant head arrangement, the specimen shall be connected through the top inlet to the constant head reservoir.

2.Open the bottom outlet.

3.Establish steady flow of water.

4.The quantity of flow for a convenient time interval may be collected.

5.Repeat three times for the same interval.

OBSERVATION AND RECORDING

The flow is very low at the beginning, gradually increases and then stands constant. Constant head permeability test is suitable for cohesionless soils. For cohesive soils falling head method is suitable.

COMPUTATION

Coefficient of permeability for a constant head test is given by

$$k = \frac{qL}{Ah}$$

where k = coefficien t of permeabili ty in cm/sec

q = Discharge cm^3/sec

L = Length of specimen in cm.

A = Cross -sectional area of specimen in cm^2

H = Constant head causing flow in cm.

Presentation of data

The coefficient of permeability is reported in cm/sec at 27o C. The dry density, the void ratio and the degree of saturation shall be reported.The test results should be tabulated as below:

Project:

Tested By:

Location:

Boring No. :

Depth:

Details of sample

Diameter of specimen ..cm

Length of specimen(L) ..cm

Area of specimen (A) .cm2

Specific gravity of soil Gs ..

Volume of specimen (V) ..cm3

Weight of dry specimen (Ws) gm

Moisture content %

Experiment No.		1	2	3
Length of specimen	L(cm)			
Area of specimen	A(cm^2)			
Time t	(sec)			
Discharge	q(cm^3)			
Height of water	h(cm)			
Temperature	(^{0} C)			

FALLING HEAD METHOD

OBJECTIVE

To determine the coefficient of permeability of the given soil sample, using falling head method.

NEED AND SCOPE

The test results of the permeability experiments are used:

1.To estimate ground water flow.

2.To calculate seepage through dams.

3.To find out the rate of consolidation and settlement of structures.

4.To plan the method of lowering the ground water table.

1. Coefficient of Permeablity $= \dfrac{qL}{Ah}$

Discharge = Quantity of water collected (ml)/Time interval (sec)

2. The temperature correction shall be applied by the following formula :

$k_{27} = k_t \, x V_t / V_{27}$

where k_{27} = coefficient of permeability at $27^{\cdot 0}$ C.

k_t = Coefficient of permeability at t° C.

V_t = Coefficient of viscosity at t^0C.

V_{27} = Coefficient of viscosity at 27^0C.

3. Void Ratio, $e = \dfrac{VG_s \gamma_w - W_s}{W_s}$

where V = Volume of specimen in cm^3

G_s = Specific gravity of specimen

W_s = weight of dry specimen

γ_w = Density of water

γ_d = Dry density of soil sample

4. Degree of saturation

$S_r = G_s \, w/e$

Where w = Moisture content

e = Voids ratio.

5.To calculate the uplift pressure and piping.

6.To design the grouting.

7.And also for soil freezing tests.

8.To design pits for recharging.Thus the study of seepage of water through soil is very important, with wide field applications.

The falling head method of determining permeability is used for soil with low discharge, where as the constant head permeability test is used for coarse-grained soils with a reasonable discharge in a given time. For very fine-grained soil, capillarity permeability test is recommended.

PRINCIPLE OF THE EXPERIMENT

The passage of water through porous material is called seepage. A material with continuous voids is called a permeable material. Hence permeability is a property of a porous material which permits passage of fluids through inter connecting conditions. Hence permeability is defined as the rate of flow of water under laminar conditions through a unit cross-sectional area perpendicular to the direction of flow through a porous medium under unit hydraulic gradient and under standard temperature conditions.The principle behind the test is Darcys law for laminar flow. The rate of discharge is proportional to (i x A)

$$q= kiA$$

where q= Discharge per unit time.

A=Total area of c/s of soil perpendicular to the direction of flow.

i=hydraulic gradient.

k=Darcy’s coefficient of permeability =The mean velocity of flow that will occur through the cross-sectional area under unit hydraulic gradient.

PLANNING AND ORGANIZATION

The tools and accessories needed for the test are:

1.Permeameter with its accessories.

2.Standrd soil specimen.

3.Deaires water.

4.Balance to weigh up to 1 gm.

5.I.S sieves 4.75 mm and 2 mm.

6.Mixing pan.

7.Stop watch.

8.Measuring jar.

9.Meter scale.

10.Thermometer.

11.Container for water.

12. Trimming knife etc.

KNOWLEDGE OF EQUIPMENT

(a) The permeameter is made of non-corrodible material with a capacity of 1000 ml, with an internal diameter of 1000.1 mm and effective height of 127.3 0.1 mm.

(b) The mould has a detachable base plate and a removable exterior collar.

(c) The compacting equipment has a circular face with 50 mm diameter and a length of 310 mm with a weight of 2.6 kg.

(d) The drainage base is a porous disc, 12 mm thick with a permeability 10 times that of soil.

(e) The drainage cap is also a porous disc of 12 mm thickness with an inlet/outlet fitting.

(f) The container tank has an overflow valve. There is also a graduated jar to collect discharge.

(g) The stand pipe arrangements are done on a board with 2 or 3 glass pipes of different diameters.

PREPARATION OF THE SPECIMEN

The preparation of the specimen for this test is important. There are two types of specimen, the undisturbed soil sample and the disturbed or made up soil sample.

A. UNDISTURBED SOIL SPECIMEN

It is prepared as follows:

1. Note down-sample no., borehole no., depth at which sample is taken.

2.Remove the protective cover (wax) from the sampling tube.

