DEPARTMENT OF CIVIL ENGINEERING

SOIL MECHANICS LABORATORY

COURSE: SOIL MECHANICS LAB

MUFFAKHAM JAH

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MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Soil Mechanics Laboratory

Exp.No.1

SPECIFIC GRAVITY OF SOIL PARTICLES

IS. 2720 (Part 3 /sec 1) - 1987

AIM:- To determine the specific gravity of soil particles of the given sample by specific gravity bottle method.

Theory:- The specific gravity is the ratio of weight in air of a given volume of dry soil solids to the weight in air of an equal volume of distilled water at a temperature of 27°C i.e., $Gs = r_s / r_w$.
Sp. Gravity bottle method is used for fine grained soils.
The specific gravity of the soil particles is useful mainly for deriving other needed properties of soils like void ratio, grain size distribution etc. for sand grains the average value of specific gravity is about 2.65 and for clay particles it varies form 2.5 to 2.9 with a statistical average of about 2.7. The values of the specific gravity of some of the common minerals are given in Table 1.1

APPARATUS:- 50cc density bottle spirit lamp, balance, thermometer, distilled water, wash bottle, soil sample etc.

PROCEDURE:-

1. Dry the density bottle thoroughly and find its weight with cap (w_1)
2. Take about 25 g of the given soil into the density bottle and find the weight of the density bottle with soil correctly (w_2)
3. Add sufficient water (up to about half the capacity of density bottle) to cover the soil.
4. Heat the density bottle on spirit lamp to remove the entrapped air.
5. Make sure that all the entrapped air has been expelled out and then fill the bottle completely with water.
6. Wipe out any excess water on the outer surface of the bottle and find out its wt (w_3) Note also the temperature of the suspension Ts in degrees.
7. Throw out the contents of the density bottle and wash it thoroughly .
8. Fill the density bottle completely with water
9. Take the average value of at least three sets of readings. Report the specific gravity of the soil corresponding to the standard temperature of 27°C
10. Wipe of any excess water on the outer surface of the bottle and find its wt. (w4) and corresponding temp of water (Tw).

PRECAUTIONS:

Inaccuracies in weighing the failure to completely eliminate the entrapped air are the main sources of error. Avoid them by careful working.

DETERMINATION OF SPECIFIC GRAVITY

Soil Type:
Tested by:

Sl. No.	Description	Test-1	Test-2	Test-3
1	Weight of the dry density bottle w_1. g			
2	Wt. of the density bottle + soil w_2. g			
3	Wt. of density bottle + soil +water (w_3)g.			
4	Temperature corresponding to Steps 3 in deg. C (T_s)			
5	Wt. of density bottle + water (w_4) g.			
6	Specific gravity corresponding To T_s $(G_s) = \dfrac{(w_2 - w_1)}{(w_4 - w_1) - (w_3 - w_2)}$			
7	[redacted]			

$$G_o = G_s \times \frac{r_w @ T_s}{r_w @ 27^\circ}$$

For density of water (rw at diff. Temp. See Table 1.2)

RESULT:- Average specific gravity G=_________

TABLE 1.1 VALUES OF SPECIFIC GRAVITY FOR COMMON SOIL MINERALS

Anhydrite	3.0	Hematite	4.90 – 5.30
Aragonite	2.94	Hornblande	3.2 – 3.5
Augite	3.2 – 3.6	Illite	2.6
Bentonite	2.13 – 2.18		
Biotite	3.0 –3.1	Kaolinite	2.6
Calcite	2.8 – 2.9	Limonite	3.8
Chlorite	2.6 – 3.0	Magnetite	5.17
Dolomite	2.87	Micas	2.7 – 3.1
Orthoclase	2.57	Mont-morillo Nite	2.4
Plagioclase	2.62 – 2.76	Muscovite	2.8 – 2.9
Gibbsite	2.30 – 2.40	Olivane	3.27 – 3.37
Gypsum	2.32	Quartz	2.6
		Talc	2.7 – 2.8
		Siderite	3.83 – 3.88

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CIVIL ENGINEERING DEPARTMENT

Soil Mechanics Laboratory

EXP.NO: 2 SPECIFIC GRAVITY AND WATER CONTENT BY PYCHNOMETER METHOD

IS: 2720 (Part 3/sec 2) – 1987
IS: 2720 (Part – 2) – 1975

Aim:- To determine the specific gravity of soil particles and water content by pychnometer

Theory:- The specific gravity is the ratio of weight in air of a given volume of dry soil solids to the weight in air of an equal volume of distilled water at a temp. of 27°C. Pychnometer method is used for determining the sp gr. For coarse grained soils.

The natural water content will give an idea of the state of soil in the field. Natural moisture content is used in determining the bearing capacity and settlement and it is essential in all studies of soil machines. Moisture content is the ratio of the weight of the water to the weight of the dry soil,. The ratio is expressed as percentage.

APPARATUS:- Pychnometer, glass rod stirer balance thermometer distilled water, non- corrodible air tight container soil sample etc.

2A. SPECIFIC GRAVITY BY PYCHNOMETER

PROCEDURE:-

1. Dry the pychnometer thoroughly and finds its weight with cap(w_1)

2. Take about 100gms of given soil into the pychnometer and find the weight of the pychnometer with soil correctly (w_2)

1. Add sufficient water (upto about half the capacity of pychnometer) to cover the soil and strir the soil with glass rod stirer to remove the entrapped air.

2. Make sure that all the entrapped air has been expelled out and then fill the pychnometer completely with water, and take its weight (w_3)

3. Throw out the contents of the pychnometer and wash it thoroughly and fill the pychnometer completely with water and screw on the cap.

4. Wipe off any excess water on the outer surface of the pychnometer and find its weight (w_4)

5. Take the average value of atleast three sets of readings.

Sl. No.	Description	Test-1	Test-2	Test-3
1	Weight of empty pychnometer any (w_1.)gm			
2	Wt. of the pychnometer + soil (w_2.)gm			
3	Wt. of pychnometer + soil +water (w_3)g.			
4	Temperature corresponding to Steps 3 in deg. C (T_s)			
5	Wt. of pychnometer + water (w_4) g.			
6	Specific gravity corresponding To T_s (G_s) = $\frac{(w_2 - w_1)}{(w_4 - w_1) - (w_3 - w_2)}$			
7	[redacted]			

RESULT:- Average sp. gravity = (G)

2B DETERMINATION OF WATER CONTENT BY PYCHNOMETER METHOD:

PROCEDURE:-

1 Clean and dry the pychnometer and take its weight (w_1)

2 Place a sample of wet soil about one third of into the bottle & weight (w_2)

3 Add distilled water to soil in pychnometer till it is about half full, mix thoroughly with glass rod and remove entrapped air. Entrapped air may be removed by vacuum pump if available.

4 Fill the pychnometer completely full with water and take its weight (w_4)

5 Empty the pychnometer, clean it and refill complete pychnometer with water and take its weight (w_4)

S.No	Description	1	2	3
1	Empty wt. Of pychnometer (w_1)gms			
2	wt of pychnometer + soil (w_2)gms			
3	Pychnometer + soil +water (w_3)gms			
4	Pychnometer +water (w_4)gms			
5	Water content $w = \frac{(w_2 - w_1)}{(w_3 - w_4)} \frac{(G-1)}{G} - 1 \times 100$			

RESULT:- Ave water content w =

GENERAL REMARKS :- 1) water content by pychnometer can be determined only if the value of sp. gr (G) is known is in advance.

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Exp.No.3: **SIEVE ANALYSIS**

IS: No (2720 Part 4) - 1985

A. SIEVE ANALYSIS:

AIM:- To determine the grain size distribution of the given coarse soil sample by conducting sieve analysis.

APPRATUS:

Indian Standard test sieves with opening sizes of 4.75, 2.00, 0.600, 0.425, 0.212 and 0.075 (all in mm) suitable sized lid and pan, cleaning brushes, balances sieve shaking machine, oven ,sample splitter etc.

THEORY:

The results of grain size analysis are used in soil classification, design of filters for earth dams, determination of suitability of soils for ear then embankments and road construction. Soil fraction coarser bhan 0.075 mm size is known as a coarse fraction and finer than that size as fine fraction of fines. Gravel (particle sizes greater than 4.75mm, and sand 4.75 between 0.075 mm) form the coarse fraction in soils, while silts (sizes in between 0.075mm and 0.002mm) and clays (finder than 0.002mm) form the fines.

