LAB MANUAL FOR

GEOTECHNICAL ENGINEERING LAB

(III YEAR- I SEMESTER)

UNDER GRADUATE

DEPARTMENT OF CIVIL ENGINEERING

MALLA REDDY ENGINEERING COLLEGE (AUTONOMOUS)

(An Autonomous Institution approved by UGC and affiliated to JNTUH, Approved by AICTE, Accredited by NAAC with 'A' Grade and NBA & Recipient of World Bank Assistance under TEQIP Phase- II S.C.1.1)

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PREFACE

This laboratory manual contains the details of the laboratory experiment as per the curriculum of B.Tech under JNTU. The laboratory manual helps the student to understand the aim and then procedure Further the student will also come to know the application of this laboratory in future endeavoring civil engineering projects.

The **Geotechnical Engineering Laboratory** helps the student to understand the test procedures and it will helpful to them in the field practices. This laboratory manual also contains the sample viva voce questions and sample external experiments which will be asked frequently during the regular labs. Further the information regarding the experiments to be incorporated in the syllabus is also mentioned.

The precautions to be taken and the code of conduct is also incorporated at the end.

1.OBJECTIVE, RELEVANCE AND OUTCOME

OBJECTIVE & RELEVANCE

Soil is one of the very important engineering materials. Determination of soil conditions is the most significant task in every civil engineering activity. Properties of the soil can be determined by both field and laboratory test methods. It is critical to quantify the various properties of soil in order to predict its behavior under different loading conditions for the safe design of soil structures. This laboratory is a compulsory and basic undergraduate course where introduction to Geotechnical Engineering will be provided and also for graduate level research students.

The main objectives of the Geotechnical Engineering lab will be:

1) Provide civil engineering students with the basic knowledge to carry out field investigations and to indentify soils in Geotechnical engineering practice.

2) Educate civil engineering students in performing and interpretation of laboratory tests for evaluating sub grade performance and for pavement design.

3) Knowledge of and ability to perform laboratory tests needed to determine soil design parameters.

4) Ability to design and conduct experiments as well as analyze and interpret data.

2 OUTCOMES :

1. Knowledge of site specific field investigations including collection Of soil samples for testing and observation of soil behavior/ Building damage.

2. Be able to identify and classify soil based on standard geotechnical engineering practice.

3. Be able to perform laboratory compaction and in-place density Tests for fill quality control.

4. Be able to perform and evaluate un soaked and soaked California Bearing ratio (CBR) tests used to estimate sub grade behavior during construction and beneath permanent structures.

5. Be able to perform and interpret direct shear tests and estimate Shear strength parameters.

6. Be able to conduct and estimate shear strength of soils in unconfined compression.

7. Be able to perform and analyze constant head permeability tests.

8. Be able to conduct one-dimensional compression tests and estimate Settlement parameters.

9. Be able to develop and implement laboratory procedures to test Geotechnical engineering concept(s).

3. LIST OF EXPERIMENTS

1. Atterberg's Limits.
2. Field density-core cutter and sand replacement method
3. Grain size analysis
4. Permeability of soil, constant and variable head test
5. Compaction test
6. CBR Test
7. Consolidation test
8. Unconfined compression test
9. Tri-axial Compression test
10. Direct shear test.
11. Vane shear test

4 SYLLABUS ANALYSIS

S.No	Name of the Experiment	Unit No	Text/Reference Books
1	Atterberg's Limits.	2	**T:70-74**
2	2. Field density-core cutter and sand replacement method	2	**T1:73-76**
3	3. Grain size analysis	2	**T:57-59**
4	4. Permeability of soil, constant and variable head test	3	**T:137-140**
5	5. Compaction test	5	**T:358-360**
6	6. CBR Test	8	**T1:775-777**
7	7. Consolidation test	7	**T1:354-355**
8	8. Unconfined compression test	8	**T1:442-443**
9	9. Tri-axial Compression test	8	**T1:436-439**

10	10. Direct shear test.	8	**T1:434-436**
11	11. Vane shear test	8	**T:450-451**

TEXT AND REFERENCE BOOKS

Text Books

1. **T**-Arora, K. R., "Soil Mechanics & Foundation Engineering", Standard Publishers, 2005.
2. Venkataramaiah, C.,"Geotechnical Engineering" (3rd Edn.), New Age International (P) Ltd., New Delhi, 2005.
3. Gulhati, S.K. and Datta, M., "Geotechnical Engineering", Tata McGraw-Hill, New Delhi, 2005.
4. **T1**-Soilmechanics And Foundation By B.C.PUNMIA, Lakshmi Publications

Reference Books

1. Terzaghi, K. and Peck, R.B., "Soil Mechanics in Engineering Practice", John Wiley & Sons, USA, 1967.
2. Gopal Ranjan and Rao, A. S. R., "Basic & Applied Soil Mechanics", New Age International Publishers, 2000.
3. IS 1498-1970, "IS code of Practice for classification and identification of soils for general engineering purposes", Bureau of Indian Standards, New Delhi.
4. IS 2720, "IS code of Practice for methods of test for soils. (Latest Edition)". Bureau of Indian Standards, New Delhi.

5. SESSION PLAN

SL.NO	**Week no.**	**Unit no.**	**Activity**	**Remarks**
1	1	1-8	Introduction To GE Lab	Prerequisite
2	2	2	1. Atterberg’s Limits.	MREC(A)
3	3	2	2. Field density-core cutter and sand replacement method	MREC(A)
4	4	2	3. Grain size analysis	MREC(A)
5	5	3	4. Permeability of soil, constant and variable head test	MREC(A)
6	6	5	5. Compaction test	MREC(A)
7	7	8	6. CBR Test	MREC(A)
8	8	7	7. Consolidation test	MREC(A)
9	9	8	8. Unconfined compression test	MREC(A)
10	10	8	9. Tri-axial Compression test	MREC(A)
11	11	8	10. Direct shear test.	MREC(A)
12	12	8	11. Vane shear test	MREC(A)

EQUIPMENT USED IN LAB

EQUIPMENTS USED IN GE LAB
1.UNCONFINED COMPRESSIVE TEST:

It consists of a load frame 50 kN capacity. The lower platen is moved up for applying load. The top cross head is adjustable and carries hexagonal adaptor for taking standard proving rings. A strain dial gauge bracket is provided and fitted to one of the pillars. The instruments is supplied with upper and lower platens, an adaptor for the proving ring and a cone seating. Supplied complete with Proving Ring 2 kN capacity & Dial Gauge 0.01 x 25mm.

3.COMPACTION TEST

The Proctor compaction mold and hammer is 4" in diameter and 4.584" in height. The inner volume is 1/30 ft^3. The height of fall of the hammer is 12".
Weight of the rammer: 2.5Kg
Diameter of the hammer: 50mm
Drop: 300mm
Dia of the compaction mold: Φ100×127mm

4.Falling Head Permeability Test

The equipment comprises one each: Gun metal mould, 100mm I.D. x 127.3mm high x 1000ml Volume

* Gun metal mould extension collar, 100mm diameter x 60mm high for the above mould
* Tested in the mould: 10 mm
* Range of: 0 10-3 to 10-7 cm/sec

5.CONSTANT HEAD PERMEABILITY TEST

This equipment is used for testing the permeability of granular soils (sands and gravels).The specimen is formed in a permeability cell and water is passed through
it from a constant level tank. Take-off points located along the sides of the permeability cell are connected to three manometer tubes mounted on a panel complete with a metre scale. Water passing through the specimen is collected and measured, either for a specific quantity or over a period of time. The reduction of head is noted from the variation of water level in the manometer tubes

6.CORE CUTTER

The core cutter is driven into the soil using the driving hammer. Then the core is dug out, trimmed, weighed, dried and the density and moisture content calculated. Made of steel protected against corrosion. The set includes core cutter, driving dolly and driving rammer. Two versions available: dia. 100x 130 mm high and dia. 150x180 mm core.

7. Liquid limit devices (Casagrande)

Used to determine the moisture content at which clay soils pass from a plastic to a liquid state.

Comprises: removable brass cup, adjustable crank and cam mechanism, blow counter, and base. Different versions are available conforming to the various Standards in use. They are identical in shape and differ, generally, from the type of base and weight of the cup. Furthermore all versions are available either manually or motor operated. The grooving tools, which also refer to the different Standards, are not included and have to ordered separately.

Weights approx.:
Standard versions 2 kg
Motorized versions 4 kg

8. Plastic Limit Determination Equipments

Used for determining the lowest moisture content of a soil at which the sample can be rolled into little rolls, 3 mm dia., without breakages.
The set includes:
Plastic limit plate, 300x300 mm
Stainless steel rod 3 mm dia.
Mixing dish 120 mm dia.
Flexible spatula
Moisture content tin dia. 75 x 30 mm (Q.ty 6)
9.Triaxial Shear Test

Consists of -

1. Load frame, Motorized, Capacity 50 kN, to give 6 rates of strain Proving Ring ‘BENT’, 2.5 kN. Dial Gauge, 0.01 x 25 mm

2. Triaxial Cell ‘BENT’, for 38 mm dia. x 76 mm high specimen for lateral pressure upto 10 kg./cm^2 (0 – 150)psi

3. Pore Pressure Apparatus ‘BENT’, for measurement of low negative and positive pore pressures, high pore pressures upto 10 kg/cm^2

4. Volume Change Gauge ‘BENT’, for measurement of large volume changes with a sensitivity of 0.003 ml/mm with 6 ml volume of fluid per cycle.

5. Lateral Pressure Assembly ‘BENT’, 10 kg./cm^2, with pressure gauge and foot pump

6. Self Compensating Constant Pressure System (Oil / Water type) ‘BENT’, pressure range 10 kg/cm^2, rotated through reduction gear

6 EXPERIMENTAL DETAILS

EXPERIMENT 1A

6.1.1 Determination of liquid limit of the soil

Ref : IS:2720 (Part V) -1985

PREAMBLE

AIM : To determine the liquid limit of a soil.

APPARATUS : The mechanical liquid limit device, grooving tool, porcelain evaporating dish, flat glass plate, spatula, palette knives, balance, oven, wash bottle with distilled water and containers, soil sample passing 425 micron IS Sieve.

Theory: The liquid limit (LL) is arbitrarily defined as the water content, in percent, at which a pat of soil in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm (1/2 in.) when subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of two shocks per second.

The liquid limit (LL) is often conceptually defined as the water content at which the behavior of a clayey soil changes from plastic to liquid. Actually, clayey soil does have a very small shear strength at the liquid limit and the strength decreases as water content increases; the transition from plastic to liquid behavior occurs over a range of water contents. The precise definition of the liquid limit is based on standard test procedures described below.

Procedure : The liquid limit is determined in the laboratory with the aid of the standard mechanical liquid limit device designed by Arther Caragrande and adopted by the ISI. The apparatus consists of a hard vulcanised rubber compound base with a brass cup suitably mounted. The brass cup can be raised and made to fall on the rubber base through a cam arrangement operated by a handle. The height of fall of the cup can be adjusted with the help of an adjusting screw. Before the start of the test, the height of fall of the cup is adjusted to 10mm. A grooving tool is used to make a groove in the part of soil placed in the cup. Depending upon the type of soil, two types of grooving tools are used. These are a] Casagrande Tool whick make a groove of 2mm width at the central bottom and 11mm width at the top and 8mm deep and b] ASTM tool which cuts a groove of 2mm wide at bottom, 13.6mm wide at top.

About 120 gm of soil passing through 425 micron IS:Sieve is taken and mixed with water such that the soil attains a pretty like paste or consistency. A portion of the paste is placed in the cup and is levelled with the spatula so as to have a max. depth of about 10mm. A groove is cut in the soil placed in the cup using the grooving tool. In cutting the groove, the grooving tool is drawn through along the symmetrical axis of the cup holding the tool perpendicular to the cup. The handle is rotated at the rate of 2 revolutions per second and the number of blows necessary to close the groove over a length of 12 or 13mm is noted. The groove should close by flow and not by slippage of soil. Then about 10 gm of the soil near the closed groove is taken and its water content is determined.

By altering the water content of the paste and repeating the operations mentioned above for four to five readings of water content in the range of 10 to 40 or 50 blows.

A grapth is then plotted between number of blows, N on logarithmic scale and the water content, W on the natural scale. It will be seen that the semi logarithmic plot is a straight line and is called the " Flow curve".

The liquid limit is determined from the plot by noting the water content corresponding to 25 blows on the flow curve.

From the definition of liquid limit, all soils possess the same value of shearing strength at liquid limit. It is about 27 gm/cm^2.

Observations

Tabular Form for observations for liquid limit test.

S.No./Trial No.	Number of blows, N	Water content, W
1		
2		
3		
4		
5		

Determination of water content for each trial.

Container No. …………………….