3.Place the sampling tube in the sample extract or and push the plunger to get a cylindrical shaped specimen not larger than 85 mm diameter and height equal to that of the mould.

4.This specimen is placed centrally over the drainage disc of base plate.

5.The annular space in between the mould and specimen is filled with an impervious material like cement slurry to block the side leakage of the specimen.

6.Protect the porous disc when cement slurry is poured.

7.Compact the slurry with a small tamper.

8.The drainage cap is also fixed over the top of the mould.

9.The specimen is now ready for test.

B. DISTURBED SPECIMEN

The disturbed specimen can be prepared by static compaction or by dynamic compaction.

(a)Preparation of statically Compacted (disturbed) specimen.

1.Take 800 to 1000 gms of representative soil and mix with water to O.M.C determined by I.S Light Compaction test. Then leave the mix for 24 hours in an airtight container.

2.Find weight W of soil mix for the given volume of the mould and hence find the dry density γ_d *for* $W = \gamma_d(1+W)V$ *by weighing correct to 1 gm.*

3.Now, assemble the permeameter for static compaction. Attach the 3 cm collar to the bottom end of 0.3 liters mould and the 2 cm collar to the top end. Support the mould assembly over 2.5 cm end plug, with 2.5 cm collar resting on the split collar kept around the 2.5 cm- end plug. The inside of the 0.3 lit. Mould is lightly greased.

4.Put the weighed soil into the mould. Insert the top 3 cm end plug into the top collar, tamping the soil with hand.

5.Keep, now the entire assembly on a compressive machine and remove the split collar. Apply the compressive force till the flange of both end plugs touch the corresponding collars. Maintain this load for 1 mt and then release it.

6.Then remove the top 3 cm plug and collar place a filter paper on fine wire mesh on the top of the specimen and fix the perforated base plate.

7.Turn the mould assembly upside down and remove the 2.5 cm end plug and collar. Place the top perforated plate on the top of the soil specimen and fix the top cap on it, after inserting the seating gasket.

8.Now the specimen is ready for test.

(B) Preparation of Dynamically Compacted Disturbed sample:

1.Take 800 to 1000 gms of representative soil and mix it with water to get O.M.C, if necessary. Have the mix in airtight container for 24 hours.

2.Assemble the permeameter for dynamic compaction. Grease the inside of the mould and place it upside down on the dynamic compaction base. Weigh the assembly correct to a gram (w). Put the 3 cm collar to the other end.

3.Now, compact the wet soil in 2 layers with 15 blows to each layer with a 2.5 kg dynamic tool. Remove the collar and then trim off the excess. Weigh the mould assembly with the soil (W_2).

4.Place the filter paper or fine wore mesh on the top of the soil specimen and fix the perforated base plate on it.

5.Turn the assembly upside down and remove the compaction plate. Insert the sealing gasket and place the top perforated plate on the top of soil specimen. And fix the top cap.

6.Now, the specimen is ready for test.

EXPERIMENTAL PROCEDURE

1.Prepare the soil specimen as specified.

2.sturate it. Deaired water is preferred.

3.assemble the permeameter in the bottom tank and fill the tank with water.

4.Inlet nozzle of the mould is connected to the stand pipe. Allow some water to flow until steady flow is obtained.

5.Note down the time interval t for a fall of head in the stand pipe h.

6.Repeat step 5 three times to determine t for the same head.

7.Find a by collecting q for the stand pipe. weigh it correct to 1 gm and find a from q/h=a.

Therefore the coefficient of permeability

$$k = \frac{2.3 \times a \times L \times (\log_{10} h_{21} / h_2)}{A \times t} \quad cm/\sec$$

K at standard temperature of $27^{o}C = Kx\,\gamma_t / \gamma_{27}$

γ_t = Viscosity of water at temperature ,$t\,^{0}C$

γ_{27} = Viscosity of water at room temperature $27^{0}C$

Interpretation of the result

There are high values, medium values and lowvalues for permeability

$K > 10^{-1}$ $cm/\sec$, the permeability is high

$= 10^{-1}$ $cm/\sec$, it is medium

$< 10^{-1}$ $cm/\sec$, it is low.

Observation and Recording:

1.Area of stand pipe (dia. 5 cm a. …………

Sample No.	*Moulding water content :*
Dry density :	μ_{27} =
Specific gravity :	γ_{27} =
voids ratio :	

2.Cross sectional area of soil specimen A………

3.Length of soil specimen L……….

4.Initial reading of stand pipeh1………

5.Final reading of stand pipeh2

6.Time t…………

7.Test temperature T……….

8.Coefficient of permeability at T kt….. ……

9.Coefficient of permeability at 27o C k27………..

GENERAL REMARKS:

- **a.** During test there should be no volume change in the soil, there should be no compressible air present in the voids of soil i.e. soil should be completely saturated. The flow should be laminar and in a steady state condition.

B. Coefficient of permeability is used to assess drainage characteristics of soil, to predict rate of settlement founded on soil bed.

EXPERIMENT NO: 06

Conduct of 1-dimensional consolidation

OBJECTIVE

To determine the settlements due to primary consolidation of soil by conducting one dimensional test.

NEED AND SCOPE

The test is conducted to determine the settlement due to primary consolidation. To determine :

i. Rate of consolidation under normal load.
ii. Degree of consolidation at any time.
iii. Pressure-void ratio relationship.
iv. Coefficient of consolidation at various pressures.
v. Compression index.