Grain size analysis is normally done in two stages. For coarse grained faction, sieve analysis is used and for fines, the pipette/hydrometer analysis is used. When the fines are not greater than 10% sieve analysis along would sufficient. Sieve analysis is a more direct method where the grain size refers to the size of the sieve opening.

PROCEDURE:

1 Air dry the soil after pulverizing it. Pulverization is done only to break the soil lumps and clods and not to split. Individual soil particles. Obtain about 300g. of representative soil either y a quartering or using sample splitters (dryers) & Oven dry the soil.

2 weigh the oven dry soil and wash it with water thoroughly on 75 micron sieve. Soil retained on the sieve is dried Weighed and used in the sieve analysis while soil fraction passing through the sieve (in the form of fine settlement which is collected in a bucket) is to be used for hydrometer analysis.

3 Clean the sieves with proper brushes. Note their sizes and take their (empty) weights.

4 Arrange the sieves vertically such that each sieve is finer than the one above and coarser than the one below place a collecting pan under the finest sieve.

5 Find the dry weight of the soil to be used for the sieve analysis (this weight should preferably be not greater than 300 g.) place the soil on the coarsest (top most) sieve and cover it which the lid.

6 Place the entire assembly of sieves on the sieve shaker and shake for 10mts. Alternatively sieving may be done by hand, shaking each of the sieve (starting form the coarsest sieve) one at a time for about 5 minutes.

7 Weigh each of the sieves along with the soil retained on it. Check that the sum of the weights of the soil sample retained on all the sieves (including the pan) is equal to the total weight of the soil taken for the sieve analysis. (1% loss is allowed).

8 Enter the observations in the tabular form provided. Calculate the cumulative percentage of soil retained on each sieve on the basis of the total soil taken for the combined grain size analysis.

9 Calculate the (cumulative) percentage finer (p%) corresponding to each of the sieve sizes.

10 Draw the grain size curve, which represents graphically the relation between he grain size (plotted to log scale on x-axis)and the percentage finer (plotted to ordinary scale on y axis). This curve may not be the complete grain size curve since it reflects only the grain size distribution of coarse grained fraction contained in the given soil.

11 If substantial amount of soil fraction is gravel (having sizes greater than 4.75mm sieves for aperture sized of 20mm and 80mm are also used to determine the boulder content of the soil (having sizes greater than 80mm). Only air dried soil coarser than 4.75 mm could be used for this purpose

12 Form the grain sized determine the percentage of gravel, sand and finer fraction.

13 Determine (I) affective size D_{10} i.e., the size in mm such that 10% by weight of the soil taken is finer than that size (ii) the uniformity coefficient $C_u = (D_{60} / D_{10})$ and (iii) coefficient of curvature $C_c = (D_{30})^2 / (D_{60} X D_{10})$ for the soil.

RESULT:-

1 Effective size D_{10} =
2 Uniformity co-efficient C_u =
3 Co-efficient of curvature C_c =

COMMENT:-

Total weight of the soil sample in g.
(before washing through 75 u sieve):

Soil type

Total weight of the soil retained on 75 μ sieve (used in sieve analysis) in g.

Tested by

Total weight of the soil passing through 75 μ sieve in g.

Date:

Sieve opening D mm	Mass of sieve (g).	Mass of sieve + soil retained (g).	Mass of soil retained (g).	Cumulative Mass of soil retained (g),	Cumulative % retained (g).	*Cumulative % Passing (p%)
4.75						
2.00						
1.00						
0.600						
0.425						
0.212						
0.150						
0.075						
PAN						

Exp.No. 4

LIQUID LIMIT AND PLASTIC LIMIT
LIQUID LIMIT

IS: 2720 (Part 5) – 1985

AIM:- To determine the Liquid Limit of the given soil sample.

Theory:- Liquid Limit is the water content at which the soil has such a low shear strength that it flows to close a groove of standard dimensions for a length of 12.5 mm when jarred 25 times using the standard liquid limit device. (It is the water content corresponding to the boundary between liquid and plastic sates of a soil mass).

(A). MECHANICAL METHOD

Apparatus: Liquid Limit device and grooving tools, spatula, porcelain dish, balance of sensitivity 0.01 g. and container for moisture content determination, drying oven, beaker and measuring jar.

Procedure:

1 Weigh about 120 g. of air dried soil passing through 425 micron I.S. Sieve (0.425mm)

2 Take the soil in a porcelain dish and add clean water till it becomes a paste. Mix the soil thoroughly (certain soils may require mixing up to 40 minutes).

3 Check and adjust the fall of the liquid Limit device cup to exactly I cm. using the gauge on the handle of the grooving tool.

4 Place the soil paste in the cup of liquid limit device and level it horizontal with lowest edge of the cup, with spatula so that the maximum depth of soil in the cup is I cm.

5 Using the standard grooving tool, make a groove in the middle of the soil along the diameter, dividing the soil in to two parts.

6 Turn the handle of the liquid limit device at the rate of 2 revolutions per second, till the two parts of the soil in the cup join together i.e. the groove closes y 12.5 mm length. Ensure that the groove closes by flow and not by slipping of soil on the surface of the cup.

7 Note the number of blows imparted to the cup. Repeat and recheck this value. Take a small quantity (about 10g. of the moist soil form the center of the groove into a moisture determination container and determine the moisture content.

8 By altering (increasing) the water content of the soil and repeating the above operation, obtain five or six water content determinations for blows in the range of 15 to 35.

9 The test should always proceed form drier (more blows) to the wetter (less blows) condition of the soil. Each time the soil is thoroughly mixed to ensure that the water content is uniform throughout the soil mix. Add water to soil but never add dry soil to the thoroughly mixed soil.

10 Interpretation fo results: Plot the results of the experiment of a semi-log sheet. The percentages of moisture content are marked as ordinates on the arithmetical scale and the corresponding number of blows are marked as abscissa on the logarithmic scale. The various points obtained are joined by a straight line and the moisture content corresponding to 25 blows is denoted as the liquid limit of the soil. At least four readings should be taken though five readings are desirable. The above straight line is known as FLOW CURVE. It shall be extended at either ends, so as to intersect the abscissa corresponding to 10 and100 blows. The slope of this line expressed as the difference in water content at5 10 blows and at 100 blows shall be reported as the flow index (I_f).

The flow index may be calculated from the following equation also.

$I_f = (w_1 - w_2) / \log_{10} (N_2 / N_1)$ $\frac{w_1 - w_2}{\log_{10} (N_2 / N1)}$

where

I_f = flow index

w_1 = Moisture content in % corresponding to 'N_1' blows

w_2 = Moisture content in % corresponding to 'N_2' blows

CONE PENETRATION METHOD

Theory:- The basic principle is to observe depth of Penetrations of metallic Cone of standard weight and apex angle into soils at various initial moisture contents. The Liquid water content corresponds to a specified depth of Penetration.

Apparatus:- Cone Penetrometer with an cone apex angle of 30° and a mass of 80 g. Balance with sensitively of 0.01g. containers for moisture content determination, Oven, Spatula, Porcelain dish.

Procedure:-

1. Weight about 150g. of soil passing 425μ Sieve.
2. Take the soil in Porcelain dish and add distilled water and work well into a paste.

3. Transfer the wet soil paste into the cylindrical cup of cone Penetrometer apparatus ensuring that no air is entrapped in the process level the wet soil flush with the top of cup place the cup on the base of the apparatus.

4. Adjust the penetrometer so that Cone point just touches the surface of the soil paste in the cup clamp the penetrometer

5. Adjust the initial reading on the graduated scale to zero.

6. Release the vertical clamp, allowing the cone to penetrate into the soil paste under its own weight.

7. Note the penetration of the cone after five seconds to the nearest millimeter collect a soil sample in a container and determine the moisture content.