Empty weight of container with Lid (W_1) gm

Weight of container + wet soil (W_2) gm

Weight of container + dry soil (W_3) gm

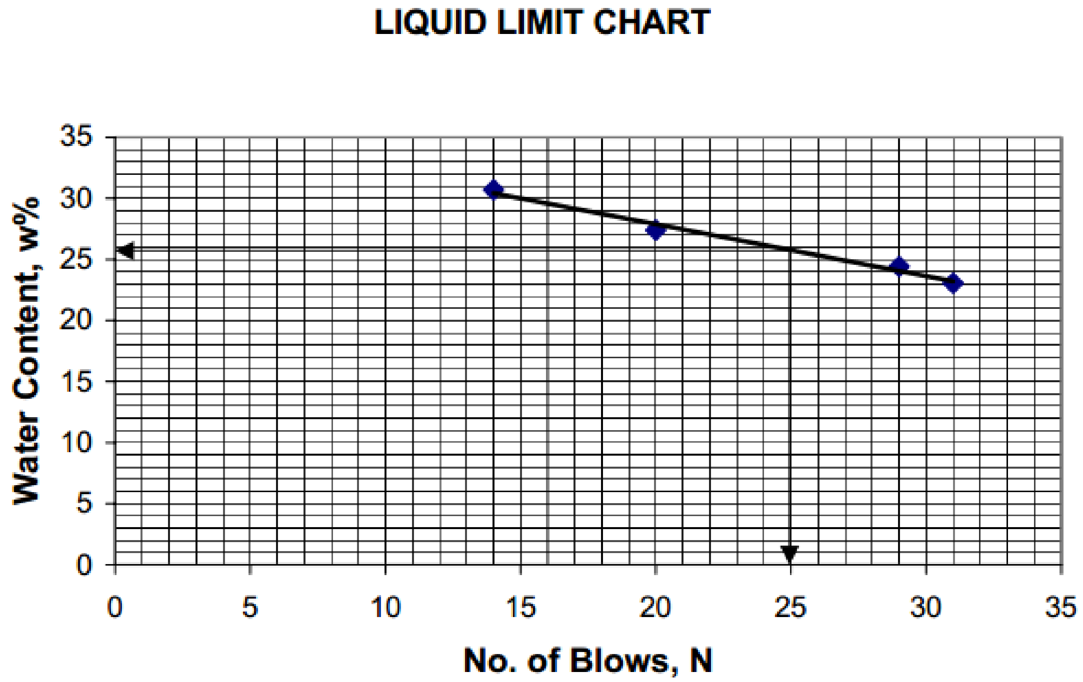
Weight of dry soil, W_s, gm (W_3 - W_1) gm

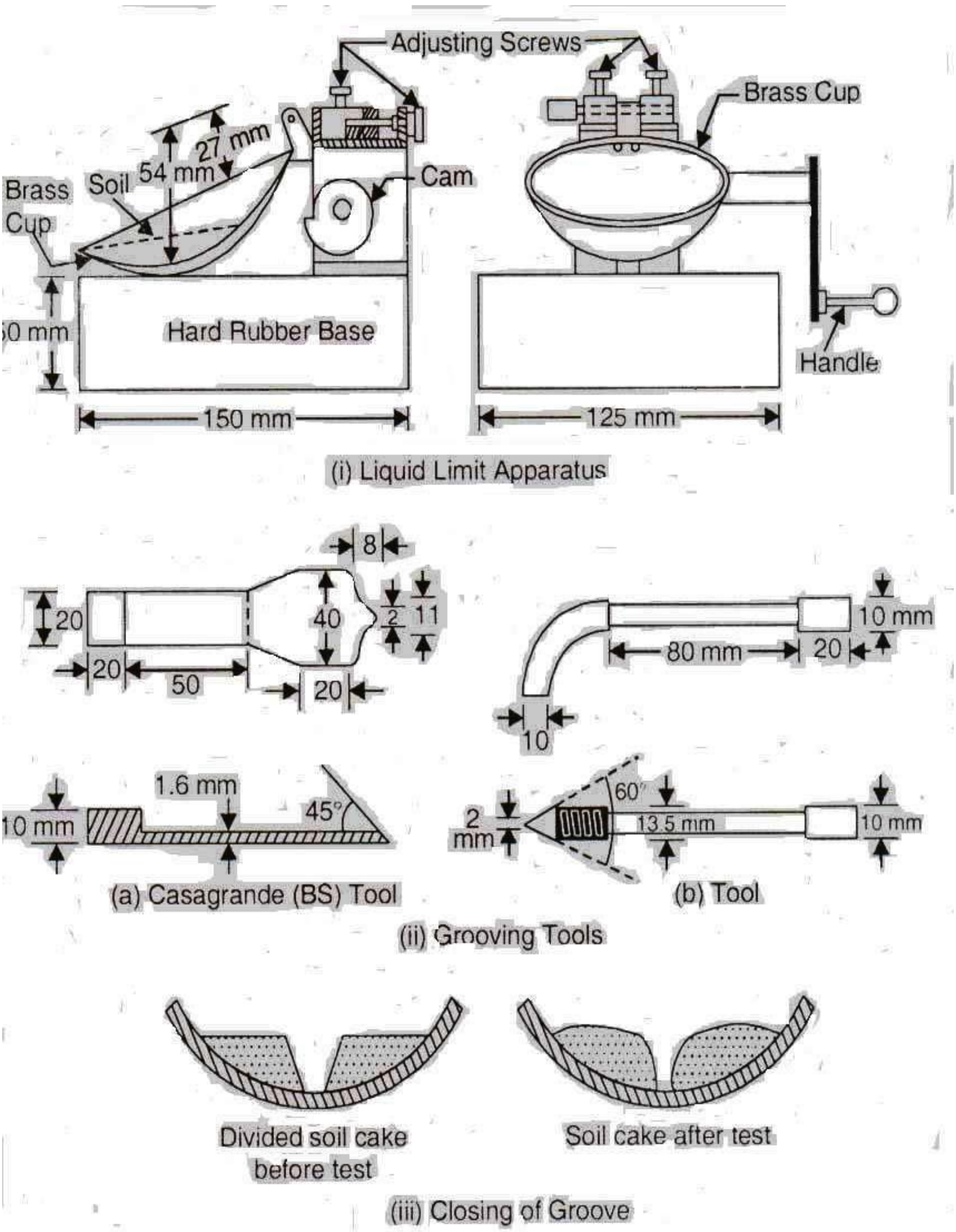
Weight of water, W_w, gm (W_2 – W_3) gm

$$\text{Water content, } w = \frac{(W_2 - W_3)}{(W_3 - W_1)} \times 100$$

Four to five trials may be performed such that the number of blows are obtained between 10 to 50.

Graphs





LIQUID LIMIT APPARATUS

Application

This testing method is used as an integral part of several engineering classifications systems to characterize the finegrained fractions of soils and to specify the finegrained fraction of construction materials. The liquid limit, plastic limit and plasticity index of soils are also used extensively, either individually or together, with other soil properties to correlate with engineering behavior such as compressibility, permeability, compactibility, shrinkswell and shear strength.

Viva voce

1. What are atterberg limits?
2. Define liquid limit. How are they useful in classifying soils?
3. Name the apparatus commonly used for determining liquid limit?
4. Name the sieve no. used in preparing soil sample.
5. If plastic limit is greater than or equal to limit limit, how will you report I_p of the soil.
6. Is soil fully saturated at shrinkage limit?
7. What is the value of shear strength of soil possessed at limit liquid?
8. What is the size of groove cut?
9. What is the rate of revolution of the mechanical device?

EXPERIMENT 1B

6.1.2 Determination of plastic limit of the soil

Ref : IS:2720 (Part V) -1985

AIM : To determine the plastic limit of a soil.

APPARATUS : Porcelain evaporating dish of about 12cm in dia or a flat glass plate. 10mm thick and 45cm square, spatula 8cm long and 2cm wide, a ground glass plate of about 20 x 15cm for surface rolling, balance, oven, containers and a rod of 3mm in dia and about 10mm long.

Procedure : The soil specimen passing IS:Sieve 425 microns and about 25 to 30 gm is mixed thoroughly with distilled water until the soil mass becomes plastic enough to be easily moulded with fingers. The plastic soil mass should be left for enough time to allow water to permeate through the soil mass. A ball is formed with about 8 to 10 gm of this plastic soil mass and rolled between fingers and over the ground glass plate with just sufficient pressure to roll the mass into a thread of uniform dia throughout its length. When a dia of 3mm is approximately reached, the soil is remoulded again in to ball. The ball is again rolled into a thread over the glass plate to an approximate dia of 3mm.

The process of rolling, remoulding is repeated until the thread at the approximate dia of 3mm starts just crumbling (i.e. shows surfacial cracks). The crumbled threads are taken and the water content is determined which is called the plastic limit.

If for this soil the liquid limit is determined then plasticity index, $I_p = W_L - W_p$

W_L=Liquid limit , W_p=Plastic limit

From the flow curve, compute the flow index as

$$I_f = \frac{W_1 - W_2}{Log_{10} \frac{N_2}{N_1}}$$

$$I_t = \frac{I_p}{I_f}$$

Then obtain the value of toughness index as
Observations for determinig plastic limit.

Trial No.	1	2
Container No.		
Weight of empty container with lid, W_1 gm		
Weight of container + wet soil (W_2) gm		
Weight of container + dry soil (W_3) gm		
Weight of water = (W_2 – W_3) gm		
Weight of Dry soil = (W_3 – W_1) gm		
Water content, $w = \frac{(W_2 - W_3)}{(W_3 - W_1)} \times 100$		

This water content is called the plastic limit.

EXPERIMENT 2A
6.2.1 Determination of in-situ density of soil by core cutter Method

Ref : IS:2720 (Part XXIX) -1975 : Methods of test for soils – Determination of in-situ density by the core cutter method.

AIM : To determine the in-place density of a soil using core cutter method.

APPARATUS : A core cutter of Mild steel provided with a cutting edge at its bottom and with a 25mm high dolly to fit its top; A metal rammer; a steel scale and a spaturba; A balance with a weight box.

Procedure : The apparatus consists of mild steel cylindrical in shape open at top and bottom and provided with a cutting edge and dolly of 25 mm in height to fit its top and a metal rammer.

The core cutter is 10cm in dia and 12.5 cm in height. (However these measurements must be made carefully with a steel scale and recorded). The core cutter is manufactured to give a volume of 1000cc. The dolly fitted to its top is 2.5cm in height. The bottom 1 cm of the core cutter is sharpened in to a cutting edge. The empty weight of the core cutter without dolly is found – W_1 gm. The site where the soil's in-situ density is to be determined is cleaned and levelled. The core cutter with the dolly in position is placed on the levelled portion. It is gently driven into the soil completely with the dolly by means of a rammer. After driving completely, the soil surrounding the core cutter is excavated with a small crowbar so as to enable to cut the bottom of the core cutter with a spatula and the total unit is removed from the position and kept on a plane surface. The surfaces of soil at top (remove the dolly gently from its position) and bottom are then, trimmed with a spatula gently so as to be flush with the top and bottom of the core cutter.

The core cutter in this position is cleaned carefully from outside.

Now the weight of core cutter with the wet soil (without dolly) is determined as W_2 gm.

Now the weight of wet soil = $W_2 - W_1$ gm

The in-situ soil is generally assumed to be moist.

$$\text{In-situ moist density of soil} = \frac{\text{Weight of moist soil}}{\text{Volume of soil (gm/cc)}}$$

The volume of the soil is equal to the volume of core cutter.

A small but representative sample from the core cutter is then taken and its moisture content is determined (w)

$$\text{Now the Dry Density of in-situ soil} = \frac{\text{Wet or moisture density}}{1 + w}$$

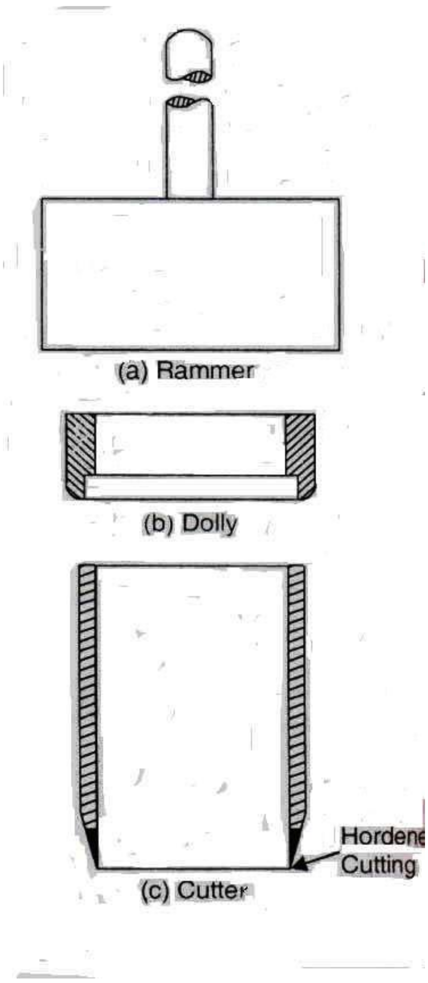
It is always preferable to express the soil density in terms of its dry density because the dry density for the soil at any given place and at any time is constant.

	Trial 1	**Trial 2**
Empty wt. of core cutter without dolly (gm) (w_1)		
Wt. of core cutter with soil trimmed flush with top & bottom (gm) (w_2)		
Weight of moist soil gm $W = (W_2 - W_1)$		
Height of Core cutter (cm)		

Volume of core cutter equal to volume of soil = V_{cc}		
Bulk or moist density of soil gm/cc w/v		
Wt. of container with moist soil (gm) (w_1)		
Empty wt. of container gm (w_3)		
Weight of containing with dry soil gm (w_2)		
Weight of water (W_2 - W_1) gm		
Wt. of dry soil (gm) Ws=($W_2 – W_3$)		
Water content (%) $W = \frac{(W_1 – W_2)}{(W_2 – W_3)} \times 100$		
Dry Density (gm / cc) $= \frac{\text{Wet density}}{1 + w}$		

Average Moist density = ………………………….. gm / cc

Average dry density = ………………………….. gm / cc


(a) Rammer
(b) Dolly
Hordene
Cutting
(c) Cutter

EXPERIMENT 2B

6.2.2 Determination of in-situ density by sand replacement methods

Ref : IS:2720 (Part XXVIII) -1974. Methods of test for soils –
Determination of In-place density by sand replacement method.

AIM : To determine the In-place density of a soil by sand replacement method.

APPARATUS : Sand pouring cylinder, spatula, excavating tools a tray with central hole, weighing unit, scoop etc., calibrating can.

Procedure : The equipment in the sand replacement method consists of

i) A sand pouring cylinder mounted above a pouring cone and separated by a valve or shutter
ii) Calibrating container
iii) Tray with central circular hole and
iv) A small excavating tool, scoop, balance etc.

The procedure consists of

a] Calibration of the cylinder
b] measurement of soil density
c] determination of water content and dry density

a] Calibration of the cylinder :- This consists of the determination of the weight of sand required to fill the pouring cone of the cylinder and the determination of the bulk density of sand.

Uniformly graded, dry, clean sand preferably passing 600 micron sieve and retained on 300 micron sieve is used in the cylinder. The cylinder is filled up to a height (¾ the level) or 1cm below the top and its initial weight W_1 gm is recorded. The cylinder is then placed on a plane surface the valve is opened and the sand is allowed to run out to fill the conical portion below. When no further sand runs out, the valve is closed. The weight of sand pouring cylinder with the sand after filling the conical portion is determined as W_2 gm.

Now weight of sand filling the conical portion = W_1- W_2 gm. Now the sand pouring cylinder with the sand (after W_2 is recorded) is placed centrally over the calibrating can such that the axis of the sand pouring cylinder coincides with the axis of calibrating can. Now release sand to fill the calibration can and the conical portion. When no sand runs out, close the valve and find the weight of sand pouring cylinder with the remaining sand after filling calibrating can the conical portion. Let this weight be W_3

Now weight of sand filling the calibrated can

$$= (W_2 - W_3) - (W_1 - W_2)$$

Volume of calibrating can = V_{cc} (a known quantity)
(generally supplied by manufacturer)

$$\text{Unit weight of sand} = r_{sand} = \frac{\text{Weight of sand filling calibrated can}}{\text{Volume of calibrating can}}$$

Measurement of the unit weight of in place soil :

The site at which the in-situ unit weight is to be determined is cleaned and levelled. A square tray with a central hole in it is placed on the cleaned surface. A hole of the dia equal to the dia of the hole in the tray and a depth of about 10-15 cm is made in the ground. The excavated soil is carefully collected in to the tray and weighed. Next the sand pouring cylinder with the sand (after W_3 is taken) is placed on the hole in the tray carefully and the falling of sand is released. The excavated pit and the conical portions are filled and when no further sand falls the valve is closed and the weight of sand pouring cylinder with the remaining sand is determined and recorded as W_4 .