From the above information it will be possible for us to predict the time rate and extent of settlement of structures founded on fine-grained soils. It is also helpful in analyzing the stress history of soil. Since the settlement analysis of the foundation depends mainly on the values determined by the test, this test is very important for foundation design.

PLANNING AND ORGANIZATION

Consolidometer consisting essentially

i. A ring of diameter = 60mm and height = 20mm
ii. Two porous plates or stones of silicon carbide, aluminum oxide or porous metal.
iii. Guide ring.
iv. Outer ring.
v. Water jacket with base.
vi. Pressure pad.
vii. Rubber basket.

viii. Loading device consisting of frame, lever system, loading yoke dial gauge fixing device and weights.
ix. Dial gauge to read to an accuracy of 0.002mm.
x. Thermostatically controlled oven.
xi. Stopwatch to read seconds.
xii. Sample extractor.
xiii. Miscellaneous items like balance, soil trimming tools, spatula, filter papers, sample containers.

PRINCIPAL INVOLVED

When a compressive load is applied to soil mass, a decrease in its volume takes place, the decease in volume of soil mass under stress is known as compression and the property of soil mass pertaining to its tendency to decrease in volume under pressure is known as compressibility. In a saturated soil mass having its void filled with incompressible water, decrease in volume or compression can take place when water is expelled out of the voids. Such a compression resulting from a long time static load and the consequent escape of pore water is termed as consolidation.

Then the load is applied on the saturated soil mass, the entire load is carried by pore water in the beginning. As the water starts escaping from the voids, the hydrostatic pressure in water gets gradually dissipated and the load is shifted to the soil solids which increases effective on them, as a result the soil mass decrease in volume. The rate of escape of water depends on the permeability of the soil.

1) From the sample tube, eject the sample into the consolidation ring. The sample should project about one cm from outer ring. Trim the sample smooth and flush with top and bottom of the ring by using a knife. Clean the ring from outside and keep it ready from weighing.
2) Remoulded sample :
   a) Choose the density and water content at which samples has to be compacted from the moisture density relationship.

b) Calculate the quantity of soil and water required to mix and compact.

c) Compact the specimen in compaction mould in three layers using the standard rammers

d) Eject the specimen from the mould using the sample extractor.

PROCEDURE

Saturate two porous stones either by boiling in distilled water about 15 minute or by keeping them submerged in the distilled water for 4 to 8 hrs. Wipe away excess water. Fittings of the consolidometer which is to be enclosed shall be moistened.

Assemble the consolidometer, with the soil specimen and porous stones at top and bottom of specimen, providing a filter paper between the soil specimen and porous stone. Position the pressure pad centrally on the top porous stone.

Mount the mould assembly on the loading frame, and center it such that the load applied is axial.

Position the dial gauge to measure the vertical compression of the specimen. The dial gauge holder should be set so that the dial gauge is in the begging of its releases run, allowing sufficient margin for the swelling of the soil, if any.

Connect the mould assembly to the water reservoir and the sample is allowed to saturate. The level of the water in the reservoir should be at about the same level as the soil specimen.

Apply an initial load to the assembly. The magnitude of this load should be chosen by trial, such that there is no swelling. It should be not less than 50 g/cm3 for ordinary soils & 25 g/cm2 for very soft soils. The load should be allowed to stand until there is no change in dial gauge readings for two consecutive hours or for a maximum of 24 hours.

Note the final dial reading under the initial load. Apply first load of intensity 0.1 kg/cm2 start the stop watch simultaneously. Record the dial gauge readings at various time intervals. The dial gauge readings are taken until 90% consolidation is reached. Primary consolidation is gradually reached within 24 hrs.

At the end of the period, specified above take the dial reading and time reading. Double the load intensity and take the dial readings at various time intervals. Repeat this procedure fir successive load increments. The usual loading intensity are as follows :

a. 0.1, 0.2, 0.5, 1, 2, 4 and 8 kg/cm2.

After the last loading is completed, reduce the load to of the value of the last load and allow it to stand for 24 hrs. Reduce the load further in steps of the previous intensity till an intensity of 0.1 kg/cm2 is reached. Take the final reading of the dial gauge.

Reduce the load to the initial load, keep it for 24 hrs and note the final readings of the dial gauge.

Quickly dismantle the specimen assembly and remove the excess water on the soil specimen in oven, note the dry weight of it.

OBSERVATION AND READING

Table I

Data and observation sheet for consolidation test pressure, compression and time.