8. Repeat the test at least four times with cone penetration in the range of (10 – 30 mm).

Determination No.	1	2	3	4	5
Cone Penetration (mm) (y)					
Container No.					
Weight of container + Wet soil (g)					
Wt. of container + Oven dry soil (g)					
Wt. of water (g)					
Wt. of Container (g)					
Weight of oven dry soil (g)					
Moisture content (%) (w_y)					
Liquid Limit of soil $w_L = w_y + 0.01 (25-y) (w_y + 15)$					

Result:- Ave Liquid Limit $w_L =$

B.PLASTIC LIMIT

Plastic limit is defined as the minimum moisture content at which a soil when rolled into a thread of 3mm diameter it just begins to crumble. It is the water content corresponding to the boundary between plastic and semi - solid states of soil mass.

Procedure:-

1 Take about 20 g. of e air dried soil passing through 425 micron I.S. sieve (0.425 mm size).

2 Place the soil in a porcelain dish and mix with sufficient quantity of water until the mass becomes plastic enough to be easily moulded with fingers.

3 Take a portion of the wet soil and form it into a ball and roll it quickly on a glass plate with the palm of hand into a thread of uniform diameter. (if the soil cannot be rolled into thread at all or even if the thread on first rolling break before reaching a diameter of 3 mm, the initial trial water content is less than plastic limit of the soil. Hence add a little more water to make it more plastic. continue this process and the rolling till the thread reach a diameter of 3 mm. or less.

4 The soil is then kneaded together, rolled again on the glass plate till it begins to crumble at 3 mm diameter (The crumbling may occur even when the thread has a diameter slightly greater then 3mm)

5 Take some of the crumbled soil pieces and determine the water content.

6 Repeat the experiment for at least 3 times and the average water content is recorded as the plastic limit of the soil.

B. PLASTIC LIMIT TEST

Determination No.	1	2	3
Container No.			
Wt. of container + Wet soil (g)			
Wt. of container + Oven dry soil(g).			
Wt. of water (g).			
Wt. of Container (g).			
Wt. of dry soil (g).			
Moisture content (%) = P.L			

Average of value
Of P.L =

(Natural water content
Wn % =
Of a field soil sample if any)

Result Summary:

Liquid Limit W_l (Form graph)	Flow Index I_f	Plastic limit We (Average from P.L Table)	Plasticity index $I_p = w_l - w_p$	Toughness index $IT - \frac{I_p}{I_f}$	Liquidity index $I_L = \frac{w_n - w_p}{I_p}$	Consistancy index $Ic = \frac{w_l - w_n}{I_p}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)

(A). LIQUID LIMIT TEST

Soil Type

Tested by
Date:

Determination No.	1	2	3	4	5	6
Number of blows						
Container No.						
Wt. of container + wet soil (g)						
Wt.of container + oven dry soil(g)						
Wt. of water(g).						
Wt. of container (g).						
Wt. of oven dry soil (g)						
Moisture (%) Content						

Exp.No: 5

SHRINKAGE LIMIT

IS2720: Part (vi) - 1972

Aim:- To determine the shrinkage limit of the given fine grained soil sample.

Apparatus: Shrinkage dish, glass cup, glass plates (one plain and the other with three metal prongs). Mercury, Porcelain dish, balance, desiccator and spatulas etc.

Theory :-The maximum water content at which a reduction in water content will not cause a decrease in volume of the soil mass is defined as shrinkage limit, For soils the lower the shrinkage limit, the more will be the degree of shrinkage and expansiveness. Its concept is use full in identifying expansive clays.

Procedure:

1 Take about 30 g. of soil passing through 425 micron sieve into a porcelain dish and mix the soil thoroughly with sufficient quantity of distilled water to such a consistency that the soil may flow i.e., Water content close to the liquid limit or slightly higher).

2 Coat the inside of the shrinkage dish with a thin layer of Vaseline/grease to prevent the adhesion of the soil to the dish.

3 Fill the soil paste into the dish in three equal quantities. After placing one-third quantity of soil paste each time, tap the dish on a firm surface cushioned by several layers of blotting paper or similar materials until the paste is throughly compacted and all entrapped air has been brought to the surface in the form of bubbles. Repeat the same operation for the next tow layers. Strike off the excess soil paste with a straight edge and wipe off all soil adhered to it and bring to the outside of the dish.

4 Take the weight of the dish with wet soil (M_1). Allow the soil to dry up in air till the color of the pat changes form dark to light. Then up to the dish in oven at 110°C till its weight becomes constant.

5 Weigh the shrinkage dish with dry soil pat (M_2) and also weigh the empty dish (M_3).

6 Fill the empty shrinkage dish completely with mercury. Removed the excess mercury by pressing a plain glass plate over the dish. Find the weight of the mercury (M4 g.) filling the dish, which when divided by 13.6 would yield volume in c.c. This mercury volume is equal to the original volume (V1) of the wet soil pat.

7 Place a glass cup full of mercury in a porcelain dish. Press a glass plate with three metal prongs, over the cup removing the excess mercury into the

porcelain dish. Carefully remove the glass plate and weigh the glass cup. Full of mercury now remaining (M6 g.)

8 Again place the glass cup in the porcelain dish and keep the dry soil pat over the mercury in the glass cup. Press the dry soil pat into the glass cup using the same glass plate. In this process the day soil pat gets submerged in the mercury ensuring excess mercury to escape into the porcelain dish. After ensuring that the glass plate is pressed tight on the top of the glass cup and that no further mercury tends to escape, carefully remove the glass plate and the soil pat and weigh the glass cup with the balance of mercury in it (M_7 g.)

9 The weight of mercury displaced by the dry soil pat is equal to M5 g. ($M_4 = M_6 - M_7$)and hence the volume of mercury displaced, equal to the volume of the dry soil pat (V_2), can be computed. $V_2 = \frac{M_5}{13.6}$

10 Shrinkage limit is calculated by the formula:

$$W_s\% = \frac{M_1 - M_2}{M_2 - M_3} - r_w \frac{(V_1 - V_2)}{M_2 - M_3} \times 100$$

$$= w_{1\%} - r_w \frac{(V_1 - V_2)}{M_d} \times 100$$

Where w_1 I is the initial moisture content and M_d is the dry weight of the soil pat.

11 Determine the shrinkage limit by three trials and take the average value.

$$\text{Shrinkage Ratio } R = \frac{\text{Mass of Oven dry Pat (g)}}{\text{Volume of Oven dry Pat (ml)}}$$

Volumetric ; shrinkage $V_s = (w_1 - w_s) R$

Where w_I = given moisture content (%)

OBSERVATION FOR SHRINKAGE LIMIT

Soil Type :
Location:

Tested by:
Date:

Determination No.	1	2	3
1. Mass of shrinkage dish + wet Soil (M_1) g.			
2. Mass of dish + dry soil (M_2) g.			
3. Mass of dish alone (M_3) g.			
4. Mass of mercury to fill the dish (M_4) g.			
5. original volume of soil (v_1)cc $v_1 = \frac{m4}{13.6}$			
6. mass of mercury without dry soil pat (m_6) g.			
7. mass of mercury after immersion of soil pat = m_7 g			
8. Final volume of soil (dry pat) (V_2) cc (V_2) = $\frac{M_5}{13.6}$			
9. Initial moisture content (w1%) $W_1^{\%} = \frac{M_1 - M_2}{M_2 - M_3} \times 100$			
10. Shrinkage limit $W_s^{\%}$ $w_s = w_1^{\%} - r_w \frac{(V_1 - V_2)}{M_2 - M_3} \times 100$			

Average value of $W_s^{\%}$

Shrinkage ratio = $\frac{M_2 - M_3}{V_2}$

Volumetric shrinkage Vs = $(w_1 - w_s)$ R

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Soil Mechanics Laboratory

Exp.No:6 **DETERMINATION FOR FILED DENSITY**

IS. 2720 part – XXVIII 1974

Aim:- To determine the field density of soils.

Theory:- The field density of a soil is the mass of the soil per unit volume. The filed density of natural soil is needed for (I) determination of bearing capacity of soils (II) stability analysis of natural slopes (III) determination of over burden pressure on underlying strata for calculation for settlement etc. In compacted soils the in-situ dry density is needed to check the degree of compaction that the soil has under gone for comparison with design data. Dry density of soil is defined as the mass of dry soil per unit volume (including voids) knowing the field density and water content of a soil one can estimate its dry density. The natural void ratio of a soil can estimated knowing its dry density and specific gravity of soil particles.