Now the weight of sand filling the excavated pit and conical portion = $W_3 - W_4$

Weight of sand filling the excavated pit = $(W_3 - W_4) – (W_1 - W_2)$

$$\text{Volume of sand filling the excavated pit} = \frac{\text{Weight of sand filling excavated pit}}{\text{Density of sand}}$$

This volume of sand filling the excavated pit is nothing but the volume of soil excavated from pit.

$$\therefore \frac{\text{Weight of sand filling excavated pit}}{r_{sand}}$$ - is the volume of soil excavated from pit.

$$\text{Now in-situ density soil} = \frac{\text{Wet (bulk) density (gm/cc)}}{\text{Volume of soil excavated from pit}}$$

The core cutter method for this purpose cannot be used in the case of hard or gravelly soils.

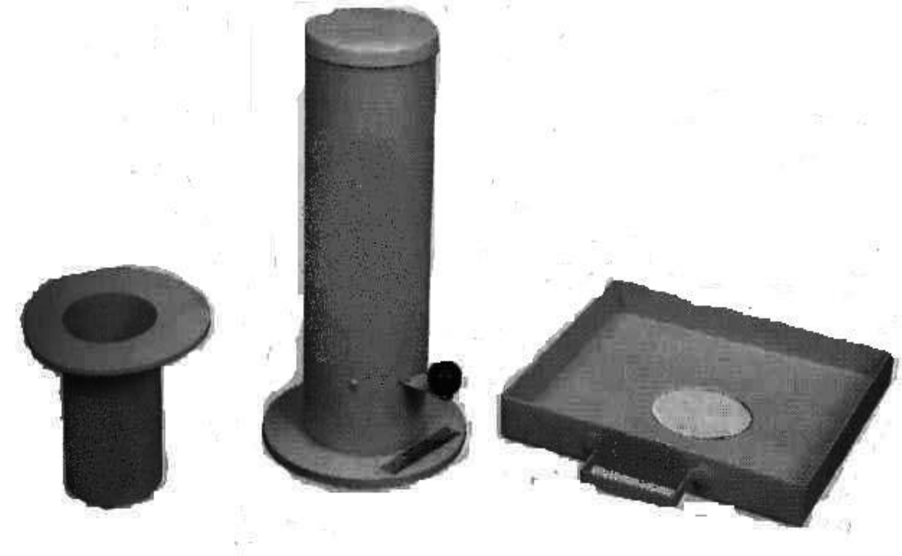
Under such situations the sand replacement method is convenient.

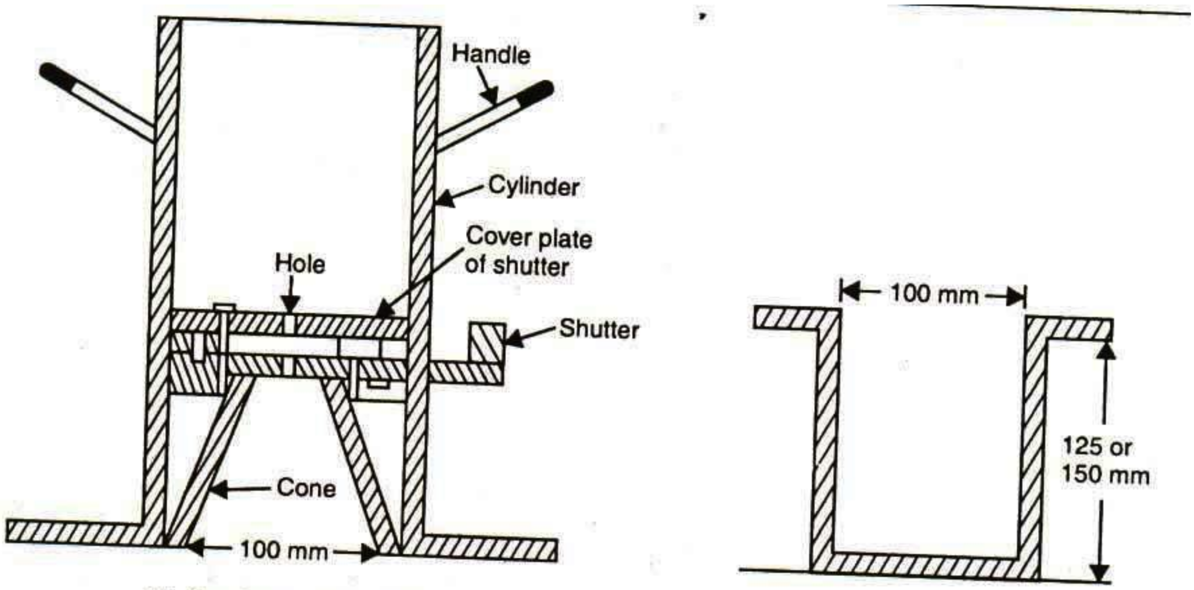
Observation sheet for sand-replacement method for in-situ density of soil.

Wt. of sand pouring cylinder + ¾ sand (gm) (W_1)	
Wt. of empty sand pouring cylinder (gm) (W_2)	
Wt. of sand pouring cylinder + remaining sand after filling conical portion (W_3) (gm)	
Wt. of sand filling conical portion (W_4) (gm) $W_4 = (W_1 – W_3)$ gm	
Wt. of sand pouring cylinder + sand after filling pit and conical portion (W_5) (gm)	
Wt. of sand filling pit and conical portion (W_6) (gm) $W_6 = (W_3 – W_5)$	
Wt. of sand filling only pit portion (gm) (W_7) $W_7 = (W_6 – W_4)$	
Volume of sand occupying pit portion (cc) $= \frac{\text{Weight of sand filling pit portion}}{\text{Density of sand}}$ This is equal to volume of soil removed from pit =V	

Density of sand used in the test :

Wt. of calibrated can + sand flush with top of can (gm) (W_1)	
Empty weight of calibrated can (gm) (W_2)	
Wt. of sand in calibrated can W gm $W = W_1 - W_2$	
Dia. of calibrated can (cm) (D)	
Height of calibrated can (H) (cm)	
Volume of calibrated can $V = \frac{\Pi D^2}{4} x H$ cc	
Density of sand $r_{sand} = \frac{W}{V}$ gm/cc	
Wt. of soil excavated from pit and collected in to calibrated can + wt. of can = W_3 gm	
Wt. of soil only excavated from pit = W gm $W = (W_3 - W_2)$	
In-situ density of soil = r_b $r_b = \frac{W}{V}$ gm/cc	





(a) Sand-pouring cylinder

(b) Calibrating container

Sand pouring cylinder

EXPERIMENT 3A

6.3.1 Determination of Particle size distribution (Mechanical Analysis) by Sieve Analysis Method

Ref : IS:2720 (Part IV) -1985 – Test Procedure for sieve Analysis.

AIM : To determine the particle size distribution of a coarse grained soil by a sieve analysis test and classify the soil.

APPARATUS : Set of IS:Sieves; Wire brush; balance porcelin containers to keep the soil fractions, etc.

Procedure : The percentage of various sizes of particles in a given dry soil sample is found by a particle size analysis or mechanical analysis. By mechanical analysis is meant the separation of soil into its different size fractions. The mechanical analysis is performed in two stages:

i] Sieve Analysis and ii] Sedimentation Analysis or Wet Mechanical Analysis.

The fist stage is meant for coarse grained soils only while the second stage is performed for fine grained soils.

In general, a soil sample may contain both coarse grained particles and as well as fine particles and hence both the stages of the mechanical analysis may be necessary. The sieve analysis is, however, the true representative of grain size distribution since the test is not effected by temperature etc.

In the Indian standard (IS:460:1962), the sieves are designated by the size of aperture in mm.

The following IS : sieves are generally used in a sieve analysis procedure. The sieves are cleaned with a brush for any soil particles sticking in the sieve openings.

The sieves aer 4.75mm; 2.36mm; 1.18 mm; 500 micron or 600 micron; 300 micron ; 150 micron ; 75 micron.

In the dry sieve analysis a suitable quantity of (generally 500gm) pulverized dry soil is taken and is sieved through a set of selected sieves arranged according to their sizes with the largest aperture sieve at the top and the smallest aperture sieve at the bottom. A receiver is kept at the bottom and a cover is kept at the top of the whole assembly. The soil sample is put on the top sieve and the whole assembly is fitted on a sieve shaking machine. The amount of shaking depends upon the shape and number of particles. However 10 minutes of shaking by a mechanical shaker is usually sufficient for soils with smallest particles. The portion of the soil sample retained on each sieve is weighed. The percentage of soil retained on each sieve is calculated on the basis of total weight of sample taken and from these results the percent passing through each is calculated (also termed as percent finer than) as shown below

$$\% \text{ retained on a particular sieve} = \frac{\text{Weight of soil retained on that particular sieve}}{\text{Total weight of soil taken}} \times 100$$

Cumulative % retained = sum of %retained on all sieves of larger sizes and the % retained on that particular sieve.

Percentage finer than the sieve under reference = 100% - cumulative% retained.

The finest sieve size used in the sieve analysis is 75 microns or 0.075 mm.

The results of grain size analysis are usually represented in the form of a graph.

The aggregate or cumulative weight as a percentage of the total weight of all grains smaller than any given diameter is plotted on the ordinate using an arithmetical scale and the size of the soil particle (or particle diameter) in mm is plotted on the abscissa using a logarithmic scale. In view of the very large range of particle sizes, a logarithmic scale becomes necessary.

The plot generally of curve is called "particle size distribution curve" or "Grain size distribution curve". From the curve the gradation of the soil can be studied and the soil is classified from the plot and the results from the plot.

Total weight of by soil taken =

Sieve Size mm	Weight retained gm	% wt. retained	Cumulative % wt. retained	% finer than
4.75				
2.36				
1.18				
0.6				
0.3				
0.15				
0.075				
-0.075				

EXPERIMENT 3B

6.3.2 Determination of Particle size distribution (Mechanical Analysis) by Hydrometer Analysis Method

Purpose:

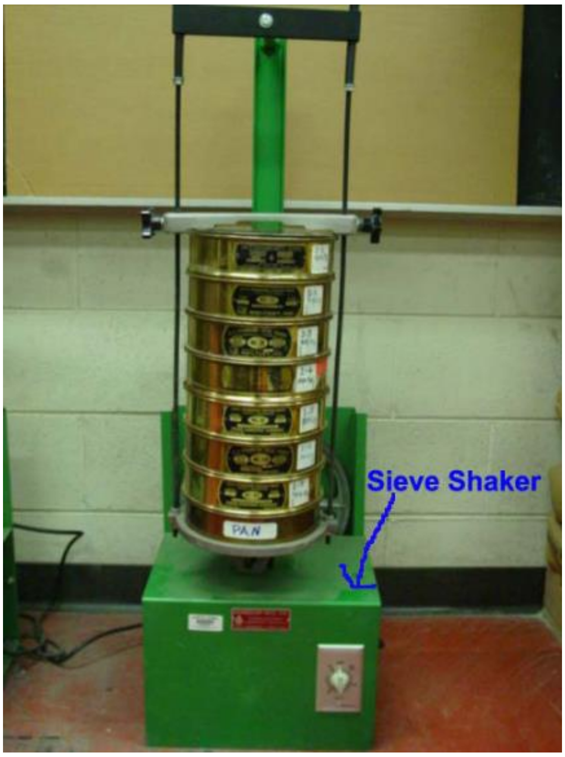
This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles, and the hydrometer method is used to determine the distribution of the finer particles.

Significance:

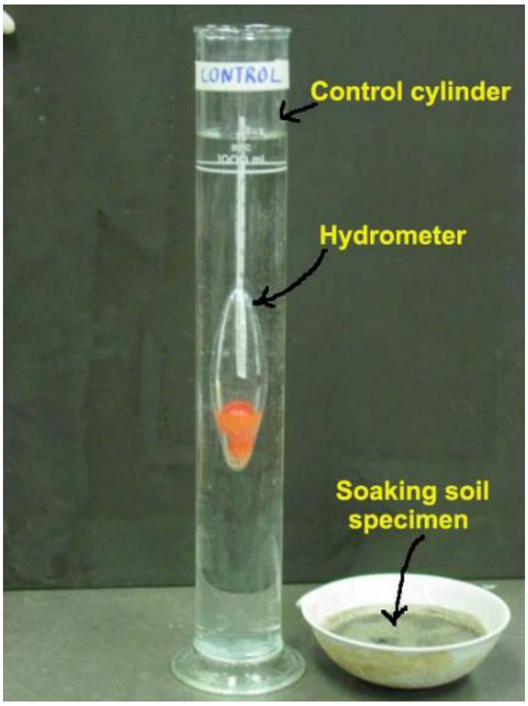
The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil.

Equipment:

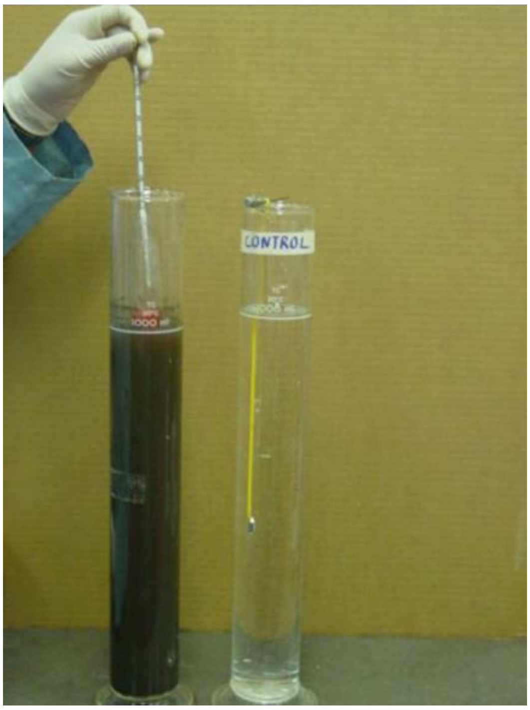
Balance, Set of sieves, Cleaning brush, Sieve shaker, Mixer (blender), 152H Hydrometer, Sedimentation cylinder, Control cylinder, Thermometer, Beaker, Timing device.


Sieve Shaker
PAN


Adventurer


CONTROL
Control cylinder
Hydrometer
Soaking soil specimen


Soaked soil specimen
Blender



Test Procedure:

Sieve Analysis:

(1) Write down the weight of each sieve as well as the bottom pan to be used in the analysis.

(2) Record the weight of the given dry soil sample.

(3) Make sure that all the sieves are clean, and assemble them in the ascending order of sieve numbers (#4 sieve at top and #200 sieve at bottom). Place the pan below #200 sieve. Carefully pour the soil sample into the top sieve and place the cap over it.

(4) Place the sieve stack in the mechanical shaker and shake for 10 minutes.

(5) Remove the stack from the shaker and carefully weigh and record the weight of each sieve with its retained soil. In addition, remember to weigh and record the weight of the bottom pan with its retained fine soil.