Project : Name of the project

Borehole no. : 1

Depth of the sample : 2m

Description of soil :

Empty weight of ring : 635 gm

Area of ring : 4560 mm2 (45.60 cm2)

Diameter of ring : 76.2 mm (7.62 cm)

Volume of ring : 115.82 cm3. Height of ring : 25.4 (2.54 cm)
Specific gravity of soil sample No: Dial Gauge = 0.0127 mm (least count)

CALCULATIONS

Pressure Intensity (Kg/cm^2)	0.1	0.2	0.5	1	2	4	8
Elapsed Time							
0.25							
1							
2.5							
4							
6.25							
9							
16							
25							
30							
1 hr							
2 hrs							
4 hrs							
8 hrs							
24 hrs							

Observation Sheet for Consolidation Test : Pressure Voids Ratio

Applied pressure	Final dial reading	Dial change	Specimen hieght	Height solids	Height of voids	Void ration
0						
0.1						
0.2						
0.5						
1.0						
2.0						
4.0						
8.0						
4.0						
2.0						
1.0						
0.5						
0.2						
0.1						

1. **Height of solids** (H_S) is calculated from the equation

$$H_S = W_S/G\ \ A$$

2. **Void ratio.** Voids ratio at the end of various pressures are calculated from equation

$$e = (H\ \ H_S)/H_S$$

3**. Coefficient of consolidation**. The Coefficient of consolidation at each pressures increment is calculated by using the following equations :

i. $C_v = 0.197\ d^2/t_{50}$ (Log fitting method)
ii. $C_v = 0.848\ d^2/t_{90}$ (Square fitting method)

In the log fitting method, a plot is made between dial reading and logarithmic of time, the time corresponding to 50% consolidation is determined.

In the square root fitting method, a plot is made between dial readings and square root of time and the time corresponding to 90% consolidation is determined. The values of C_v are recorded in table II.

4. Compression Index. To determine the compression index, a plot of voids ratio (e) V_s logt is made. The initial compression curve would be a straight line and the slope of this line would give the compression index C_c.

5. Coefficient of compressibility. It is calculated as follows

$$a_v = 0.435\ C_c/\text{Avg. pressure for the increment}$$

where C_c = Coefficient of compressibility

6. Coefficient of permeability. It is calculated as follows

$$K = C_v.a_v \text{*(unit weight of water)}/(1+e).$$

Graphs

1. Dial reading V_S log of time or

Dial reading V_S square root of time.

2. Voids ratio V_S $\log\sigma$ (average pressure for the increment).

General Remarks

1. While preparing the specimen, attempts has to be made to have the soil strata orientated in the same direction in the consolidation apparatus.

2. During trimming care should be taken in handling the soil specimen with least pressure.

3. Smaller increments of sequential loading have to be adopted for soft soils.

EXPERIMENT NO: 07

Conduct of standard proctor compaction test.

THEORY:

In geotechnical engineering, soil compaction is the process in which a stress applied to a soil causes densification as air is Displaced from the pores between the soil grains. It is an instantaneous process and always takes place in partially saturated Soil (three phase system). The Proctor compaction test is a laboratory method of experimentally determining the Optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density

NEED &SCOPE:

Determination of the relationship between the moisture content and density of soils compacted in a mould of a given Size with a 2.5 kg rammer dropped from a height of 30 cm. the results obtained from this test will be helpful in increasing the Bearing capacity of foundations, Decreasing the undesirable settlement of structures, Control undesirable volume changes, Reduction in hydraulic conductivity, Increasing the stability of slope sand so on.

APPARATUS REQUIRED:

iv. Proctor mould having a capacity of 944 cc with an internal diameter of 10.2 cm and a height of 11.6 cm. The mould shall Have a detachable collar assembly and a detachable base plate.

v. Rammer: A mechanical operated metal rammer having a 5.08 cm diameter face and a weight of 2.5 kg. The rammer shall Be equipped with a suitable arrangement to control the height of drop to a free fall of 30 cm.

vi. Sample extruder, mixing tools such as mixing pan, spoon, towel, and spatula.

vii. A balance of 15 kg capacity, Sensitive balance, Straight edge, Graduated cylinder, Moisture tins.

PROCEDURE:

Take a representative oven-dried sample, approximately 5 kg in the given pan. Thoroughly mix the sample with sufficient Water to dampen it with approximate water content of 4-6 %. Weigh the proctor mould without base plate and collar. Fix the collar and base plate. Place the soil in the Proctor mould And compact it in 3 layers giving 25 blows per layer with the 2.5 kg rammer falling through. The blows shall be distributed

Uniformly over the surface of each layer.

- Remove the collar; trim the compacted soil even with the top of mould using a straight edge and weigh.
- Divide the weight of the compacted specimen by 944 cc and record the result as the bulk density
- Remove the sample from mould and slice vertically through and obtain a small sample for water content.
- Thoroughly break up the remainder of the material until it will pass a no.4 sieve as judged by the eye. Add water in
- Sufficient amounts to increase the moisture content of the soil sample by one or two percentage points and repeat the

- Above procedure for each increment of water added. Continue this series of determination until there is either a decrease or no change in the wet unit weight of the compacted soil.

OBSERVATIONS:

Mould Diameter ……….. cm, Height ……….. cm, Volume ………. Cc, Weight ……….. gm

GENERAL REMARKS:

Density						
Determination No.	1	2	3	4	5	6
Weight of water added, W_w (gm)						
Weight of mould + compacted soil (gm)						
Weight of compacted soil, W (gm)						
Average moisture content, w %						
Bulk density(gm /cc) = W / (Mould volume)						
Dry density (gm/cc) = Bulk density/(1+w)						
Water content						
Container No.						
Wt. of container (gm) = W_c						
Wt. Of container + wet soil (gm) = W_1						
Wt. Of container + dry soil (gm) = W_2						
Watercontent, $w = (W_2 - W_1)/(W_1 - W_c) \times 100\%$						

***Note:** Plot dry density vs. moisture content and find out the max dry density and optimum moisture for the soil.*

The peak point of the compaction curve:

The peak point of the compaction curve is the point with the maximum dry density dry density ρd max. Corresponding to the maximum dry density ρd max is a water content known as the optimum water content (also Known as the optimum moisture content, OMC). Note that the maximum dry density is only a maximum for a Specific compactive effort and method of compaction. This does not necessarily reflect the maximum dry density That can be obtained in the field.