Field density can be determined by various methods: Popular among them being (I) core cutter and (II) sand replacement methods. In the core cutter method mass of the soil obtained in a core cutter of known volume is determined. This method is simple and is suitable for clayey and moist soils. In the sand replacement method, soil is dug out form a small pit which need not necessarily conform to a regular geometric shape but preferably hemispherical of diameter equal to that of the circular hole In the metal tray. The mass of soil dug out is determined by knowing the mass of dry a sand (of pre-calibrated density) required just to fill the pit. Knowing the mass and volume o f excavated soil the field density can be calculated. This method is suitable for all types of soils.

A. SAND REPLACEMENT METHOD

Apparatus:-

Sand pouring cylinder, cylindrical calibrating can, metal try with a circular hole, excavating tools like crow bar, trowel etc., balance, plane surface like glass or Perspex plate, moisture can, clean uniformly graded natural sand (passing through 1.0 mm and retained on 600 micron IS Sieves).

Procedure:-

1 weigh the tray with central hole (M1)

2 Clear a flat area, approximately 450 mm square, and trim it down to a level surface .

3 Place the metal tray on the prepared surface with its central hole ove the portion of the soil to be excavated

4 Excavate the soil using the hole in the tray as a pattern to a depth of 125mm. Collect the excavated soil carefully into the tray leaving no loose material in the hole and weight it (M2).

5 Fill the pouring cylinder with sand so that the level of the sand in the cylinder is within about 10mm form the top Weigh the cylinder with sand (M3)

6 Place the pouring cylinder such that the base of the cylinder covers the hole centrally.

7 Open the shutter and allow the sand to run out into the hole. Close the shutter when no further movement of sand takes place.

8 Remove the cylinder and weight it (M4)

9 Collect representative soil sample in a moisture can and put in the oven and determine the moisture content (w_i%)

<u>CALIBRATION FO APPARATUS:</u>

1 Place the pouring cylinder with the remaining sand on a plane surface (such as glass or Perspex plate) open the shutter and allow the sand to run out. Close the shutter when no further movement of sand takes place in the cylinder.

2 Remove the cylinder carefully and weigh it (M5)

3 Determine the internal volume (V) of the calibrating can form the measured internal dimensions. Find the weight of empty can (M6)

4 Fill the pouring cylinder so that the level of the sand in the cylinder is within about 10mm for the top.

5 Place the pouring cylinder centrally on the top of the calibrating can. Open the shutter and allow the sand to run cut . Close the shutter when no further movement of sand takes place in the cylinder. Remove the pouring cylinder.

6 Remove the excess sand carefully , with a straightedge on the top of the can so that the top the sand is flush with the can. Weigh it (M7).

DETERMINATION OF FIELD DENSITY
A. (sand replacement Method)

Location: Tested By:
Soil Type: Date:

Sl.No.	Description	Test-1	Test-2
1	Mass of empty Tray (M_l) g		
2	Mass of Tray excavated soil (M_2)g		
3	Mass of excavated soil ($M_2 - M_1$) g.		
4	Mass of cylinder + sand before Pouring into pit (M_3) g		
5	Mass of cylinder + sand after Pouring into pit (M_4)g.		
6	Mass of sand filling cone + pit ($M_3 - M_4$) g.		
7	Mass of cylinder + sand after pouring into cone (M_5) g.		
8	Mass of sand filling cone ($M_4 - M_5$) g.		
9	Mass of sand filling the pit ($M_3 - 2M_4 + M_5$) = M		
10	Mass of empty calibrating can (M_6) g.		
11	Mass of can sand flush with can (M_7) g.		
12	Mass of sand filling can ($M_7 - M_6$) g.		
13	Density of sand used g/cc ($M_7 - M_6$) /V_s = r_s		
14	Volume of pit = $\frac{M_s}{r_s} = V_s$		
15	Volume of the can (V_s) cc		
16	Field density of soil = $\frac{M_2 - M_1}{V} = r$		
17	Moisture content (w) in %		
18	Dry density g./cc = $\frac{r}{1 + (W)/100}$		

water content determination:

Sl.No.	Description	Test –1	Test – 2
a)	Container no.		
b)	Mass of container + wet soil		
c)	Mass opf container + dry soil		
d)	Mass of water = ( )		
e)	Mass of container = ( )		
f)	Mass of dry soil = ( )		
g)	Moisture content (wl%) = ( )		
**	dia of Can = cm.,		
	height of can = cm		

Exp.No:7

CORE CUTTER METHOD

IS: 2720 Part – XXIX – 1966

Apparatus: Cylindrical core cutter with dolly, hammer, trowel tray, balance, straight edge, crow bar, moisture can.

Procedure:

1. Clean the core cutter and dolly. Weigh the core cutter (M1) and determine its volume (V). Apply grease inside the core cutter.
2. Clear a small area of ground where the field density of soil is to be found out and make it level
3. Drive the core cutter (with dolly fitted on top) with hammer to this full depth. Avoid over driving by seeing the top level of the soil in the cutter
4. Dig out the core cutter with the help of crow bar and lift it carefully form the ground with the help of a trowel placed at the bottom of the cutter. Trim the top and bottom surface of the sample with a straight edge.
5. Determine the weight of the core cutter with soil (M2)
6. Find the moisture content of the soil (w_{l}%)

Calculations:

Calculate the field density (r), water content (w%) dry density (rd) and void ratio (e)

DETERMINATION OF FIELD DENSITY
(CORE CUTTER METHOD)

Soil Type

Tested by:
Date:

Sl.No	Description	Test – 1	Test – 2
	Internal dia of Core cutter cm .. Weight of Core cutter cm..		
1	Mass of core cutter (M1)g.		
2	Mass of core cutter + wet Soil (M2) g.		
3	Mass of wet soil (M2-M1)g.		
4	Volume of core cutter (V) cc..		
5	Bulk density rb = $\frac{M_2 - M_1}{V}$ g/cm^3		
6	M.C. Container No.		
7	Mass of container dry soil ..		
8	Mass of water		
9	Mass of container		
10	Mass of dry soil		
11	Moisture content in % (w) =		
12	Dry density dry = $\frac{rb}{(I + \frac{W}{100})}$ g./cm^3		

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Soil Mechanics Laboratory

Exp.No: 8

DETERMINIATION OF COEFFICIENT OF PERMEABILITY OF A COARSE GRAINED SOIL SAMPLE (CONSTANT HEAD PERMEAMETER)

IS:2720 (Part XXXVI) – 1975

AIM:- To determine the coefficient of permeameter of the given undisturbed or remolded coarse grained soil sample with a constant head permeameter

APPARATUS:- permeameter, stop watch, measuring jar, scale, calipers thermometer, soil sample etc.

THEORY:- The coefficient of permeameter (k) of a soil is defined as the rate of discharge of water through a unit cross sectional area of the soil under unit hydraulic gradient for a laminar flow condition. This cab be determine d in the laboratory by constant head permeability test for coarse grained soils with $k>10^{-3}$ cms /sec.

PROCEDURE :-

1 Note the dimensions of the permeability mould and calculate its volume.

2 For testing an undisturbed soil sample, obtain the sample in the mould. Trim the soil sample if necessary and weigh the mould with the soil,. Knowing the weight of empty mould determine the weigh of undisturbed sample. Determine the natural water content of sample form soil trimmings.

3 For testing remoulded soil sample, first calculate the dry density of soil at the given void ratio. Take the required weight of dry soil, (finder than 9.5 mm) knowing the volume of the mould and the dry density of the soil. Compact the soil in to the mould in layers, after fixing , the mould to its base plete containing porous stone, and placing the collar on top.

4 Put a porous stone on the top of the soil and fix the to plate which is provided with an inlet valve and air-cock. Secure both the base plate and the top plate to the mould with suitable clamps and rubber gaskets to make the entire assembly water tight

5 Place this assembly in a shallow metal tray with an outlet. Fill the tray with water to submerge the base plate completely. All the heads of water must be measured with respect to the tail water level corresponding to the center of the outlet pipe or crest of the out let in the tray.

6 Attach the constant head water tank with the sliding bracket to a vertical stand. This tank has three openings. Connect on e of the to a water supply

source, the second to an overflow tube and the third to the inlet valve provided on the cap of the permeameter. Admit the water into the permeameter. Remove all the air bubble with the help of the air cock provided on the top plate. Allow the soil sample to saturated. Check this by containing constant values of discharge collected over a given time under a given head.