Hydrometer Analysis:

(1) Take the fine soil from the bottom pan of the sieve set, place it into a beaker, and add 125 mL of the dispersing agent (sodium hexameta-phosphate (40 g/L)) solution. Stir the mixture until the soil is thoroughly wet. Let the soil soak for at least ten minutes.

(2) While the soil is soaking, add 125mL of dispersing agent into the control cylinder and fill it with distilled water to the mark. Take the reading at the top of the meniscus formed by the hydrometer stem and the control solution. A reading less than zero is recorded as a negative (-) correction and a reading between zero and sixty is recorded as a positive (+) correction. This reading is called the zero correction. The meniscus correction is the difference between the top of the meniscus and the level of the solution in the control jar (Usually about +1). Shake the control cylinder in such a way that the contents are mixed thoroughly. Insert the hydrometer and thermometer into the control cylinder and note the zero correction and temperature respectively.

(3) Transfer the soil slurry into a mixer by adding more distilled water, if necessary, until mixing cup is at least half full. Then mix the solution for a period of two minutes.

(4) Immediately transfer the soil slurry into the empty sedimentation cylinder. Add distilled water up to the mark.

(5) Cover the open end of the cylinder with a stopper and secure it with the palm of your hand. Then turn the cylinder upside down and back upright for a period of one minute. (The cylinder should be inverted approximately 30 times during the minute.)

(6) Set the cylinder down and record the time. Remove the stopper from the cylinder. After an elapsed time of one minute and forty seconds, very slowly and carefully insert the hydrometer for the first reading. (Note: It should take about ten seconds to insert or remove the hydrometer to minimize any disturbance, and the release of the hydrometer should be made as close to the reading depth as possible to avoid excessive bobbing).

(7) The reading is taken by observing the top of the meniscus formed by the suspension and the hydrometer stem. The hydrometer is removed slowly and placed back into the control cylinder. Very gently spin it in control cylinder to remove any particles that may have adhered.

(8) Take hydrometer readings after elapsed time of 2 and 5, 8, 15, 30, 60 minutes and 24 hours

Data Analysis:

Sieve Analysis:

(1) Obtain the mass of soil retained on each sieve by subtracting the weight of the empty sieve from the mass of the sieve + retained soil, and record this mass as the weight retained on the data sheet. The sum of these retained masses should be approximately equals the initial mass of the soil sample. A loss of more than two percent is unsatisfactory.

(2) Calculate the percent retained on each sieve by dividing the weight retained on each sieve by the original sample mass.

(3) Calculate the percent passing (or percent finer) by starting with 100 percent and subtracting the percent retained on each sieve as a cumulative procedure.

For example: Total mass = 500 g

Mass retained on No. 4 sieve = 9.7 g
Mass retained on No. 10 sieve = 39.5 g

For the No.4 sieve:
Quantity passing = Total mass - Mass retained
= 500 - 9.7 = 490.3 g

The percent retained is calculated as;
% retained = Mass retained/Total mass
= (9.7/500) X 100 = 1.9 %

From this, the % passing = 100 - 1.9 = 98.1 %
For the No. 10 sieve:
Quantity passing = Mass arriving - Mass retained
= 490.3 - 39.5 = 450.8 g

% Retained = (39.5/500) X 100 = 7.9 %
% Passing = 100 - 1.9 - 7.9 = 90.2 %
(Alternatively, use % passing = % Arriving - % Retained
For No. 10 sieve = 98.1 - 7.9 = 90.2 %)

(4) Make a semilogarithmic plot of grain size vs. percent finer.

(5) Compute Cc and Cu for the soil.

Hydrometer Analysis:

(1) Apply meniscus correction to the actual hydrometer reading.

(2) From Table 1, obtain the effective hydrometer depth L in cm (for eniscus corrected reading).

(3) For known Gs of the soil (if not known, assume 2.65 for this lab purpose), obtain the value of K from Table 2.

(4) Calculate the equivalent particle diameter by using the following formula:

$$D = K\sqrt{\frac{L}{t}}$$

Where t is in minutes, and D is given in mm.

(5) Determine the temperature correction *CT* from Table 3.

(6) Determine correction factor "*a*" from Table 4 using Gs.

(7) Calculate corrected hydrometer reading as follows:
Rc = RACTUAL - zero correction + CT

(8) Calculate percent finer as follows:

$$P = \frac{Rc \times a}{W_S} \times 100$$

Where WS is the weight of the soil sample in grams.

(9) Adjusted percent fines as follows:

$$P_A = \frac{P \times F_{200}}{100}$$

F200 = % finer of #200 sieve as a percent

(10) Plot the grain size curve D versus the adjusted percent finer on the semilogarithmic sheet.

Grain Size Analysis

Sieve Analysis

Visual Classification of Soil: Brown Clayey to silty sand, trace fine gravel

Weight of Container: _______ gm

Wt. Container+Dry Soil: _______ gm

Wt. of Dry Sample: _______ gm

Sieve Number	Diameter (mm)	Mass of Empty Sieve (g)	Mass of Sieve+Soil Retained (g)	Soil Retained (g)	Percent Retained	Percent Passing
4	**4.75**					
10	**2.0**					
20	**0.84**					
40	**0.425**					
60	**0.25**					
140	**0.106**					
200	**0.075**					
Pan	**---**					
				Total Weight =		

From Grain Size Distribution Curve:

% Gravel= D10= ____ mm

% Sand= D30= ____ mm

% Fines= D60= ____ mm

Cu= _______________ CC= _________

Unified Classification of Soil: _________

Hydrometer Analysis

Specific Gravity of Solids : ________

Dispersing Agent : _________

Weight of Soil Sample : _________gm

Zero Correction : _________

Meniscus Correction : _________

Date	Time	Elapsed Time (min)	Temp. OC	Actual Hydro. Rdg. Ra	Hyd. Corr. for Meniscus	L from Table 1	K from Table 2	D Mm	CT from Table 3

Unified Classification of Soil:

EXPERIMENT 4A

6.4.1 Coefficient of Permeability (Soil Head Test) :

Purpose:

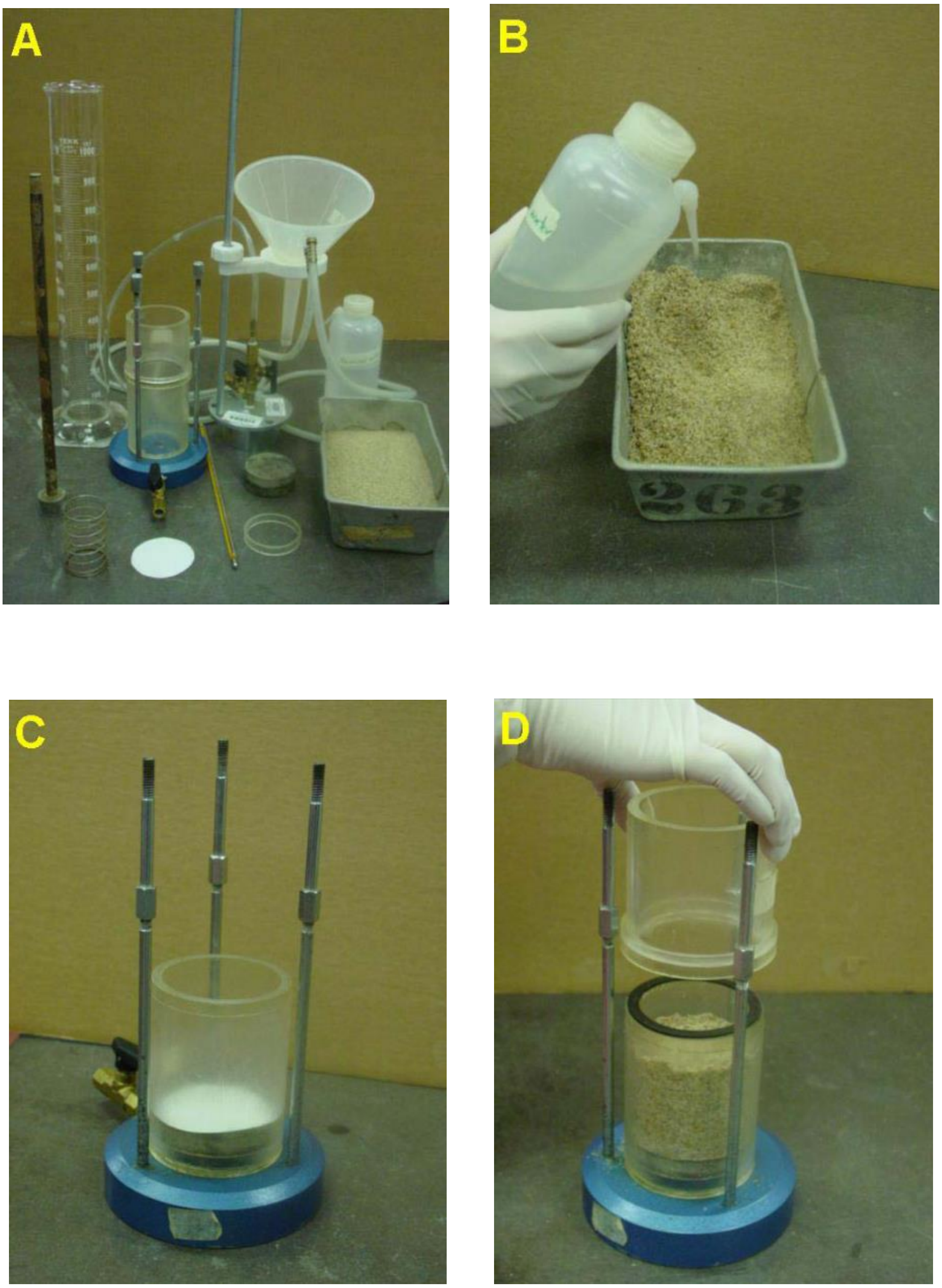
The purpose of this test is to determine the permeability (hydraulic conductivity) of a sandy soil by the constant head test method. There are two general types of permeability test methods that are routinely performed in the laboratory: (1) the constant head test method, and (2) the falling head test method. The constant head test method is used for permeable soils ($k>10^{-4}$ cm/s) and the falling head test is mainly used for less permeable soils ($k<10^{-4}$ cm/s).

Significance:

Permeability (or hydraulic conductivity) refers to the ease with which water can flow through a soil. This property is necessary for the calculation of seepage through earth dams or under sheet pile walls, the calculation of the seepage rate from waste storage facilities (landfills, ponds, etc.), and the calculation of the rate of settlement of clayey soil deposits.

Equipment:

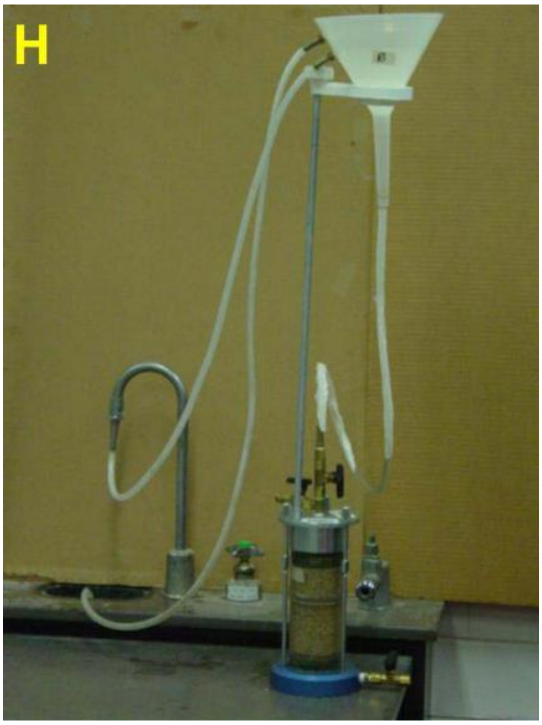
Permeameter, Tamper, Balance, Scoop, 1000 mL Graduated cylinders, Watch (or Stopwatch), Thermometer, Filter paper


A
B
263
C
D


E


F


G


H

Test Procedure:

(1) Measure the initial mass of the pan along with the dry soil (M1).

(2) Remove the cap and upper chamber of the permeameter by unscrewing the knurled cap nuts and lifting them off the tie rods. Measure the inside diameter of upper and lower chambers. Calculate the average inside diameter of the permeameter (D).

(3) Place one porous stone on the inner support ring in the base of the chamber then place a filter paper on top of the porous stone (see Photo C).

(4) Mix the soil with a sufficient quantity of distilled water to prevent the segregation of particle sizes during placement into the permeameter. Enough water should be added so that the mixture may flow freely (see Photo B).

(5) Using a scoop, pour the prepared soil into the lower chamber using a circular motion to fill it to a depth of 1.5 cm. A uniform layer should be formed.

(6) Use the tamping device to compact the layer of soil. Use approximately ten rams of the tamper per layer and provide uniform coverage of the soil surface. Repeat the compaction procedure until the soil is within 2 cm. of the top of the lower chamber section (see Photo D).

(7) Replace the upper chamber section, and don't forget the rubber gasket that goes between the chamber sections. Be careful not to disturb the soil that has already been compacted. Continue the placement operation until the level of the soil is about 2 cm. below the rim of the upper chamber. Level the top surface of the soil and place a filter paper and then the upper porous stone on it (see Photo E).

(8) Place the compression spring on the porous stone and replace the chamber cap and its sealing gasket. Secure the cap firmly with the cap nuts (see Photo F).

(9) Measure the sample length at four locations around the circumference of the permeameter and compute the average length. Record it as the sample length.

(10) Keep the pan with remaining soil in the drying oven.

(11) Adjust the level of the funnel to allow the constant water level in it to remain a few inches above the top of the soil.

(12) Connect the flexible tube from the tail of the funnel to the bottom outlet of the permeameter and keep the valves on the top of the permeameter open (see Photo G).

(13) Place tubing from the top outlet to the sink to collect any water that may come out (see Photo G).

(14) Open the bottom valve and allow the water to flow into the permeameter.

(15) As soon as the water begins to flow out of the top control (deairing) valve, close the control valve, letting water flow out of the outlet for some time.

(16) Close the bottom outlet valve and disconnect the tubing at the bottom. Connect the funnel tubing to the top side port (see Photo H).

(17) Open the bottom outlet valve and raise the funnel to a convenient height to get a reasonable steady flow of water.

(18) Allow adequate time for the flow pattern to stabilize (see Photo I).

(19) Measure the time it takes to fill a volume of 750 - 1000 mL using the graduated cylinder, and then measure the temperature of the water. Repeat this process three times and compute the average time, average volume, and average temperature. Record the values as t, Q, and T, respectively (see Photo I).

(20) Measure the vertical distance between the funnel head level and the chamber outflow level, and record the distance as h.

(21) Repeat step 17 and 18 with different vertical distances.