Zero air voids curve:

The curve represents the fully saturated condition (S = 100 %). (It cannot be reached by compaction).

EXPERIMENT NO: 08

UNCONFINED COMPRESSION TEST

OBJECTIVE

determine shear parameters of cohesive soil

NEED AND SCOPE OF THE EXPERIMENT

It is not always possible to conduct the bearing capacity test in the field. Some times it is cheaper to take the undisturbed soil sample and test its strength in the laboratory. Also to choose the best material for the embankment, one has to conduct strength tests on the samples selected. Under these conditions it is easy to perform the unconfined compression test on undisturbed and remoulded soil sample. Now we will investigate experimentally the strength of a given soil sample.

PLANNING AND ORGANIZATION

We have to find out the diameter and length of the specimen.

EQUIPMENT

1. Loading frame of capacity of 2 t, with constant rate of movement. What is the least count of the dial gauge attached to the proving ring!
2. Proving ring of 0.01 kg sensitivity for soft soils; 0.05 kg for stiff soils.
3. Soil trimmer.
4. Frictionless end plates of 75 mm diameter (Perspex plate with silicon grease coating).
5. Evaporating dish (Aluminum container).
6. Soil sample of 75 mm length.
7. Dial gauge (0.01 mm accuracy).
8. Balance of capacity 200 g and sensitivity to weigh 0.01 g.
9. Oven, thermostatically controlled with interior of non-corroding material to maintain the temperature at the desired level. What is the range of the temperature used for drying the soil !
10. Sample extractor and split sampler.
11. Dial gauge (sensitivity 0.01mm).
12. Vernier calipers

EXPERIMENTAL PROCEDURE (SPECIMEN)

In this test, a cylinder of soil without lateral support is tested to failure in simple compression, at a constant rate of strain. The compressive load per unit area required to fail the specimen as called Unconfined compressive strength of the soil.

Preparation of specimen for testing

A. Undisturbed specimen

- Note down the sample number, bore hole number and the depth at which the sample was taken.
- Remove the protective cover (paraffin wax) from the sampling tube.
- Place the sampling tube extractor and push the plunger till a small length of sample moves out.

- Trim the projected sample using a wire saw.
- Again push the plunger of the extractor till a 75 mm long sample comes out.
- Cutout this sample carefully and hold it on the split sampler so that it does not fall.
- Take about 10 to 15 g of soil from the tube for water content determination.
- Note the container number and take the net weight of the sample and the container.
- Measure the diameter at the top, middle, and the bottom of the sample and find the average and record the same.
- Measure the length of the sample and record.
- Find the weight of the sample and record.

B. Moulded sample

a. For the desired water content and the dry density, calculate the weight of the dry soil Ws required for preparing a specimen of 3.8 cm diameter and 7.5 cm long.
b. Add required quantity of water Ww to this soil.
c. Ww = WS × W/100 gm

d. Mix the soil thoroughly with water.
e. Place the wet soil in a tight thick polythene bag in a humidity chamber and place the soil in a constant volume mould, having an internal height of 7.5 cm and internal diameter of 3.8 cm.
f. After 24 hours take the soil from the humidity chamber and place the soil in a constant volume mould, having an internal height of 7.5 cm and internal diameter of 3.8 cm.
g. Place the lubricated moulded with plungers in position in the load frame.
h. Apply the compressive load till the specimen is compacted to a height of 7.5 cm.
i. Eject the specimen from the constant volume mould.
j. Record the correct height, weight and diameter of the specimen.

Test procedure

- Take two frictionless bearing plates of 75 mm diameter.Place the specimen on the base plate of the load frame (sandwiched between the end plates)
- Place a hardened steel ball on the bearing plate.
- Adjust the center line of the specimen such that the proving ring and the steel ball are in the same line.
- Fix a dial gauge to measure the vertical compression of the specimen.
- Adjust the gear position on the load frame to give suitable vertical displacement.
- Start applying the load and record the readings of the proving ring dial and compression dial for every 5 mm compression.
- Continue loading till failure is complete.

Draw the sketch of the failure pattern in the specimen.

Project : Tested by :

Location : Boring No. :

Depth :