7 When steady state flow is attained, collect sufficient quantity of water (say about 600 c.c) and note the time interval. Measure the quantity of water exactly . Repeat the collection of water twice for the same time interval. Measure the correct hydraulic head. Note the temperature of water. (T^oC) .

8 Repeat the test for 4 different hydraulic heads covering the full range of head available in the apparatus.

9 Calculate the coefficient of permeameter of soil using the following formula:

$$K = \frac{Q.l}{A.h.t}$$

Where K = coefficient of permeability of the soil (cm/sec) at room temperature T^oC

Q = Quantity of water collected (c.c) in a time interval of 't' seconds.

l = Length of the sample (cm)

A = Area of cross section of t he soil sample (sq.cm)

h = Total head lost (cm)

Apply the temperature correction to determine the coefficient of permeability corresponding to 27oC.

$$K27^o = KT\ (U_T)\ /\ (U_{27})$$

Where UT = Coefficient of viscosity of water at temp. T^oC

$U_{27}{}^o$ = Coefficient of viscosity of water at 27^oC (= 0.00854 poises)

CONSTANT HEAD PERMEABILITY TEST

Soil Type:

Date:

Tested by:

Dia. Of mould = cm
Area of mould (A) = cm^2
Length of mould (l) = cm
Volume of mould (V) = cm^3
Temperature of water ($T^\circ C$)

FOR REMOULDED SAMPLE:

Sp.Gr. of soil (Gs) =

Void ratio (e) =
Dry density (r_d) = (G_s r_w) / (l + e) g/cc =
Mass of dry soil W_s = r_d. V = g =

FOR UNDISTURBED SAMPLE:

Mass of Wet soil (W) = g.
Wet density (r_{wet}) = W/V
Water content (w%) =
Dry density (rd) = r_{wet} / (l + w%) g./cc.
Void ratio (e) = $\frac{(r_w Gs)}{r_d} - 1$

Head (h) Cm	Quantity of water (Q) cc			Time (t) Sec	Coefficient of permeability (cm/sec)	Remarks
	1	2	3			

Average value of $K_T{}^\circ C$
The value of $K_{27}{}^\circ C$=

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Exp.No:9 **VARIABLE HEAD PERMEAMETER**

IS: 2720 (Part – XVII) – 1966

AIM:- To determine the coefficient of permeability of the given fine grained (remoulded / undisturbed) soil sample using variable head permeameter.

APPARATUS :- Variable head permeameter, stop watch , scale , Inside calipers, thermometer, soil sample, accessories.

THEORY:- The coefficient of permeameter (k) of a soils defined as the rate of discharge of water through a unit cross sectional area of the soil under unity Hydraulic gradient under laminar flow conditions.; This can be determined in the laboratory by variable head permeability test of fine grained soils with $k < 10^{-3}$ cms/sec

PROCEDURE :-

1 Note the dimensions of the permeability mould and calculate its volume.

2 For testing an undisturbed soil sample obtain the sample into the mould. Trim the soil sample if necessary and weigh the mould with the soil. Knowing the weight of empty mould find the weigh of undisturbed sample. Determine the natural water content of sample form soil trimmings.

3 For testing remoulded soil sample first calculate the dry density of the soil at the given void ratio. Knowing the volume of the mould and the dry density of the soil, compute the mass of soil needed to fill the mould. Compact he soil in to the mould in layers, after fixing the mould to its base plate. Put a filter paper on the top of the soil.

4 Attach the top cap with stand pipe and scale to the mould and tighten the bolts to make the assembly water tight

5 Place this assembly in a shallow metal tray with an outlet. Fill the tray with water to submerge of the base plate completely, The head of water causing flow through the samples at any time is equal to vertical distance between the free surface of water in the supply stand pipe and the tail water level in the tray with suitable outlet.

6 Pour water into the stand pipe and allow it to run through the soil sample. Operate the air cock to remove any air. Check the saturation of the soil by noting the same fall of head of water form the same initial head of equal time intervals. To determine the cross sectional area of stand pipe, close the inlet

tube and pour known volume (10c.c) of water exactly measured by means of a pipette into the stand pipe and note the rise of water level in the stand pipe. The cross sectional area of the stand pipe (a)

a = (volume of water poured into the sand pipe/water level rise in stand pipe)

7 Open the inlet value and allow the water to flow through the soil sample. Note the height (h1) of the water level in the stand pipe and corresponding to time t1.

8 Allow sufficient time so that water level falls by about 30 to 50 cms in the stand pipe. The height (h_2) of the water level in the stand pipe and corresponding time t_2.

9 Take two more sets of reading with different h_1 and h_2

10 Note the temperature of water T° C.

11 Calculate the Coefficient of permeability form the relation.

$$K = \frac{2.300\ a\ l}{A\ (t_2 - t_1)} \quad Log_{10} \frac{(h_1)}{(h_2)}$$

Where

k = Coefficient of permeability of the soil (cm/sec.)
a = Area of cross section of stand pipe (sq.cm)
l = Length of soil sample (cm)
A = Area of cross section f soil sample (sq.cm)
t = Time interval (sec.)
h1 = Initial head of water (cm)
h2 = Final head of water (cm)

Apply the temperature correction to determine the coefficient permeability at 27°C.

Where U = Viscosity of water

$K_{27}°C = K_T (U_T / U_{27}°C)$

VARIABLE HEAD PERMEABILITY TEST

Date :

Soil Type:

Tested by:

Dia. of mould = cm

Area of mould (A) = sq.cm.

Volume of mould (V) = Cm^3

Temperature of water (T°C) =

Area of the stand pipe (a) = $\frac{\Delta V}{\Delta H}$ = Cm^2

For Remoulded sample:

Sp. G. of soil (Gs) =

Void ratio (a) =

Dry density (rd) = $G_s . r_w / (l + e)$

Weight of dry soil (w) = rd. V

For undistrubed sample:

Weight of wet soil (w) =

Wet density r_{wet} = (W/V)

Water content (W%) =

Dry density (rd) = $\frac{r\ wet}{(l + w\%)}$ gm/c.c. =

Void ratio (e) = $(\frac{r_w G_s}{r_d} - 1)$

S.No.	Initial time t1(sec)	Final Time t2(sec)	Initial head h1(cm)	Final head h2(cm)	Coeff. of Permeability kt (Cm/sec)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

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Exp.No:10 **PROCTOR'S STANDARD COMPACTION TEST**

IS: 2720 (Part – VII) – 1974

AIM To determine the maximum dry density (rd max.) and optimum moisture content (O.M.C) of a given soil sample using the Proctor 's standard test.

Theory:- This test determines the optimum amount of water to be mixed with a soil in order to obtain maximum compaction for a given compactive effort. This will enable the field engineer to plan field compaction of soil to a degree comparable to that obtained in the laboratory by suitably altering the affective lift or number of passes with the available roller. Maximum compaction loads to maximum dry density and hence the deformation and strength characteristics of the soil turn out to be the best possible values.

This test is based on the method given by R.R. ROCTOR(1933) and referred to as Proctor's Standard compaction test. This test is satisfactory for cohesive soils but does not lend itself well to the study of compaction characteristics of clean sand and gravels which are easily displaced with in compacted with rammer. Where higher densities are warranted as in the case of formation for air port runways higher compactive effort becomes necessary. For this case proctor's and field compaction test is adopted..

PROCEDURE :-

1 Weigh the empty mould (w1) with base plate and attach the collar to the mould. Apply thin layer of oil to the inside surface of the mould and the collar.

2 Take 2 kg of soil passing through 4.75mm size sieve, and add water to bring its moisture constant to about 8% in the case of silty soil sand 14% in the case of clayey soils. For uniformity , this quantity of water is sprinkled on the soil and the soil is mixed thoroughly.

3 Divide the Wet soil into three equal parts. Fill the mould with one part of the soil and compact it with 25 evenly distributed blows with the standard rammer of 2.6 kg weight and free fall of 3l cms. Repeat this process with the second and third parts of the soil taking precaution to scratch the top of the previously compacted layer with a spatula in order to a void stratification and achieve homogeneity. Remove the collar and trim the cap of the soil flush with the top of the mould. To remove the collar, rotate it to break the bond between it and the soil. Then lift the collar vertically off the mould. This prevents the possible loss of compacted soil form the mould when the collar is removed.