(22) Remove the pan from the drying oven and measure the final mass of the pan along with the dry soil (M2).

Analysis:

(1) Calculate the permeability, using the following equation:

$$K_T = \frac{QL}{Ath}$$

Where:
KT = coefficient of permeability at temperature T, cm/sec.

L = length of specimen in centimeters
t = time for discharge in seconds
Q = volume of discharge in cm3 (assume 1 mL = 1 cm3)
A = cross-sectional area of permeameter

$$(= \frac{\pi}{4} D^2,$$

D= inside diameter of the permeameter)
h = hydraulic head difference across length L, in cm of water; or it is equal to the vertical distance between the constant funnel head level and the chamber overflow level.

(2) The viscosity of the water changes with temperature. As temperature increases viscosity decreases and the permeability increases. The coefficient of permeability is standardized at 20°C, and the permeability at any temperature T is related to K20 by the following ratio:

$$K_{20} = K_T \frac{\eta T}{\eta 20}$$

Where:
ηT and η20 are the viscosities at the temperature T of the test and at 20°C, respectively. From Table 1 obtain the viscosities and compute K20.

(3) Compute the volume of soil used from: V = LA.

(4) Compute the mass of dry soil used in permeameter (M) = initial mass - final mass:
M = M1-M2

(5) Compute the dry density (ρd) of soil

$$\rho d = \frac{M}{V}$$

Initial Dry Mass of Soil + Pan (M1) = ___________________ g

Length of Soil Specimen, L = __________________ cm

Diameter of the Soil Specimen (Permeameter), D = ______________ cm

Final Dry Mass of Soil + Pan (M2) = __________________ g

Dry Mass of Soil Specimen (M) = ______________________ g

Volume of Soil Specimen (V) = ____________________ cm3

Dry Density of Soil (ρd) = ___________________ g/cm3

Trial Number	Constant Head, h (cm)	Elapsed Time, t (seconds)	Outflow Volume, Q (cm3)	Water Temp., T (°C)	KT	K20
1						
2						
3						
4						

Average K20= ______________________ cm/sec

EXPERIMENT 4B

6.4.2 Coefficient of Permeability (Constant Head Test) :

Ref : IS:2720 (Part XVII)

AIM : To determine the coefficient of Permeability of a soil by (i) Constant Head Permeability Test and (ii) Falling Head or Variable Head Permeability Test.

APPARATUS :Permeameter mould of internal dia 100mm and effective height 127.3mm, capacity 1000 ml; Detachable collar 100mm dia & 60mm high, Dummy plate 108mm diameter and 12mm thick; Drainage base having porous disc; Drainage cap having a porous disc with a spring attached to the top; Compaction equipment such as Proctor’s rammer or a static compaction equipment, constant head water supply reservoir, vacuum pump; constant head collecting chamber; stop watch; large funnel; Thermometer; weighing balance; accuracy 0.1 gm; filter papers.

Procedure :

1] Remove the collar of the mould. Measure the internal dimensions of the mould. Find the weight of the mould with dummy plate to the nearest gram.

2] Apply a little grease or oil on the inside to the mould clamp the mould between the base plate and the extension collar and place assembly on solid base.

3] Take about 2.5 kg of the soil sample from a thoroughly mixed wet soil in the mould. Compact the soil at the required dry density using a suitable compacting device.

4] Remove the collar and the base plate. Trim the excess soil and level the soil surface in level with the top of the mould.

5] Clean the outside of the mould and the dummy plate. Find the weight of soil in the mould.

6] Take a small specimen of the soil in a container and determine the water content.

7] Saturate the porous discs (stones).

8] Place a porous disc on the drainage base and place a fitter paper on the porous disc.

9] Remove the dummy plate and place the mould with the soil on the drainage base after inserting the washer in between.

10] Clean the edges of the mould. Apply grease or oil in the grooves around them.

11] Place a fitter paper on the top soil face and the porous disc on the fitter paper and fix the drainage cap using washers.

12] Connect the water reservoir to the outlet at the base and allow the water to flow upwards till it has saturated the sample. Let the free water collect for a depth of about 100mm on the top of the sample.

13] Fill the empty portion of the mould with deaired water without disturbing soil.

14] Disconnect the reservoir from the outlet at the bottom.

15] Connect the constant head reservoir to the drainage cap inlet.

16] Open the stop cock and all the water to flow downward so that all the air is removed.

17] Close the stop cock and allow the water to flow through the soil till a steady state is attained.

18] Start the stop watch and collect the water flowing out of the base in a measuring jar for some known time period (say for 1 min. or 1½ min.)

19] Repeat this thrice, keeping the interval the same. Check that quantity of water collected is approximately the same each time.

20] Measure the difference of head (h) in levels between the constant head reservoir and the outlet in the base.

The constant head permeability test is suitable for clean sands and Gravels with $K>10^{-2}$ mm/sec.

: Observation (Data) sheet for Constant Head Permeameter Test :

S.No. Observations & Determination No. Calculations 1
2 3

Observations :

1] Weight of empty mould with base plate W_1 gm
2] Weight of mould, base & soil W_2 gm

3] Hydraulic Head causing flow, h cm

4] Trim for which discharge is collected, t sec

5] Quantity of flow or discharge (Q) ml

a) First time in period, t

b) Second time in period, t

c) Third time in period, t

Average Q (in ml x 10^3=mm^3)

Calculations :

6] Weight of soil = $(W_2 – W_1)$ gr

7] Bulk density = $r_b = \frac{\text{Weight}}{\text{Volume}}$

8] Water content, w, determined

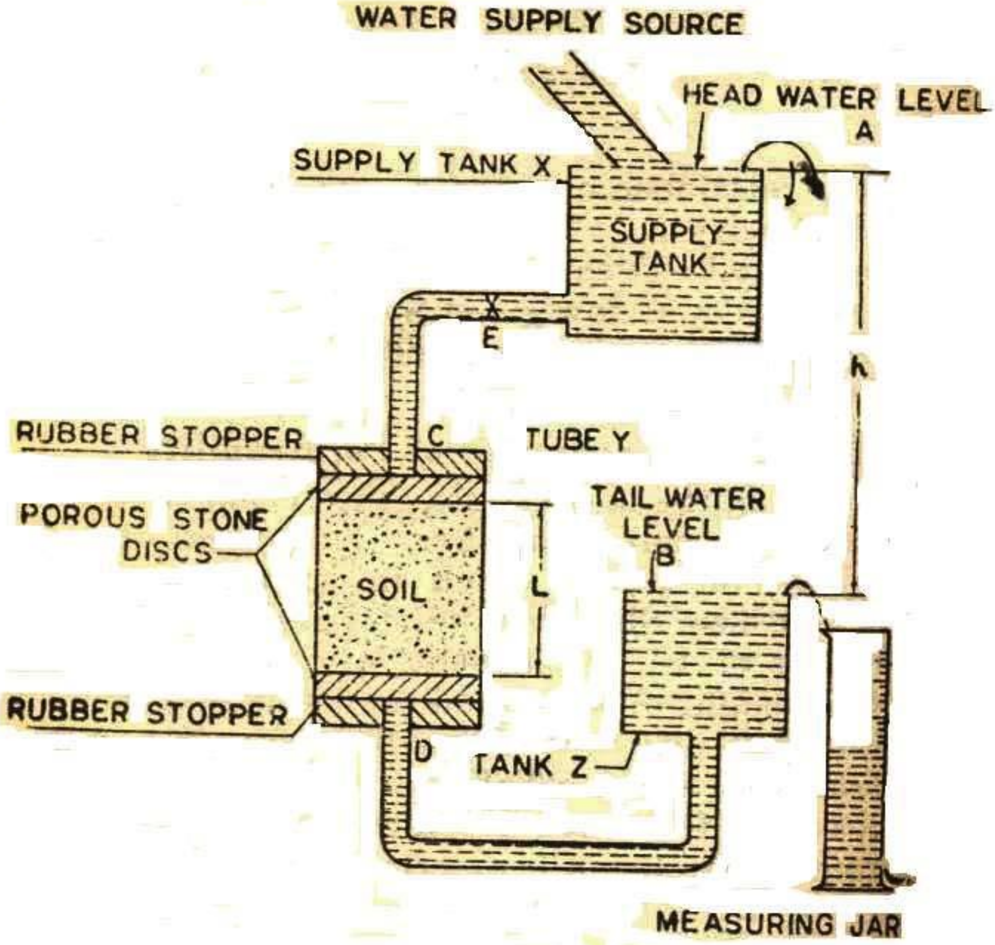
9] Dry Density = $r_{dry} = \frac{r_{wet}}{1+w}$

10] $K = \frac{QL}{Aht}$

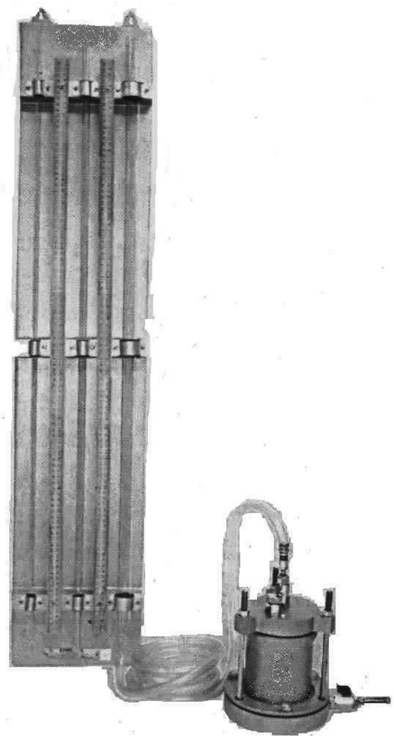
Dia. of soil sample = Dia. Of mould (D) = 100mm

Area = $\frac{\square D^2}{4}$ = 7854 mm^2

L = Length or height of sample to be measured before commencing test



Constant Head Permeameter



EXPERIMENT 4C

6.4.3 Coefficient of Permeability (Variable Head Test) :

Ref : IS:2720 (Part XVII)

AIM : To determine the coefficient of Permeability of a soil by variable or falling head test.

APPARATUS : Metallic mould of 100mm internal diameter, 127.3mm effective height and 1000ml capacity as per IS. The mould is provided with a detachable extension collar, 100mm diameter and 60mm high required during compaction of soil. The mould is provided with a drainage base plate with a recess for porous stone. The mould is fitted with a drainage cap having an inlet valve and an air release valve. The drainage base and cap have fitting for clamping to the mould. A vertical graduated stand pipe (½ cm; 1cm dia and 2 cm dia) is fitted to the top of permeameter, proctor's rammer, fitter papers; weighing balance, accuracy 0.1 gm; stop watch; supporting frame for stand pipe and clamping unit.

Procedure : The variable read permeameter is used to measure the permeability of relatively less pervious soils such as very fine sand and silt and silty clays with $K=10^{-2}$ to 10^{-5} mm/sec.

The hydraulic head causing flow through soil sample is variable during the period of conducting the test.

The coefficient of permeability of the soil is given by

$$K = \frac{2.303 x a L}{At} \log_{10}\left(\frac{h_1}{h_2}\right)$$

Where h_1 = intial head ; h_2 = final head

t = time interval during which the head has fallen from h_1 to h_2

a = cross sectional area of stand pipe

A = cross sectional area of soil specimen

L = length or height of specimen

1] Remove the collar of the mould, measure the internal dimensions of the mould. Find the empty weight of mould (W_1 gm).

2] Apply a little grease or oil on the inside to the mould.

3] Take about 2.5Kg of soil sample, from a thoroughly mixed wet soil, in to the mould. Compact the soil at the required dry density using a suitable compacting device.

4] Remove the collar and the base plate. Trim the excess soil in level with the top of the mould.

5] Clean the outside of the mould and the dummy plate. Find the weight of mould+soil (W_2 gm).

(W_2 - W_1) = W=weight of soil in the mould

6] Take a small soil specimen and determine the water content .

7] Saturate the porous discs (stone).
Please note that the porous stones used shall be at least 10 times more pervious than the soil.

8] Place a porous disc on the drainage base and on this keep a fitter paper.

9] Remove the dummy plate and place the mould with the soil on the drainage base after inserting a washer in between.

10] Clean the edges of the mould. Apply grease or oil in the grooves around them.

11] Place a fitter paper and the porous disc and fix the drainage cap using washers.

12] Connect the stand pipe to the outlet at the base and allow the water to flow upwards till it has saturated the sample. Let the free water collect for depth of about 100mm on the top of the sample.

13] Fill the empty portion of the mould with deaired water without disturbing the sample.

14] Disconnect the stand pipe connection from the outlet at the bottom.

15] Connect the stand pipe to the drainage cap inlet. Fill the stand pipe with water.

16] Note the intial head h_1 above the centre of the outlet. Before noting h_1, open the stop cock at the top and allow the water to flow out till all the air in the mould is removed and close the stop cock. Now note h_1.

17] and allow the water from the stand pipe to flow through the soil specimen simultaneously start the stop watch.

18] After the head h_1 has fallen to a level h_2 difference in (h_1 and h_2 shall 100mm to 300mm) note final head h_2 and note the time taken for this.

It is necessary that steady state conditions shall be established.

It is fulfilled if the time for h_1 to h_2 is approximately the same as from h_2 to h_3.

19] Repeat the test for different values of h_1 and h_2 and record the time required.

20] In both the trials, the time, t, required for the head to tall from h_1 to h_2 and that from h_2 to h_3 shall be noted carefully.

Stop the flow and disconnect all the parts.

Take a small quantity of the soil specimen and determine its water content.