Sample details

Type UD/R : soil description

Specific gravity (GS) 2.71 Bulk density

Water content Degree of saturation .%

Diameter (Do) of the sample cm Area of cross-section = cm2

Initial length (Lo) of the sample = 76 mm

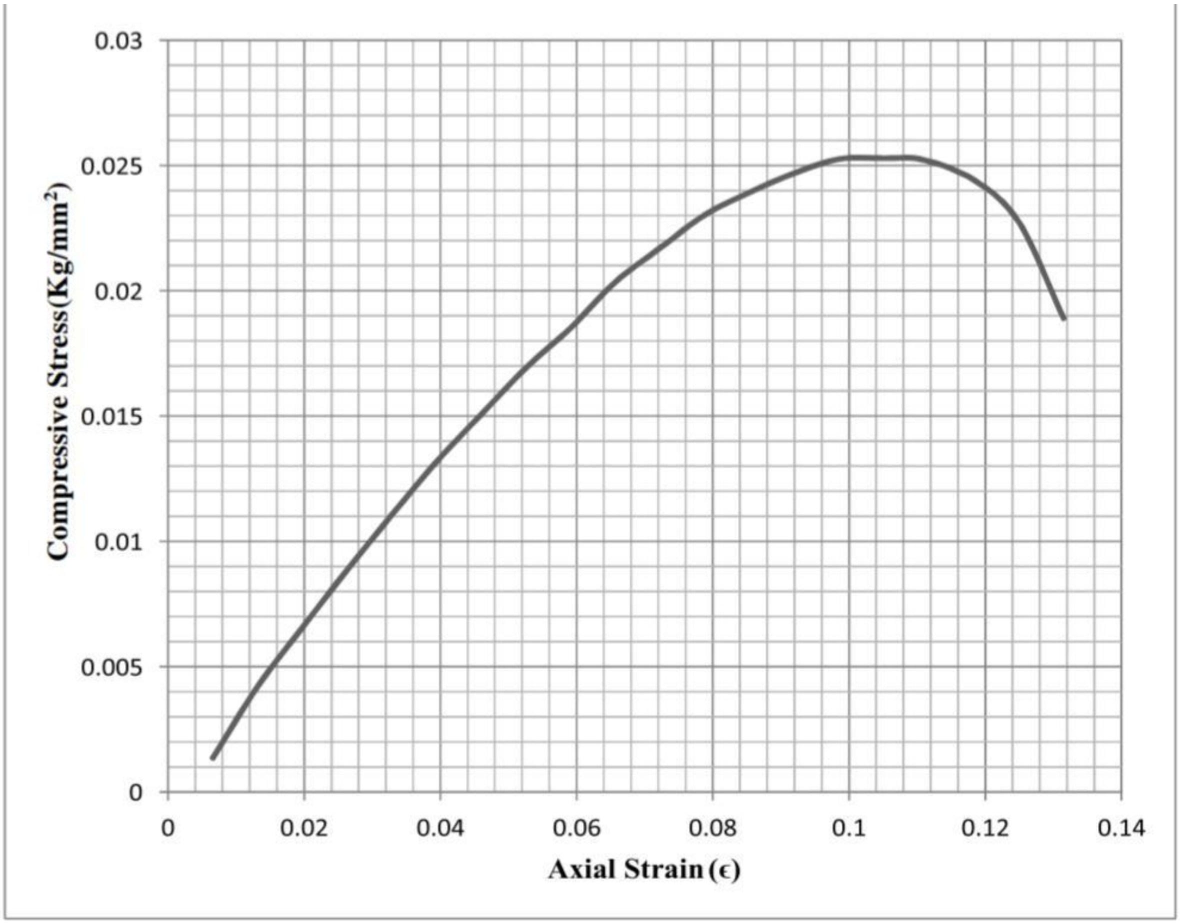
Elapsed time (minutes) 1	Compression dial reading (L) (mm) 2	Strain L� 100/L_0 (%) (e) 3	Area A A_0 /(1-e) $(cm)^2$ 4	Proving ring reading (Divns.) 5	Axial load (kg) 6	Compressive stress (kg/cm^2) 7

Interpretation and Reporting

Unconfined compression strength of the soil = qu =

Shear strength of the soil = qu/2 =

Sensitivity = (qu for undisturbed sample)/ (qu for remoulded sample).



STRESS STRAIN CURVE OF SOIL

General Remarks. Minimum three samples should be tested, correlation can be made between unconfined strength and field SPT value N. Upto 6% strain the readings may be taken at every min (30 sec).

EXPERIMENT NO: 09

DIRECT SHEAR TEST

Objective

To determine the shearing strength of the soil using the direct shear apparatus.

NEED AND SCOPE

In many engineering problems such as design of foundation, retaining walls, slab bridges, pipes, sheet piling, the value of the angle of internal friction and cohesion of the soil involved are required for the design. Direct shear test is used to predict these parameters quickly. The laboratory report cover the laboratory procedures for determining these values for cohesionless soils.

PLANNING AND ORGANIZATION

Apparatus

1. Direct shear box apparatus
2. Loading frame (motor attached).
3. Dial gauge.
4. Proving ring.
5. Tamper.
6. Straight edge.
7. Balance to weigh upto 200 mg.
8. Aluminum container.
9. Spatula.

KNOWLEDGE OF EQUIPMENT:

Strain controlled direct shear machine consists of shear box, soil container, loading unit, proving ring, dial gauge to measure shear deformation and volume changes. A two piece square shear box is one type of soil container used.

A proving ring is used to indicate the shear load taken by the soil initiated in the shearing plane.

PROCEDURE

1. Check the inner dimension of the soil container.

2. Put the parts of the soil container together.

3. Calculate the volume of the container. Weigh the container.

4. Place the soil in smooth layers (approximately 10 mm thick). If a dense sample is desired tamp the soil.

5. Weigh the soil container, the difference of these two is the weight of the soil. Calculate the density of the soil.

6. Make the surface of the soil plane.

7. Put the upper grating on stone and loading block on top of soil.

8. Measure the thickness of soil specimen.

9. Apply the desired normal load.

10. Remove the shear pin.

11. Attach the dial gauge which measures the change of volume.

12. Record the initial reading of the dial gauge and calibration values.

13. Before proceeding to test check all adjustments to see that there is no connection between two parts except sand/soil.

14. Start the motor. Take the reading of the shear force and record the reading.

15.Take volume change readings till failure.