4 Remove all loose soil adhering to he mould and (w2) with base plate.

5 Detach the mould with base plate and Extract the soil form the mould. Cut the compacted soil sample longitudinally into tow equal parts. Obtain equal amount of soil sample form top center and bottom and put then together in a container and determine the average moisture content.

6 Repeat this procedure (4 to 5 times) by taking fresh soil sample each time and adding water to make the water content 2 to 4% more than he previous water

CALCULATIONS:

Calculate moist density (r_m) form the known wet weight of the soil and the volume of the proctor mould. Calculate dry density (rd) knowing the moist density and water content of the soil.

Calculate the dry densities form the following formula for different assumed water contents.

$$r_d = \frac{G\, r_o}{(I + w\, G/S)}$$

GRAPHS: Draw the following graphs.

1 A graph between moisture content and the corresponding dry density obtained form the compaction test to find (r_d) Max. and OMC.

2 A graph between the assumed water content and the corresponding dry densities calculated form the above formula. The curve is known as zero air voids curve.

STANDARD PROCTRO'S COMPACTION TEST

Date:

Tested by:

Soil Type:

Dia. of mould: Cm
Ht. Of mould Cm

Test No.	1	2	3	4	*5	6
Weight of empty mould (w1) g.						
Wt. Of mould + Compacted soil (w2)						
Volume of mould (V) cc						
Wt. Of compacted soil (w2 – w1)g						
Moist. Density rm = $\frac{(w2 - w1)}{V}$ g/cc						
Container No.						
Wt. Of Container (x_1)g.						
Wt. Of Container + wet soil (x_2)g						
Wt. of container + dry soil (x_3)g						
Wt. Of dry soil (x3 – x1) g.						
Wt. Of water (x2-x3)g.						
Water content = W% = $\frac{(x2 - x3)}{(x3 - x1)} \times 100$						
Dry density rd = $\frac{rm}{(1 + \frac{w}{100})}$ g/cc						
Theoretical dry density for ZAVD curve:- rd = $\frac{G\ rw}{1 + \frac{Gw}{100}}$ (g/cc)						

Exp.No:11 UNCONFINED COMPRESSION TEST

IS: 2720 (Part –X) – 1973

AIM:- To determine the unconfined compressive strength of the given cohesive soil sample.

APPARATUS :- Unconfined compression testing apparatus, proving ring with fittings, sampling tubes, sample extractor, deformation dialgauge, stop watch, scale, knife etc.

THEORY:- In this test, a cylindrical soil sample with length to diameter ratio of two is subjected to an axial compression without any confining pressure. During the test the length of the specimen decreases with consequent increase in its lateral dimension. Thus at any axial strain, the actual average, area of cross-section is more that the original area. It is obtained as the corrected area(Ac) form the expression.

$$Ac = \frac{Ao}{I - E}$$

Where Ao = Original area of cross section

E = Linear strain = Change in length/original length

The unconfined compressive strength (qu) of a soil sample tested is defined as the maximum axial stress intensity which the sample can sustain or the axial stress corresponding to 20% axial strain which ever occurs earlier. Saturated soils tested under undrained condition (like the unconfined compression test) and to be have as if they are purely cohesive soils with $\phi = 0$ and for such soils the usual expression for sheer strength.

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

$Su = Cu \sin \phi u = \phi$ where

Cu = Undrained cohesion and

ϕu = Undrained angle of friction

Su = Undrained shear strength

Drawing the Mohr's circle for the failure condition of the sample, it is seen that Su = Cu = qu/2

The unconfined compression test is also useful to calculate the sensitivity of a soil which is defined as the ratio of q_u of a soil in its undisturbed state to that in its remolded state.

SAMPLE PREPARATION:

(a). **Undisturbed samples:** Undisturbed samples are usually obtained in large diameter tubes (of not less than 100mm) For most of the fine grained cohesive soils normally 38 m dia 150 mm long sampling tubes are used to obtained the samples of the correct size. These are lightly oiled inside and then penetrated into the large diameter sampling tube (in which the field sample is obtained) using the universal extractor, as so that each of the tubes is filled with the soil sample with minimum possible disturbance. The samples of 38mm. Diameter thus obtained are extracted and filled into split moulds using the sample extractor trim the length of the sample to 76 mm. When they are still in the split moulds,. Store the moulds in a moist room (or in a dissector) to avoid moisture losses. The soil samples are taken out from the split moulds just before testing.

(b). **Remoulded Samples:** Compact the given soil either by static or dynamic compaction into a mould of 100mm. diameter tot he desired density and moisture content. Obtain three 38 mm diameter and 76mm, long test samples form this mould as explained under sample preparation for undisturbed sample.

Testing Procedure:

1 Note the dimensions of the sample (taken the average value after measuring the length and diameter at three places) and weigh it.

2 Adjust the distance between the two platens of the loading device to suit the height of specimen.

3 Place the specimen of the lower plate with its vertical axis as near the canter of the plate as possible. Operating the handle, raise the lower plate and bring the specimen just in contact with the proving ring. This is achieved with the proving ring dial gauge pointer stands to move with any little further movement of the lower plate upwards.

4 Mount the dial gauge for strain measurement on the bracket provided. The dial gauge is adjusted in a truly vertical position ensuring that the bottom of the spindle just touches the bottom plate with the initial reading at zero.

As a final check for the proper initial setting, any little movement of the lower plate is to be followed with a movement of the pointer in the dial gauge for strain measurement as well as the dial gauge of proving ring for load measurement in the positive direction.

5 Apply the compressive load on the soil ample by turning the handle so as to give an axial strain rate of about 1% per minute. This is to be practiced prior to the fixing of the sample in position and by fixing the strain measuring dial gauge in position,. Actually 1% strain in corresponds to a reading of 0.76mm.

deflection in the strain measuring dial gauge or 0.19mm. every 15 seconds. So a strain ratio of 0.20mm every 15 seconds can be adopted.

6 Note the proving ring reading s corresponding to each 0.50% axial strain value until a total strain of 20% is reached and there after not the proving ring readings for each 1% additional strain. Or use 0.5mm & 1.00mm intervals.

7 Continue loading and recording till an axial strain of 20% is attained irrespective of the fact whether load increases continuously or increase initially and decrease later.

8 Sketch the failure pattern. Measure the angle between the failure planes (cracks) and the horizontal plane (say Q_f)

9 Determine the moisture content of each specimen at the failure plane.

10 Calculate the axial stress (σ_a) corresponding to each strain (a) knowing the corrected area as explained earlier.

11 Plot the stress-strain curve σ_a V_s a. note the maximum value of the stress (q_u) and also the strain.
Corresponding to the is value. If the sample does not fail even at a strain of 20%, the axial stress at 20% strain may be taken as the value of Cu.
see (fig .1)

12 Calculate the degree of saturation for each specimens. If the values are very near 100% then the un-drained strength (Su = Cu) of the soil is half the average q_u. If not the value of Su is taken as Cu approximately.

13 Test all the three samples. If their water contents are same then report he value of q_u as the average of the 3 values obtained. If not an approximation has to be made in relation to the water content variations.