: Data sheet for variable head Permeameter Test :

S.No.	Observations & Determination No.	Calculations

Observations :

1] Weight of mould + base plate

2] Weight of mould + base + soil

3] Intial head, h_1

4] Final head, h_2

5] Time Interval from h_1 to h_2 =t

Calculations :

6] Weight of soil = (2) – (1)

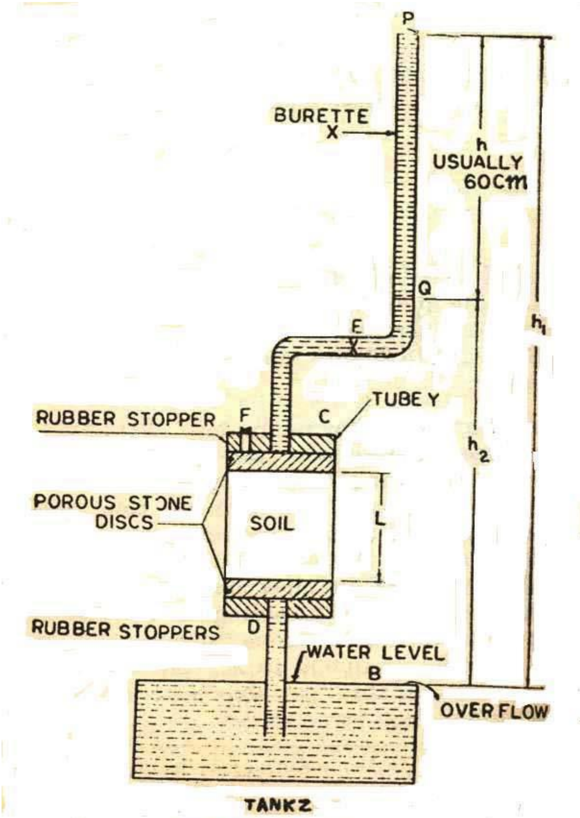
7] Bulk density = $r_b = \dfrac{\text{Weight of soil}}{\text{Volume of soil}}$

8] Dry Density = $r_{dry} = \dfrac{r_b}{1+w}$

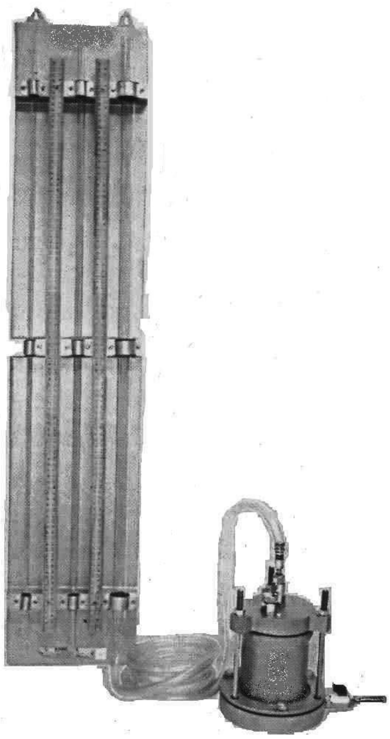
9] Void ratio, $e = \dfrac{Gr_w}{r_{dry}} - 1$

10] $$K = \frac{2.303 x a L}{At} \log_{10}\left(\frac{h_1}{h_2}\right)$$

(in mm/sec or in cm/sec)



Variable Head Permeameter



EXPERIMENT 5

6.5 Compaction Characteristics of soils

Ref : IS:2720 (Part VII) -1980 & 1987

AIM : To determine the compaction characteristics viz., Maximum Dry Density and Optimum Moisture content for a given soil by Proctor's Light compaction method.

APPARATUS : Cylindrical metal mould of capacity 1000cc with an internal diameter of 100 ± 0.1mm and an internal effective height of 127.3 ± 0.1mm. The mould is fitted with a detachable base and a removable extension (collar) approximately 50 to 60 mm high, Metal edge, 20mm and 4.75mm IS Sieves, Balances 10kg capacity sensitive to 1gm and 200gm capacity sensitive to 0.01 gm, Thermostatically controlled oven (105^{o}C-110^{o}C), water content determination containers, Mixing equipment such as mixing pan, Enamel Trays, Spoon, Trowel, Spatula etc, Measuring cylinder of glass 200ml capacity, sample extruder, metal rammer 50mm dia. Circular face weighing 2.6kg and having a free drop of 310mm.

Procedure : Clean the mould, base plate and collar and rammer free of any soil.

Take a representative soil sample weighing approximately 20 to 30 kg thoroughly mixed air dried material passing 20mm & 4.75mm IS Sieve. Add enough water to bring its water content to about 7 percent for sandy soil or 10 percent for clay soil (much less than the estimated optimum moisture content). Keep this soil in an air tight container for about 20 hours for maturing.

Clean the mould and fix the base and find the empty weight of mould with the base, W_1 gm.

Attach the collar to the mould and apply a small quantity of oil or grease to the inside of the mould, base and collar. Mix the matured soil thoroughly. From this take about 2½ Kg of the soil into a tray, level the soil and divide this soil in to three approximate portions. Introduce the first portion of the soil into the mould and compact the soil with the rammer by giving 25 blows (keeping the rammer on the soil surface, raising it to the full height and allow this to fall freely under gravity will cause one blow). The blows shall be evenly distributed during compaction to cause uniform compaction. After compaction and before introducing the second portion of the soil for compaction on similar lines, the soil surface of the first compacted portion shall be scratched in all directions to create roughness. This will help good bonding between the two layers. Keep the collar in position and now introduce the second portion of soil and compact with the rammer by giving 25 blows with the rammer and as explained above scratch the compacted surface after the compaction. Now introduce the third portion and complete the compaction and it will be seen that the soil so compacted will be occupying a portion of the collar. Remove the collar without causing breakage of soil in the mould and the collar. Using a straight edge or a spatula trim the excess soil Protruding above the top of mould to keep the trimmed surface correctly in level with the top of mould. In this condition only the volume of the wet compacted soil is equal to the volume of the mould. Now find the weight of mould with base and the compacted soil after cleaning the mould from outside and record this as W_2 gm.

If necessary using the proctor’s needle find the penetration resistance. Eject the soil from the mould. Take a representative soil sample and determine its water content.

Take another fresh 2½ Kg of soil and change the water content by about 3% mix thoroughly in the tray, level the soil and divide the soil into three portions and compact each portion as explained above. Remove the excess soil, and find the weight of mould, base and compacted soil. Find penetration resistance and determine the water content of soil.

In this manner perform the experiment for about four trials or so repeating the procedure and changing the water content each time as mentioned above. Stop the experiment with that trial when the wt. of base, mould and compacted soil will be found to be reducing instead of increasing.

After the water contents for all the trials are determined the dry density of soil for each trial is determined as

$$\text{Dry Density for any trial} = \frac{\text{Wet Density}}{1+\text{water content}} \quad (\text{gm/cc})$$

$$\text{And Wet Density for any trial} = \frac{\text{Weight of Wet compacted soil}}{\text{Volume of compacted soil}} \quad (\text{gm/cc})$$

(Volume of compacted soil is equal to volume of the mould)

Using the information of dry density and water content of all the trials, a curve is plotted with water content on X-axis and dry density on Y-axis. Also plot on the same curve between penetration resistance and water content as shown in the figure.

From the curve find the max. dry density corresponding to the peak point on the curve and the water content corresponding to max. dry density and this water content is called Optimum Moisture Content.

Max. Dry Density (gm/cc) = ……………………………….

Optimum moisture content (%) = ……………………………….

<u>Observation sheet for Proctor's Compaction Test :</u>
(Light Compaction)

Determination No. : …………………………………….. 1 2 3 4 5

a] **<u>Density :</u>**

Weight of mould, base + compacted soil (gm) W_2

Weight of empty mould with base (W_1) gm

Weight of wet compacted soil ($W_2 - W_1$) gm

Internal average dia. of mould, d cm

Height (average) of mould, h cm

Volume of mould (cc) $V = \frac{\Pi D^2}{4} x H$

Wet (bulk) density (gm/cc)

Dry density (gm/cc)

b] **<u>Water Content :</u>**

Container No. …………………….

Weight of container + wet soil (gm) W_1

Weight of empty container W_2 gm

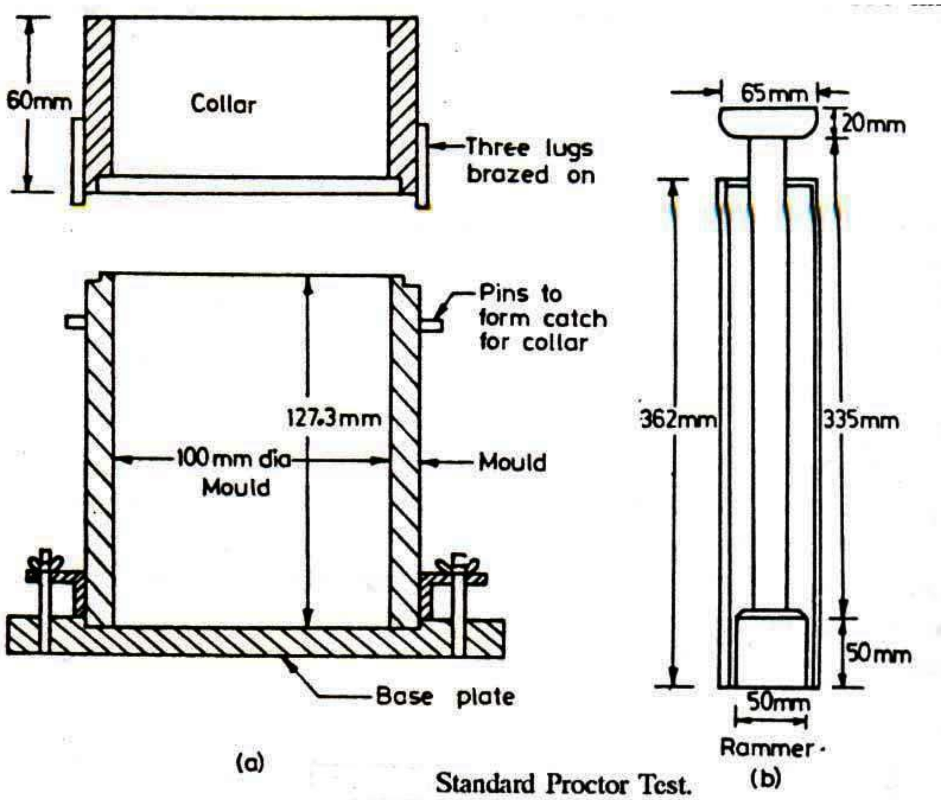
Weight of wet soil ($W_1 - W_2$) gm

Weight of container + dry soil, W_3 gm

Weight of dry soil W_d or W_s ($W_3 - W_2$) gm

Weight of water, gm ($W_1 - W_3$)

$$\text{Water content, } w = \frac{\text{weight of water}}{\text{weight of dry soil}} \times 100(\%)$$



Standard Proctor Test.

EXPERIMENT 6

6.6 CALIFORNIA BEARING RATIO TEST

OBJECTIVE

To determine the California bearing ratio by conducting a load penetration test in the laboratory.

NEED AND SCOPE

The california bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

This instruction sheet covers the laboratory method for the determination of C.B.R. of undisturbed and remoulded /compacted soil specimens, both in soaked as well as unsoaked state.

PLANNING AND ORGANIZATION

Equipments and tool required.

1. Cylindrical mould with inside dia 150 mm and height 175 mm, provided with a detachable extension collar 50 mm height and a detachable perforated base plate 10 mm thick.

2. Spacer disc 148 mm in dia and 47.7 mm in height along with handle.

3. Metal rammers. Weight 2.6 kg with a drop of 310 mm (or) weight 4.89 kg a drop 450 mm.

4. Weights. One annular metal weight and several slotted weights weighing 2.5 kg each, 147 mm in dia, with a central hole 53 mm in diameter.

5. Loading machine. With a capacity of atleast 5000 kg and equipped with a movable head or base that travels at an uniform rate of 1.25 mm/min. Complete with load indicating device.

6. Metal penetration piston 50 mm dia and minimum of 100 mm in length.

7. Two dial gauges reading to 0.01 mm.

8. Sieves. 4.75 mm and 20 mm I.S. Sieves.

9. Miscellaneous apparatus, such as a mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers.

DEFINITION OF C.B.R.

It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.

C.B.R. = Test load/Standard load � 100

The following table gives the standard loads adopted for different penetrations for the standard material with a C.B.R. value of 100%

Penetration of plunger (mm)	Standard load (kg)
2.5	1370
5.0	2055
7.5	2630
10.0	3180
12.5	3600

The test may be performed on undisturbed specimens and on remoulded specimens which may be compacted either statically or dynamically.

PREPARATION OF TEST SPECIMEN

Undisturbed specimen

Attach the cutting edge to the mould and push it gently into the ground. Remove the soil from the outside of the mould which is pushed in . When the mould is full of soil, remove it from weighing the soil with the mould or by any field method near the spot.

Determine the density

Remoulded specimen

Prepare the remoulded specimen at Proctor�s maximum dry density or any other density at which C.B.R> is required. Maintain the specimen at optimum moisture content or the field moisture as required. The material used should pass 20 mm I.S. sieve but it should be retained on 4.75 mm I.S. sieve. Prepare the specimen either by dynamic compaction or by static compaction.

Dynamic Compaction

Take about 4.5 to 5.5 kg of soil and mix thoroughly with the required water. Fix the extension collar and the base plate to the mould. Insert the spacer disc over the base (See Fig.38). Place the filter paper on the top of the spacer disc.

Compact the mix soil in the mould using either light compaction or heavy compaction. For light compaction, compact the soil in 3 equal layers, each layer being given 55 blows by the 2.6 kg rammer. For heavy compaction compact the soil in 5 layers, 56 blows to each layer by the 4.89 kg rammer.

Remove the collar and trim off soil.
Turn the mould upside down and remove the base plate and the displacer disc. Weigh the mould with compacted soil and determine the bulk density and dry density. Put filter paper on the top of the compacted soil (collar side) and clamp the perforated base plate on to it.

Static compaction

Calculate the weight of the wet soil at the required water content to give the desired density when occupying the standard specimen volume in the mould from the expression.

W =desired dry density * (1+w) V

Where W = Weight of the wet soil

w = desired water content

V = volume of the specimen in the mould = 2250 cm^3 (as per the mould available in laboratory)

Take the weight W (calculated as above) of the mix soil and place it in the mould.

Place a filter paper and the displacer disc on the top of soil.

Keep the mould assembly in static loading frame and compact by pressing the displacer disc till the level of disc reaches the top of the mould.

Keep the load for some time and then release the load. Remove the displacer disc.

The test may be conducted for both soaked as well as unsoaked conditions.

If the sample is to be soaked, in both cases of compaction, put a filter paper on the top of the soil and place the adjustable stem and perforated plate on the top of filter paper.

Put annular weights to produce a surcharge equal to weight of base material and pavement expected in actual construction. Each 2.5 kg weight is equivalent to 7 cm construction. A minimum of two weights should be put.

Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Remove the mould from tank.

Note the consolidation of the specimen.

Procedure for Penetration Test

Place the mould assembly with the surcharge weights on the penetration test machine. (Fig.39).

Seat the penetration piston at the center of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the piston on the sample is established.

Set the stress and strain dial gauge to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.

Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10 and 12.5 mm. Note the maximum load and corresponding penetration if it occurs for a penetration less than 12.5 mm.

Detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 3 cm layer and determine the moisture content.

Observation and Recording

For Dynamic Compaction
Optimum water content (%)
Weight of mould + compacted specimen g
Weight of empty mould g
Weight of compacted specimen g
Volume of specimen cm^3
Bulk density g/cc
Dry density g/cc

For static compaction

Dry density g/cc
Moulding water content %
Wet weight of the compacted soil, (W)g
Period of soaking 96 hrs. (4days).