16. Add 5 kg normal stress 0.5 kg/cm^2 and continue the experiment till failure

17. Record carefully all the readings. Set the dial gauges zero, before starting the experiment

DATA CALCULATION SHEET FOR DIRECT SHEAR TEST

Normal stress 0.5 kg/cm^2 L.C=....... P.R.C=.........

Horizontal Gauge Reading (1)	Vertical Dial gauge Reading (2)	Proving ring Reading (3)	Hori.Dial gauge Reading Initial reading div. gauge (4)	Shear deformation Col.(4) x Leastcount of dial (5)	Vertical gauge reading Initial Reading (6)	Vertical deformation= div.in col.6 xL.C of dial gauge (7)	Proving reading Initial reading (8)	Shear stress = div.col.(8)x proving ring constant Area of the specimen(kg/cm^2) (9)
0								
25								
50								
75								
100								
125								
150								
175								
200								
250								
300								
400								
500								
600								
700								
800								
900								

Normal stress 1.0 kg/cm^2 L.C=.......
P.R.C=........

Horizontal Gauge Reading (1)	Vertical Dial gauge Reading (2)	Proving ring Reading (3)	Hori.Dial gauge Reading Initial reading div. gauge (4)	Shear deformation Col.(4) x Leastcount of dial (5)	Vertical gauge reading Initial Reading (6)	Vertical deformation= div.in col.6 xL.C of dial gauge (7)	Proving reading Initial reading (8)	Shear stress = div.col.(8)x proving ring constant Area of the specimen(kg/cm^2) (9)
0								
25								
50								
75								
100								
125								
150								
175								
200								
250								
300								
400								
500								
600								
700								
800								
900								

Normal stress 1.5 kg/cm^2 L.C=.......
P.R.C=........

Horizontal Gauge Reading (1)	Vertical Dial gauge Reading (2)	Proving ring Reading (3)	Hori.Dial gauge Reading Initial reading div. gauge (4)	Shear deformation Col.(4) x Leastcount of dial (5)	Vertical gauge reading Initial Reading (6)	Vertical deformation= div.in col.6 xL.C of dial gauge (7)	Proving reading Initial reading (8)	Shear stress = div.col.(8)x proving ring constant Area of the specimen(kg/cm^2) (9)
0								
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125								
150								
175								
200								
250								
300								
400								
500								
600								
700								
800								
900								

OBSERVATION AND RECORDING

Proving Ring constant…….   Least count of the dial……..

Calibration factor……. Leverage factor……..

Dimensions of shear box 60 x 60 mm. Empty weight of shear box……..

Least count of dial gauge……… Volume change…….

S.No	Normal load (kg)	Normal stress(kg/cm^2) load x leverage/Area	Normal stress(kg/cm^2) load x leverage/Area	Shear stress proving Ring reading x calibration / Area of container
1				
2				
3				

GENERAL REMARKS

1. In the shear box test, the specimen is not failing along its weakest plane but along a predetermined or induced failure plane i.e. horizontal plane separating the two halves of the shear box. This is the main draw back of this test. Moreover, during loading, the state of stress cannot be evaluated. It can be evaluated only at failure condition i.e Mohrs circle can be drawn at the failure condition only. Also failure is progressive.
2. Direct shear test is simple and faster to operate. As thinner specimens are used in shear box, they facilitate drainage of pore water from a saturated

sample in less time. This test is also useful to study friction between two materials one material in lower half of box and another material in the upper half of box.

3. The angle of shearing resistance of sands depends on state of compaction, coarseness of grains, particle shape and roughness of grain surface and grading. It varies between 28o(uniformly graded sands with round grains in very loose state) to 46o(well graded sand with angular grains in dense state).
4. The volume change in sandy soil is a complex phenomenon depending on gradation, particle shape, state and type of packing, orientation of principal planes, principal stress ratio, stress history, magnitude of minor principal stress, type of apparatus, test procedure, method of preparing specimen etc. In general loose sands expand and dense sands contract in volume on shearing. There is a void ratio at which either expansion contraction in volume takes place. This void ratio is called critical void ratio. Expansion or contraction can be inferred from the movement of vertical dial gauge during shearing.
5. The friction between sand particle is due to sliding and rolling friction and interlocking action.
6. The ultimate values of shear parameter for both loose sand and dense sand approximately attain the same value so, if angle of friction value is calculated at ultimate stage, slight disturbance in density during sampling and preparation of test specimens will not have much effect.

EXPERIMENT NO: 10

TRIAXIAL TEST

OBJECTIVE

To find the shear of the soil by Undrained Triaxial Test.

NEED AND SCOPE OF THE TEST

The standard consolidated undrained test is compression test, in which the soil specimen is first consolidated under all round pressure in the triaxial cell before failure is brought about by increasing the major principal stress. It may be perform with or without measurement of pore pressure although for most applications the measurement of pore pressure is desirable.