14 Plot the Mohr's circle of the three samples tested at failure condition. An approximate value of C_u can be obtained if the three circles are of different diameters (See in Fig. 2)

15 Obtain the approximate value of effective angle of friction 0 form the expression 0f = 45 + φ/2

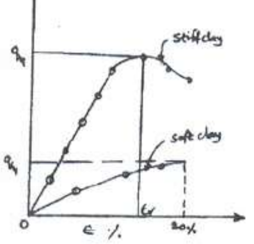

Fig. ① STRESS STRAIN CURVE

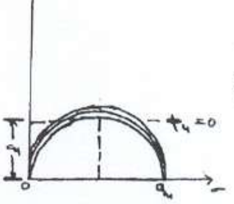

Fig ②. MOHR CIRCLES & ENVOLOPES

UNCONFINED COMPERSSION TEST

1. Project
2. B.H/Pit No.
3. Sample No.

(4). Depth
(5). Undisturbed /Remoulded
(6). Description of soil
(7). Proving ring capacity and calibration factor

Detail	Specimen No. 1	2	3
Initial height, (mm)			
Initial diameter			
Initial area			
Initial volume			
Weight of specimen before test (g)			
Bulk density g/cc.			
Weight of specimen after test (g)			
Container No.			
Weight of wet soil + container (g)			
Weight of dry soil + container (g)			
Weight of water (g)			
Weight of dry soil (g)			
Weight of container (g)			
Water content of soil (%)			
Unconfined compressive strength (kg/sq.cm) (q_u)			
Undrained cohesion (kg/sq.cm) C_u			
Strain at failure			
Angle made by failure plane with horizontal plane = ϕ_f			
Fringle angle ϕ'			

UNCONFINED COMPRESSIN TEST - TABULAR STATEMENT

			Specimen-I			Speciemn-2			Specimen-3		
dialdeformation (mm)	Strain	Corected area cm^2 A_c	Proving ring reading	Load (kg)	Axial stress (kg/cm²)	Proving ring reading	Load (kg)	Axial stress kg/cm²	Proving ring reading	Load (kg)	Axial stress kg/cm²
0											
0.5											
1.0											
1.5											
2.0											
2.5											
3.0											
4.0											
5.0											
6.0											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											

EXP.No:12 **LABORATORY VANE SHEAR TEST**

IS:2720 (Part-xxx) –1968

AIM:- To determine the undrained shear strength of soft cohesive soils.

APPARATUS :- Vane shear apparatus, porcelain dish, spatula, balance.

PROCEDURE:-

1 Take about 100g. of given soil and add sufficient water to make the soil paste of stiff consistency. Mix the soil water thoroughly and compact the soil into a tube to get a specimen of a minimum length of 75mm.

2 Mount the specimen container with the specimen on the base of the vane shear apparatus and fix it securely to the base.

3 Lower the shear Vanes in to he specimen to their full length gradually without disturbing the soil specimen that the top of the vane is at least 10mm below the top of the specimen.

4 Note the reading of the strain and torque indicators after commanding them (Q_1 is the initial angular reading).

5 Rotate the Vane at a uniform rate of about 0.1/sec by suitably operating the torque applicator handle until the specimen fails which is indicated by the return of the strain indicating pointer.

6 Note the final reading of the torque indicator (0_2 is the final angular reading)

7 Collect sample for determining moisture content

8 Repeat the test five to six times gradually increasing the water content.

CALCULATIONS:

Calculate the shear strength of the soil using the following formula

$$S = \frac{T}{\left(\frac{D2H}{2} + \frac{D3}{6}\right)}$$

Where S = shear strength in kg/cm2

T = Torque in cm kg = $\frac{\text{Torque angle X Spring cont.}}{180}$

D = Overall diameter of the Vane in cm

H = Height of vane in cm

Plot a graph water content V_s log shear strength

LABORATORY VANE SHEAR TEST

Date:
Tested by:
Soil Types:

Test No.	1	2	3	4	5	6
1. Initial Readin of Torque indicator (Q_I)						
2. Final Reading of Torque Indicator (Q_2)						
3. Torque angle (Q2 – Q1) = Q						
4. Torque (cm kg/)=						
5. Shear Strength (kg/cm_2)						
6. container No.						
7. Weight of container + wet soil (g)						
8. Weight of container + Dry soil (g)						
9. Weight of water (g)						
10. Weight of container (g)						
11. Weight of dry soil (g)						
12. Water content (%)						

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DIRECT SHEAR TEST

IS: 2720 (Part-xxxix sec-I) 1977

Exp.No:13

AIM:- To determine the shear parameter of a give soil sample (undisturbed/Remold) using a direct shear test apparatus.

APPARATUS :- Shear box with it accessories, loading frame weights proving ring, dial gauges, sample trimmer, balance spatula, varnier etc.

THEORY:- The shear strength of a soil across a plane may expressed as

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

Where

S = Shear strength (kg/sq.cm)
σ = Normal stress on failure plane (kg/sq.cm)
C = Cohesion (kg/sq.cm)
$\varnothing$ = Angle of internal friction (degrees)

In the direct shear test failure is induced in a soil sample by moving one part of the soil container while the other is kept stationary. When a shear force of sufficient magnitude is applied, the bottom portion of the box moves horizontally relative to the top one , causing the soil in the box to shear along a plane of Separation between tow halves of the shear box (horizontal plane.)

In a strength test of a soil, their are two basic stages Fist a normal load is applied to the specimen (consolidation stage) and then failure is induced by applying g a shear stress (shearing stage). If no water is allowed to escape form or enter into the specimen either during consolidation or during shearing it is called a undrained test or unconsolidated undrained test. If the specimen is allowed to consolidate under the normal load, but no drainage of water is allow during shear, it is called consolidated undrained test. If the specimen is consolidated under the normal load and sheared under fully drained conditions it is called consolidated drained test,. Undrained tests can be performed in a shear box only on highly impermeable clay.

8 Remove the specimen form the box and take samples for moisture content determination.

9 Repeat the test on atleast two more identical specimens (with same density) under increased normal loads.

CONSOLIDATED UNIRAINED TESTS:- Procedure is similar to that in undrained test, except that instead of the solid grid plates use perforated grid plates at the top and bottom of the specimen. Conduct the shear test only after complete consolidation has occurred under the applied normal stress.

CONSOLIDATED DRAINED TEST:- Procedure is similar to hat the consolidated undrained test except that the shear in is done at a slow rate (0.1% strain per minute) so that complete drainage can occur, during the shear stage

CALCULATIONS:

0 Calculate the corrected cross sectional area A_c (cm2) form the following equation:

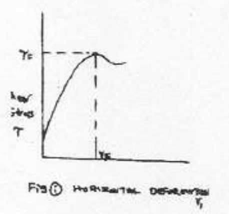
$$Ac = Ao \left(1 - \frac{\delta}{3}\right)$$

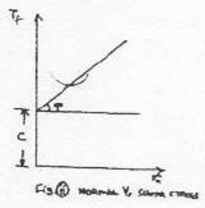
where

Ao = Initial cross sectional area of the specimen (sq.cm)

δ = Horizontal displacement (mm)

1. Divide the shear load measured by the proving ring by the corrected arof specimen to get the shear stress in the specimen.
2. Plot the shear strain versus shear stress curves to obtain the maximum shear stress corresponding to each normal stress Determine the failure strain (Fig.1)
3. Plot failure (or maximum) shear stress versus normal stress to obtain the shear parameters C and 0 (Fig.2).
4. Plot failure (or max.) shear stress Vs normal stress to ontain the shear parameters C & 0 (Fig.2)





Proparation of Samples:

(a) **Cohesive soil:** Undisturbed samples are obtained in 100 mm dia meter sampling tube Remouled samples are compacted in a mould at a required water content and compaction energy.

Push the sample cutter into the soil in the sampling tube or compaction mould. Push out the sample cutter with the soil form sampling tube /mould. Remove the soil sticking to the sides of the cutter. Trim the soil in the cutter flush with the top and bottom faces of the cutter. Weigh the sample with cutter. Push the soil specimen from the cutter into the shear box.

(b) **Choesionless Soil:** Compact the soil in the direct shear box in thin layers using a rammer to a final thickness of 20mm. Weigh the soil with the box.

Procedure

Undrained Test:-

1 Place the plate, and then the solid grid plate at the bottom of the shear box. Fix the two parts of the shear box with tow suitable locking screws, after ensuring that the spacing screws (3 Nos.) are screwed with their tips flush with the common surface between tow halves.

2 Push the soil specimen form the cutter into the shear box. Place another solid grid plate on the top of specimen. The serration's of the top an bottom grid plates should be at right angles to the direction of shear;. Place the loading pad on the top grid plate.

3 Transfer the box into the water jacket placed (on rollers) on the platform of the apparatus provided with an adjustable loading frame. See that the shear box is in its center, abutting the step provided in the water jacket slide the water jacket such that the inverted 'U' hook fixed to the top half of the shear box rests firmly against the vertical end plate of the platform.

4 Determine the average ratio and apply desired normal load intensity in the range of 0.5 to 2 kg/sq.cm. through the loading frame. Adjust the proving ring so that its attached spindle touches the water jacket outer surface. Remove the looking screws. Raise the upper part of the shear box with the help of spacer screws, such that a gap of about 0.5mm to 1.0mm between tow parts of the box in the case of sandy soil. For fine soils this step can be ignored.