For penetration Test

Calibration factor of the proving ring 1 Div. = 1.176 kg

Surcharge weight used (kg) 2.0 kg per 6 cm construction

Water content after penetration test %

Least count of penetration dial 1 Div. = 0.01 mm

If the initial portion of the curve is concave upwards, apply correction by drawing a tangent to the curve at the point of greatest slope and shift the origin (Fig. 40). Find and record the correct load reading corresponding to each penetration

C.B.R. = P_T�/P_S� 100where P_T = Corrected test load corresponding to the chosen penetration from the load penetration curve.

P_S = Standard load for the same penetration taken from the table □.

Penetration Dial		Load Dial		Corrected Load
Readings	Penetration (mm)	proving ring reading	Load (kg)	

Interpretation and recording

C.B.R. of specimen at 2.5 mm penetration

C.B.R. of specimen at 5.0 mm penetration

C.B.R. of specimen at 2.5 mm penetration

The C.B.R. values are usually calculated for penetration of 2.5 mm and 5 mm. Generally the C.B.R. value at 2.5 mm will be greater that at 5 mm and in such a case/the former shall be taken as C.B.R. for design purpose. If C.B.R. for 5 mm exceeds that for 2.5 mm, the test should be repeated. If identical results follow, the C.B.R. corresponding to 5 mm penetration should be taken for design.

EXPERIMENT 7

6.7 CONSOLIDATION TEST

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

1. Consolidometer consisting essentially

   a) A ring of diameter = 60mm and height = 20mm

   b) Two porous plates or stones of silicon carbide, aluminum oxide or porous metal.

   c) Guide ring.

   d) Outer ring.

   e) Water jacket with base.

   f) Pressure pad.

g) Rubber basket.

2. Loading device consisting of frame, lever system, loading yoke dial gauge fixing device and weights.
3. Dial gauge to read to an accuracy of 0.002mm.
4. Thermostatically controlled oven.
5. Stopwatch to read seconds.
6. Sample extractor.
7. 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

1. 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.

2. 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.

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

4. 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.

5. 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.

6. 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/cm^3 for ordinary soils & 25 g/cm^2 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.

7. Note the final dial reading under the initial load. Apply first load of intensity 0.1 kg/cm^2 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.

8. 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/cm^2.

9. 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/cm^2 is reached. Take the final reading of the dial gauge.

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

11. 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

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 mm^2

Diameter of ring : 76.2 mm (7.62 cm) (45.60 cm^2) Volume of ring : 115.82 cm^3

Height of ring : 25.4 (2.54 cm) Specific gravity of soil sample No:

Dial Gauge = 0.0127 mm (least count)

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						

CALCULATIONS

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 □□.

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□� (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 8

6.8 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)

1. 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

1. Note down the sample number, bore hole number and the depth at which the sample was taken.
2. Remove the protective cover (paraffin wax) from the sampling tube.
3. Place the sampling tube extractor and push the plunger till a small length of sample moves out.
4. Trim the projected sample using a wire saw.
5. Again push the plunger of the extractor till a 75 mm long sample comes out.
6. Cutout this sample carefully and hold it on the split sampler so that it does not fall.
7. Take about 10 to 15 g of soil from the tube for water content determination.
8. Note the container number and take the net weight of the sample and the container.
9. Measure the diameter at the top, middle, and the bottom of the sample and find the average and record the same.
10. Measure the length of the sample and record.
11. Find the weight of the sample and record.

A. Moulded sample

1. 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.

2. Add required quantity of water W_w to this soil.
   1. $W_w = W_S$ � W/100 gm
3. Mix the soil thoroughly with water.
4. 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.
5. 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.
6. Place the lubricated moulded with plungers in position in the load frame.
7. Apply the compressive load till the specimen is compacted to a height of 7.5 cm.
8. Eject the specimen from the constant volume mould.
9. Record the correct height, weight and diameter of the specimen.

Test procedure

1. Take two frictionless bearing plates of 75 mm diameter.
2. Place the specimen on the base plate of the load frame (sandwiched between the end plates).
3. Place a hardened steel ball on the bearing plate.
4. Adjust the center line of the specimen such that the proving ring and the steel ball are in the same line.
5. Fix a dial gauge to measure the vertical compression of the specimen.
6. Adjust the gear position on the load frame to give suitable vertical displacement.
7. Start applying the load and record the readings of the proving ring dial and compression dial for every 5 mm compression.
8. Continue loading till failure is complete.
9. 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 (G_S) 2.71 Bulk density

Water content Degree of saturation .%

Diameter (D_o) of the sample cm Area of cross-section = cm^2

Initial length (L_o) of the sample = 76 mm

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

Interpretation and Reporting

Unconfined compression strength of the soil = q_u =

Shear strength of the soil = $q_u/2$ =

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

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 9

6.9 UNDRAINED 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

A constant rate of strain compression machine of which the following is a brief description of one is in common use.

a) 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.

b) 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.

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

1. 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.

2. 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.

3. 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.

4. 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.

5. 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.

6. 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/cm^2 1	Strain dial 2	Proving ring reading 3	Load on sample kg 4	Corrected area cm^2 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/cm^2**	**Compressive stress**	**Strain at failure**	**Moisture content**	**Shear strength (kg/cm^2)**	**Angle of shearing resistance**

			at failure				
1.							
2.							
3.							

General Remarks

a) It is assumed that the volume of the sample remains constant and that the area of the sample increases uniformly as the length decreases. The calculation of the stress is based on this new area at failure, by direct calculation, using the proving ring constant and the new area of the sample. By constructing a chart relating strain readings, from the proving ring, directly to the corresponding stress.

b) The strain and corresponding stress is plotted with stress abscissa and curve is drawn. The maximum compressive stress at failure and the corresponding strain and cell pressure are found out.

c) The stress results of the series of triaxial tests at increasing cell pressure are plotted on a mohr stress diagram. In this diagram a semicircle is plotted with normal stress as abscissa shear stress as ordinate.

d) The condition of the failure of the sample is generally approximated to by a straight line drawn as a tangent to the circles, the equation of which is □ = C + □ tan□. The value of cohesion,C is read of the shear stress axis, where it is cut by the tangent to the mohr circles, and the angle of shearing resistance (□) is angle between the tangent and a line parallel to the shear stress.

EXPERIMENT 10

6.10. 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								
25								
50								
75								
100								
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 Mohr�s 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 28^o(uniformly graded sands with round grains in very loose state) to 46^o(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.

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 11
6.11. 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/cm^2) 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 0.1^{o}/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.

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/ π ($D^2H/2 + D^3/6$)	S=TxG Kg/cm^2	Ave-rage 'S' Kg/ cm^2	Spring Cons-tant Kg-cm

GENERAL REMARKS:

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

7. CONTENT BEYOND SYLLABUS

Determination of water content by Pycnometer method

Ref : IS:2720 (Part II) -1973 - Methods of test for soils –
Determination of water content and is based on oven – drying of the soil sample.

AIM : To determine the water content of the soil sample using the Pycnometer method.

APPARATUS : Pycnometer bottle with cap fitted with rubber washer, glass rod to stir the contents.

Procedure : This method is used when the specific gravity of soil solids is known. This relatively a quick method and is considered to suitable for course grained soils only.

Determine the weight of the clean, dry, Pycnometer with its cap and washer (W_1) Put about 200 to 400 gm (upto about ¼ to ⅓ rd of the volume) of wet soil and its weight is determined (W_2).

Weight of Pycnometer bottle with cap + wet soil = W_2 gm. Fill the Pycnometer to half of its height with water and mix it thoroughly with the glass rod. Add more water and stir it. Continue to add water. Replace the conical cap. Add water until water is flush with the hole in the conical cap. Clean the Pycnometer from the outside and dry it and its weight is obtained (W_3).

Weight of Pycnometer with conical cap + Soil + water fall = W_3 gm.

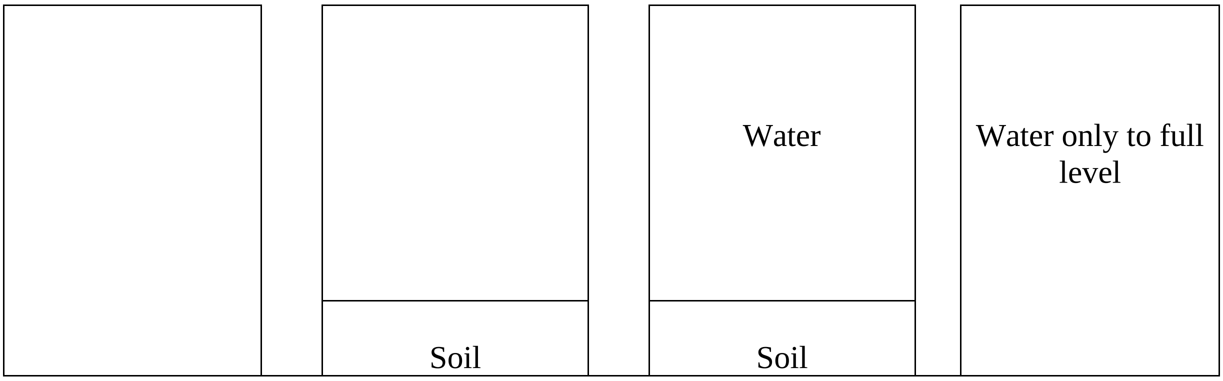
The Pycnometer is empfied of water and soil and is cleaned perfectly so as to be free from any soil particles and then it is filled with water only to the same full level. Find its weight (W_4).

Weight of Pycnometer bottle with cap + water only to the same full level as in the observation of W_3 = W_4 gm

The water content of the soil sample is calculated as follows .

$$W = \left[\left(\frac{W_2 - W_1}{W_3 - W_4} \right) \left[\frac{G-1}{G} \right] - 1 \right] x100\%$$

Since the weight W3 cannot be determined accurately the method is suitable for coarse grained soils.



Pyc. Empty Wt = w_1 | Pyc + wet soil weight = w_2 | Pyc+Soil+Water weight = w_3 | Pyc + water weight = w_4

<u>Water content Determination</u>

Determination of water content, w, using pycnometer

Empty weight of Pycnometer with conical cup (W_1) gm

Weight of Pcynometer + wet soil (W_2) gm

Weight of Pcynometer + soil + water to full level (W_3) gm

Weight of Pcynometer+water only filled to the same full level as in W_3 observation (W_4) gm

Water content is calculated as

$$W = \left[\frac{(W_2 - W_1)}{(W_3 - W_4)} \; \frac{(G-1)}{G} - 1 \right] x100\%$$

<u>Determination of specific gravity of soil solids</u>

Ref : IS:2720 (Part III) -1980 – Section 1 for fine grained soils and Section 2 for fine, medium and coarse grained soils.

AIM : To determine the specific gravity of solids.

APPARATUS : A 50 cc density bottle and/or a Pycnometer bottle.

Procedure : A 50 cc density bottle or a Pycnometer may be used. While the density bottle is the more accurate and suitable for all types of soils, the Pycnometer is used only for coarse grained soils. The procedure and sequence of observations are similar to both cases.

1. Determine the empty weight of clean, dry, Pycnometer with conical cap W_1 gm.

2. Then place the sample of oven dried and cooled in the desiccator in the Pycnometer and find its weight with conical top and soil sample W_2 gm.

   Now fill the remaining volume of the Pycnometer, gradually, with distilled water (or kerosene). The entrapped air should be removed either by gentle heating and vigorous shaking or by applying vaccum.

3. The weight of the Pycnometer with conical cap, soil and water to full level is determined as W_3 gm.

   The Pycnometer with its contents is emptied and cleaned with water till all soil particles are removed.

4. The Pycnometer is now filled with only distilled water (or kerosene) to the samefull level and its weight is determined and recorded as W_4 gm.

In both the observations W_3 and W_4, the Pycnometer shall be cleaned to dry state carefully before tooking W_3 and W_4 observations.

With the help of these four weight observations the specific gravity of solids may be determined using the formula.

$$G = \frac{\text{Weight of soil solids}}{\text{Weight of water of volume equal to that of solids}}$$

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

W_s is nothing but the dry weight of soil

Observation sheet for determination of specific gravity of solids by pycnometer

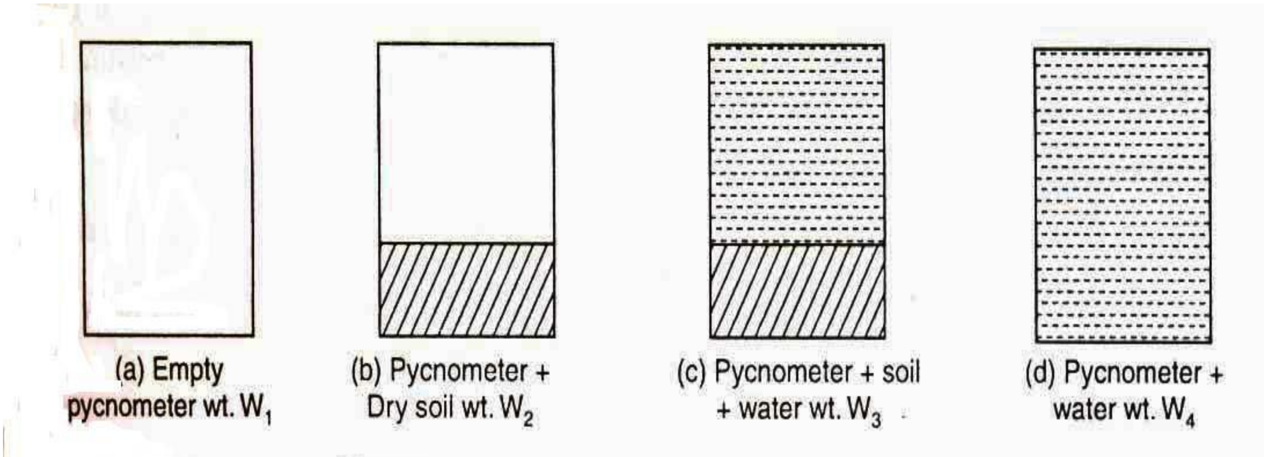
Trial No.	1	2	3
Pycnometer No.			
Weight of Pycnometer with conical cup, W_1 gm			
Weight of Pycnometer with soil W_2 gm			
Weight of Pcynometer + soil + water to full level, (W_3) gm			
Weight of Pcynometer+water only filled to the same full level as in observation W_3 , W_4 gm			
Specific gravity of solids			

The specific gravity of soil solids is calculated from the equation

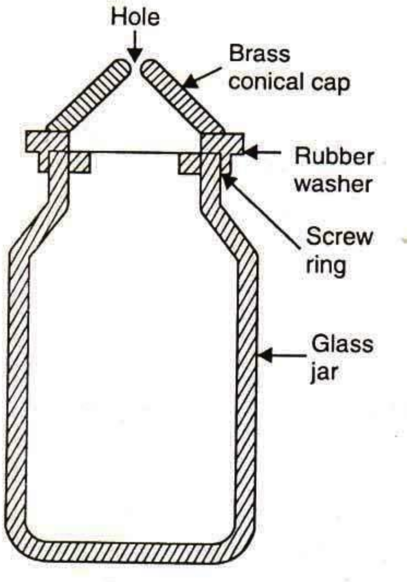
$$G = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$$