PLANNING AND ORGANIZATION

Knowledge of Equipment

1. A constant rate of strain compression machine of which the following is a brief description of one is in common use.
2. A loading frame in which the load is applied by a yoke acting through an elastic dynamometer, more commonly called a proving ring which used to measure the load. The frame is operated at a constant rate by a geared screw jack. It is preferable for the machine to be motor driven, by a small electric motor.
3. A hydraulic pressure apparatus including an air compressor and water reservoir in which air under pressure acting on the water raises it to the required pressure, together with the necessary control valves and pressure dials.
4. A triaxial cell to take 3.8 cm dia and 7.6 cm long samples, in which the sample can be subjected to an all round hydrostatic pressure, together with a vertical compression load acting through a piston. The vertical load from the piston acts on a pressure cap. The cell is usually designed with a non-ferrous metal top and base connected by tension rods and with walls formed of perspex

Apparatus for preparation of the sample

a) 3.8 cm (1.5 inch) internal diameter 12.5 cm (5 inches) long sample tubes.
b) Rubber ring.
c) An open ended cylindrical section former, 3.8 cm inside dia, fitted with a small rubber tube in its side.
d) Stop clock
e) Moisture content test apparatus.
f) A balance of 250 gm capacity and accurate to 0.01 gm.

Experimental Procedure

The sample is placed in the compression machine and a pressure plate is placed on the top. Care must be taken to prevent any part of the machine or cell from jogging the sample while it is being setup, for example, by knocking against this bottom of the loading piston. The probable strength of the sample is estimated and a suitable proving ring selected and fitted to the machine.

- The cell must be properly set up and uniformly clamped down to prevent leakage of pressure during the test, making sure first that the sample is properly sealed with its end caps and rings (rubber) in position and that the sealing rings for the cell are also correctly placed.
- When the sample is setup water is admitted and the cell is fitted under water escapes from the beed valve, at the top, which is closed. If the sample is to be tested at zero lateral pressure water is not required.
- The air pressure in the reservoir is then increased to raise the hydrostatic pressure in the required amount. The pressure gauge must be watched during the test and any necessary adjustments must be made to keep the pressure constant.
- The handle wheel of the screw jack is rotated until the under side of the hemispherical seating of the proving ring, through which the loading is applied, just touches the cell piston.

- The piston is then removed down by handle until it is just in touch with the pressure plate on the top of the sample, and the proving ring seating is again brought into contact for the begging of the test.

Observation and Recording

The machine is set in motion (or if hand operated the hand wheel is turned at a constant rate) to give a rate of strain 2% per minute. The strain dial gauge reading is then taken and the corresponding proving ring reading is taken the corresponding proving ring chart. The load applied is known. The experiment is stopped at the strain dial gauge reading for 15% length of the sample or 15% strain.

Operator : Sample No:

Date : Job :

Location : Size of specimen :

Length : Proving ring constant :Diameter : 3.81 cm
Initial area L:Initial Volume : Strain dial least count (const) :

Cell pressure kg/cm² 1	Strain dial 2	Proving ring reading 3	Load on sample kg 4	Corrected area cm² 5	Deviator stress 6
0.5	0 50 100 150 200 250 300 350 400 450				
0.5	0 50 100 150 200 250 300 350 400 450				
0.5	0 50 100 150 200 250 300 350 400 450				

Sample No.	Wet bulk density gm/cc	Cell pressure kg/cm²	Compressive stress at failure	Strain at failure	Moisture content	Shear strength (kg/cm²)	Angle of shearing resistance
1. 2. 3.							

EXPERIMENT NO: 11

VANE SHEAR TEST

OBJECTIVE

To find shear strength of a given soil specimen.

NEED AND SCOPE

The structural strength of soil is basically a problem of shear strength.

Vane shear test is a useful method of measuring the shear strength of clay. It is a cheaper and quicker method. The test can also be conducted in the laboratory. The laboratory vane shear test for the measurement of shear strength of cohesive soils, is useful for soils of low shear strength (less than 0.3 kg/cm2) for which triaxial or unconfined tests can not be performed. The test gives the undrained strength of the soil. The undisturbed and remoulded strength obtained are useful for evaluating the sensitivity of soil.

PLANNING AND ORGANIZATION

EQUIPMENT

1.Vane shear apparatus.

2.Specimen.

3.Specimen container.

4.Callipers.

EXPERIMENTAL PROCEDURE

1.Prepare two or three specimens of the soil sample of dimensions of at least 37.5 mm diameter and 75 mm length in specimen.(L/D ratio 2 or 3).

2.Mount the specimen container with the specimen on the base of the vane shear apparatus. If the specimen container is closed at one end, it should be provided with a hole of about 1 mm diameter at the bottom.

3.Gently lower the shear vanes into the specimen to their full length without disturbing the soil specimen. The top of the vanes should be atleast 10 mm below the top of the specimen. Note the readings of the angle of twist.

4.Rotate the vanes at an uniform rate say 0.1o/s by suitable operating the torque application handle until the specimen fails.

5.Note the final reading of the angle of twist.

6.Find the value of blade height in cm.

7.Find the value of blade width in cm.

CALCULATIONS

Shear strength, $S = T / \pi(D^2H/2 + D^3)$

Where S = shear strength of soil in kg/cm2

T = torque in cm kg

D = overall diameter of vane in cm

T = spring constant / 180o x difference in degrees.

OBSERVATIONS:

Name of the project:

Soil description:

S.No	Initial Reading (Deg)	Final Reading (Deg.)	Difference (Deg.)	T=Spring Constant/180x Difference Kg-cm	$G = 1/\pi(D^2H/2 + D^3/6)$	S=TxG Kg/cm^2	Average 'S' Kg/cm^2	Spring Constant Kg-cm

GENERAL REMARKS:

This test is useful when the soil is soft and its water content is nearer to liquid limit.