Average value of specific gravity of solids

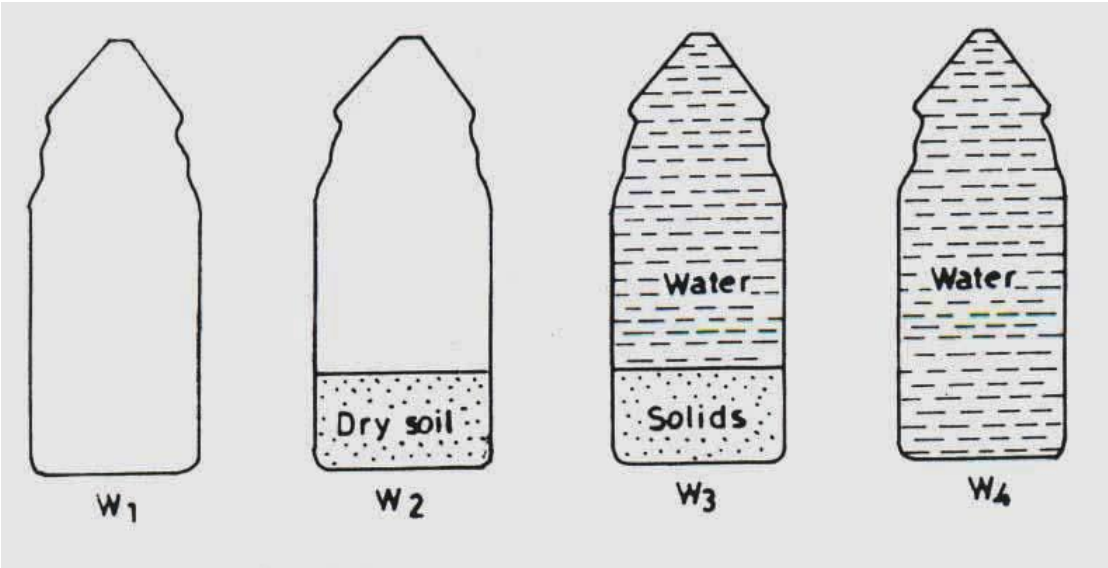
G = ………………………



Determination of grain specific gravity



Pycnometer



Specific gravity determination

Determination of Shrinkage limit of a soil

Ref : IS:2720 (Part VI) -1972

AIM : To determine the shrinkage limit of a soil.

APPARATUS : Porcelain evaporating dish of about 12cm dia and with a flat bottom, A shrinkage dish of stainless steel with flat bottom, 45cm in dia and 15mmhigh, Two glass plates each 75x75mm and 3mm thick – one plain glass and the other other with 3 metal prongs, glass cup 50mm in dia and 25mm high with its top rim ground smooth and level, straight edge, spatula, oven, mercury, desiccator, balances and sieves.

Procedure : If the test is to be made on an undisturbed sample, it is to be trimmed to a pat about 45mm in dia and 15mm high. If it is to be conducted on a remoulded sample about 100gm of thoroughly mixed portion of the material passing IS:Sieve 425 microns is to be used.

The volume V_i of the shrinkage dish is first determined by filling it with mercury, removing the excess by pressing a flat glass plate over the top and then weighing the dish filled with mercury. The weight of the mercury divided by its unit weight (0.136N/cm^3 or 13.6 gm/cm^3) gives the volume of the dish which is also the initial volume of wet soil pat (V_i). The inside of the dish is coated with thin layer of Vaseline. The dish is then filled with the prepared soil paste in instalments. Gentle tapping is given on to hard surface to eliminate the entrapped air. The excess soil is removed with the aid of straight edge and any soil adhering to the outside of the dish is wiped off. The weight of the wet soil pat of known volume is found W_i. The dish is then placed in an oven and the soil pat is allowed to dry up. The weight of the dry soil pat can be found from weighing (W_s) or (W_d).

The glass cup is filled with mercury and the excess is removed by pressing with a glass plate with three prongs firmly over the top. The dry soil pat is placed on the surface of the mercury in the cup and carefully pressed by means of the glass plate with three prongs. The weight of the displaced mercury is found and divided by its unit weight to get the volume of the dry soil pat (V_s or V_d).

The shrinkage limit may then be obtained

Shrinkage limit, $$W_s = \left[W_i - \frac{(V_i - V_d) r_w}{V_d} \right] x100\%$$

or Shrinkage limit, $$W_s = \frac{[(W_i - W_d) - (V_i - V_d or V_m) r_w]}{W_d} x100\%$$

<u>Observation sheet for shrinkage factors :</u>
(for remoulded sample)

a] <u>Water content of wet sample :</u>

Shrinkage Dish No. :…………….

Empty weight of shrinkage dish gm (W_1)

Weight of shrinkage dish + wet soil pat gm (W_2)

Weight of shrinkage dish + dry soil pat gm (W_3)

Weight of dry soil pat $W_s = (W_3 - W_1)$ gm

Weight of water $(W_w) = (W_2 - W_3)$ gm

Water content of soil pat,

$$W = \frac{(W_2 - W_3)}{(W_3 - W_1)} x100\%$$

b] <u>Volume of wet soil pat :</u>

Shrinkage limit Dish No. :…………….

Weight of empty of shrinkage dish (W_1) gm

Weight of shrinkage dish + mercury filling the dish (W_2) gm

Weight of mercury filling the dish (W_3) gm $= (W_2 - W_1)$ gm

Volume of wet soil pat (cc) $V = \frac{W_3}{13.6}$ (cc)

c] <u>Volume of Dry soil pat :</u>

Shrinkage Dish No. :…………….

Wt. of shrinkage limit dish gm (W_1)+Wt. of mercury displaced by dry soil pat=W_2 gm

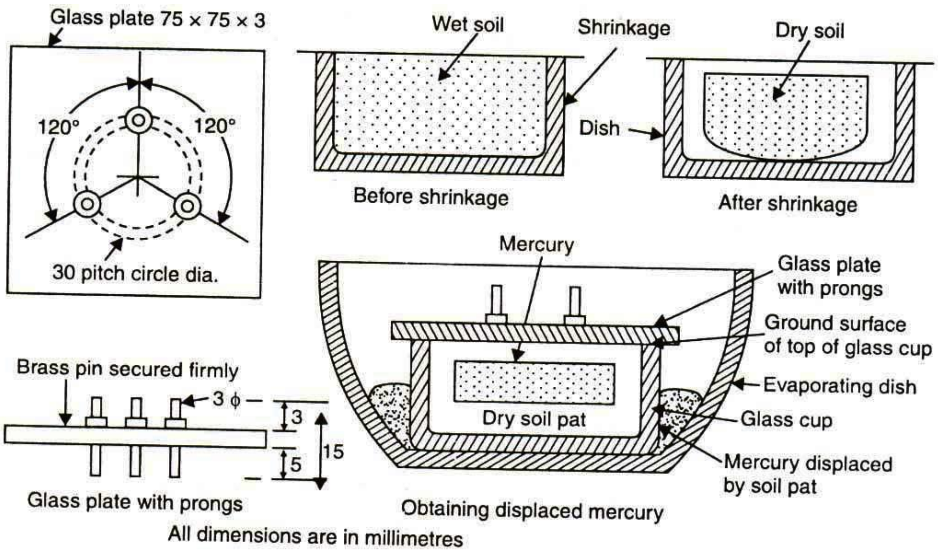
Wt. of mercury displaced by dry soil pat (W_3) gm = ($W_2 - W_1$) gm

Volume of dry soil pat (cc) $V_s = \frac{W_3}{13.6}$ (cc)

Shrinkage limit = $W_s = \left[w - \frac{V - V_s}{W_s} \right] x100$

Shrinkage ratio, $SR = \frac{W_s}{V_s}$

Volumetric shrinkage (%) = V_s = (W-W_s) SR



Apparatus for determining volume-change in the shrinkage limit test

8. SAMPLE VIVA VOCE QUESTIONS

1. What is the need and scope of CBR test?
2. What are the CBR ranges for coarse grained and Fine grained soils?
3. What is the effect on the CBR value if we move from soft to hard soil? Is it increases or decreases.
4. Name one standard material used in the CBR test which has a value of 100.
5. Out of wet density, dry density, and saturated density, which one of them is maximum and minimum? Explain.
6. What are the main factors which affect dry density of soil? Explain.
7. Beside the density what other properties do you need to calculate the void ratio and degree of saturation of soils?
8. What are the other methods to calculate the field density of soil?
9. What is the condition for maximum and minimum void ratios ?
10. Water content is also called? (Moisture content)
11. Which method is mostly used to determine the water content in field?
12. What is water content for clay soil?
13. On which factor water content is depended?
14. Water Content determined by direct weighing, this method is called? (Gravimetric)
15. Maximum water content maintained in the soil without the water draining rapidly is called? (Field capacity)
16. Wilting point means? (no water in soil)
17. Ground Penetrating Radar (GPR) method is also used for measuring water content (True / False)
18. Name different types of soil textures? (Very Fine, Fine, Medium, coarse)
19. The percentage of water remaining in an air-dry soil is called (Hygroscopic coefficient)
20. Which method is mostly used to determine the water content in field?
21. What is water content for loss soil?
22. On which factor cater content is depends?
23. What do you understand by well graded, poorly graded and uniformly graded soils?

24. What do you understand by dry sieve and wet sieve analysis? Which once did you perform and why?

25. What is the grain size distribution curve? Why do you use a semi-long graph paper for plotting it?

26. What do you understand by GW,GP,GM,GC,SW,SP,SM,SC,SW-SM,GP-SC?

27. Sonic sieving is used for coarse type of soils (True/ False)

28. A dense gradation will result in an _____ curve on the gradation graph (Even, Steep, Horizontal, vertical)

29. The results of Sieve analysis are generally presented by semi-logarithmic plots known as --------- (Particle size distribution cure, Fines ness distribution curve)

30. What is liquid limit?

31. What is plastic limit?

32. What apparatus is used to measure the liquid limit of a given soil sample.

33. What number of blows is taken for consideration while determining the liquid limit of a given soil sample.

34. What is plasticity index?

35. What is Darcy's law of flow velocity through soils? What are its Limitations?

36. What are the steady and unsteady flows of water? What type of flow is

37. assumed to occur in soils?

38. What are the laboratory methods of determination of coefficient of permeability of soil? State their suitability.

39. What is the effect of entrapped air on the coefficient of permeability of soil?

40. What is meant by dry side and wet side of optimum? Which side is preferred in the field compaction? Explain.

41. Explain how the gravel content in the soil mass affect the laboratory compaction specifications.

42. What is the energy imparted by the standard and modified compaction test?

43. What are the approximate values of OMC and MDD for coarse grained and fine grained soils?

44. What are the field methods of compaction the soils?

45. Differentiate between the angle of repose and angle of shearing resistance of soils.

46. What are the advantages and disadvantages of direct shear test?
47. What are other laboratory tests to determine the shear strength of soils?
48. Why do you put the grids keeping the serration at right angles to the direction of shear?
49. Are you using stress or strain controlled device?
50. Why triaxial testing is considered. As test-like conditions in the most natural?
51. How CU test is different from a test CD.
52. Why has the UU test φ = 0, or in other words, when adding Confining Pressure. Under the soil to the same explanation.
53. Why there is a need of Plate load test?
54. How Plate load test is better than SPT and CPT methods?
55. What is the difference between Ultimate bearing capacity and safe bearing capacity?
56. Why there is a need of Standard Penetration Test?
57. What is the scope of Standard Penetration Test?
58. What is the SPT value(N-value) for a sample, if it sinks under it is own weight?
59. What does SPT value of a sample tells?
60. What does Vane shear test measure?
61. What is the principle of Vane Shear Test?
62. What is the rate of rotation of Vane during testing?

9. SAMPLE EXTERNAL LAB QUESTION PAPER

1. Determine moisture content of given coarse grained soil sample using Pycnometer method.
2. Perform sieve analysis for the given soil sample. Draw the grading curve.
3. Determine field density of the soil using core-cutter method.
4. Determine field density of the soil using sand replacement method.
5. Determine maximum dry density and optimum moisture content for the given soil sample using compaction test.
6. Determine liquid limit of the given soil sample. Draw flow curve.
7. Determine plastic limit of the given soil sample.
8. Determine permeability of the given soil sample using variable permeability test.

10. APPLICATIONS

Exposure to this lab would enable the student as a geotechnical engineer to determine and design the type of foundations, earthworks, and/or pavement sub grades required for the intended man-made structures to be built and also to design foundations and structures of various sizes such as high-rise buildings, bridges, medium to large commercial buildings, and smaller structures where the soil conditions do not allow code-based design.

11. PRECAUTIONS

Laboratory equipment is never cheap, but the cost may vary widely. For accurate experimental results, the equipment should be properly maintained. The calibration of certain equipment, such as balances and proving rings, should be checked from time to time. It is always necessary to see that all equipment is clean both before and after use. Better results will be obtained when the equipment being used is clean, so always maintain the equipment as if it were your own.

12. CODE OF CONDUCT

1. Students should report to the labs concerned as per the timetable.

2. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.

3. After completion of the experiment/program, certification of the staff in-charge concerned in the observation book is necessary.

4. Students should bring a notebook of about 200 pages and should enter the readings/observations/results into the notebook while performing the experiment.

5. The record of the program(s) executed, results along with the description and algorithm performed in the immediate previous session should be submitted and certified by the staff member in-charge.

6. Before occupying the system students must enter appropriate information into the Log book kept in the respective lab.

7. After completion of the lab work students should shut down the system properly.

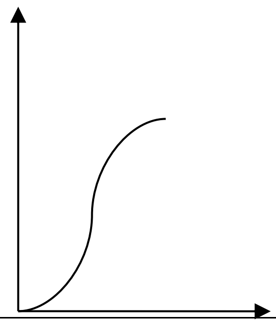
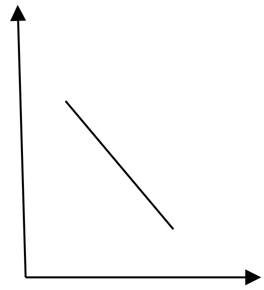
8. Any damage of the equipment or burnout of components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year.

9. Students should be present in the labs for the total scheduled duration.

10. Students are expected to prepare thoroughly to perform the experiment/program before coming to Laboratory.

Horseplay will not be tolerated and will constitute grounds for dismissal from the course.

13.GRAPHS

Experiment Name	Name of the graph	Plot between Y v/s X	Approximate shape of the curve
Sieve analysis	**Grading curve**	**% finer v/s particle size**	
Liquid Limit test	**Flow Curve**	**Number of blows v/s Moisture content**	
Compaction Test	**-------**	**Dry Density v/s moisture content**