5 Attach a dial gauge to the fitting fixed to the vertical end plate fixed to the water jacket. This gauge measures the shear (horizontal) displacement.

6 Induce shear displacement at a rate of about 1% strain per minute (0.6 mm/min).

7 Take the readings of proving ring dial gauge at every 0.3 or 0.6 mm of (shear) displacement till failure or till a displacement of 12mm. (20% strain) whichever occurs earlier.

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Direct Shear Test or Sandy Soil

Summary of Results:

Test No.	Normal Stress (kg/cm^2)	Shear Stress at failure kg/cm^2	Horizontal Strain at failure	Initial water content	Final water content

Exp.No:14

TRIAXIAL COMPRESSION TEST
(UNCONSOLIDATED UNDRAINED TEST)

IS:2720 (Part – xi)- 1971

AIM:- To determine the shear strength parameters of a given cohesive soil sample by conducting "Unconsolidated undrained triaxial compression test".

APPARATUS :- 5 ton loading frame, triaxial cell, specimen mould, rubber sheath, sheath stretcher, "" rings, constant lateral pressure assembly, foot pump balance, drying oven, desiccator etc.

THEORY:- A triaxial test is intended to provide strength data of a soil sample subjected to compressive stresses in three mutually perpendicular directions. When a soil sample is subjected to a stress system and if σ_1 is the major principal stress and σ 3 the minor principal stress at failure across a plane then the condition of shear failure is indicated by Mohr's diagram as shown in a Fig.2. The shear strength parameters 'C' and " φ (as indicated in Fig.2) are known as cohesion and angle of internal friction respectively.

PROCEDURE :-

1 Obtain three soil samples of size 38mm diameter and 76mm long from a sampling tube usually of diameter 100 mm.

2 Attach the 38mm dia. Solid base cap at the center of base plate of the triaxial cell.

3 Place the soil sample centrally on the base cap of the triaxial cell and cover it with the loading cap.

4 Enclose the sample in a rubber membrane using a sheath stretcher.

5 Seal the rubber membrane against the top and bottom caps with " rings. Place a steal ball in the central conical seat of the top cap.

6 Carefully lower the upper assembly of the triaxial cell into position checking that the plunger bottom just rests on the spherical ball on the top cap of the sample.

7 Fix the upper assembly to the base plate by tightening the nuts evenly. Place the cell centrally on the loading frame.

8 Admit water into the lucite chamber by opening the corresponding value provided in the base plate of triaxial cell and ensuring that the air lock at top

of the cell is open to facilitate escape of air as the water flows in . When the water flows out of the air lock, close it and build up the cell pressure to the required magnitude by connecting the cell to the lateral pressure assembly, which maintains a constant pressure by self adjustment.

9 The loading ram will pushed up against the proving ring t due to the upward thrust of the cell pressure action on its lower end. By means of handle provided and to be operated (when the motor is switched off) bring down the loading ram such that tits bottom is just 0.5cm above the steal ball. Then, lock the handle and start the motor till the loading ram bottom just touches the spherical ball. When this happens the proving ring dial gauge pointer just starts moving. Immediately stop the motor, adjust the proving the dial gauge reading to zero.

10 The axial strain of the soil sample in measured by a dial gauge fixed to the ram between the proving ring and top of triaxial cell. Now adjust the deformation dial gauge reading to zero. (this is checked by noting that when the motor drive is started, the dial gauge in the proving ring and the dial gauge for measuring axial strain start moving simultaneously).

11 If the motor is now started. The indicators in the dial by gauge of proving ring and the dial gauge for strain measurement starts moving. This ensures that the apparatus is all set for application of deviator load on the soil specimen.

12 Start loading the sample at a constant rate of deformation of 0 .75mm /minute (i.e. 1% strain /minute)

13 Record the load (proving ring dial reading tat every 1/2% to 1% strain . Continue the loading until an axial strain of 20% is reached or the proving ring readings decrease after attaining maximum values.

14 Remove the deviator load completely and read the final proving ring reading as a check to ensure that the reading is close to initial reading.

15 Drain out the cell water. Take out the soil sample. Remove the rubber membrane. Sketch the failure pattern. Weigh the sample . determine the water content at the failure plane by collecting soil sample at 3 different places along the failure plane.

16 Calculate the deviator stress using the corrected area Ac corresponding to various axial strain values as follows:

$$Ac = \frac{Ao}{I - E} \quad \text{Where } E = \Delta l / lo$$

Δ l being the change in length, l o the initial length and Ao the initial area of the soil sample.

17 Plot a graph between percentage axial strain (on x axis) and deviator stress (on y axis) and determine the maximum deviator stress (See Fig.1) and the corresponding axial strain. Compute the major and minor principal stresses at failure.

18 Conduct the test for atleast three different cell pressures. Draw Mohr's circle in each case and evaluated the Shear Parameters for the given soil sample

(Fig.2.)

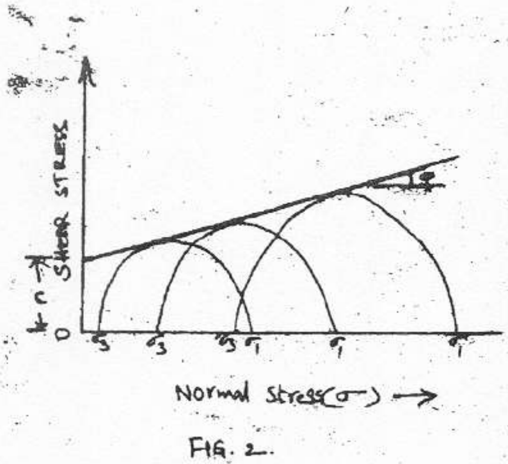

FIG. 2.

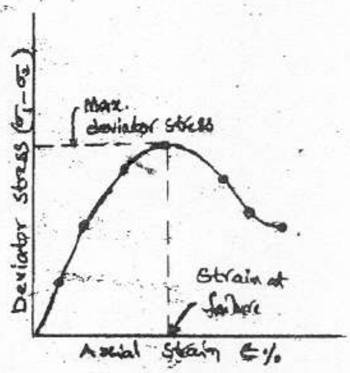

FIG. 1.

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

(Without the measurement of pore water pressure)

Soil type:

Date:

Specimen type:

Tested by:
Proving ring No.

Initial length of
Specimen (mm)

Proving ring
constant

Initial diameter of
Specimen (mm)

Rate of deformation
(mm/min.)

Description of specimen	Specimen No. 1	2	3
Initial Length (mm)			
Initial diameter (mm)			
Initial cross sectional area (cm^2)			
Initial volume (cm)			
Initial weight of specimen (g)			
Bulk density g/cc			
Cell [pressure (O 3) kg/sq.cm			
Mode of failure			
Angle of shear plane with Horizontal plane			
Weight of wet soil + Container (g)			
Weight of dry soil + Container (g)			
Weight of container (g)			
Weight of water (g)			
Weight of dry soil (g)			
Water content of soil (%)			

			Specimen -1			Specimen -2			Specimen -3		
Axial deformation (mm)	Axial strain %	Corrected area (sq.cms)	Proving ring reading	Deviator load (kg)	Deviator Stress (σ l – 0 3 kg/cm^2	Proving ring reading	Deviator load (kg)	Deviator Stress (σ l – σ3 kg/cm^2)	Proving ring reading	Deviator load (Kg)	Deviator Stress (0 l – 0 3 kg/cm^2)
0											
0.5											
1.0											
1.5											
2.0											
3.0											
4.0											
5.0											
6.0											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0											
19.0											
20.0											

SPECIFIC GRAVITY OF DISTILLED WATER

C	0	1	2	3	4	5	6	7	8	9
0	0.9999	0.9999	1.0000	1.0000	1.0000	1.0000	1.000	0.9999	0.9999	0.9999
10	0.99973	0.99963	0.999	0.999940	0.99927	0.99913	0.99897	0.99880	0.99862	0.99843
20	0.99823	0.99802	0.99780	0.99757	0.99733	0.99707	0.99681	0.99654	0.99626	0.99597
30	0.99566	0.99540	0.9951	0.9947	0.9944	0.9941	0.9937	0.9934	0.9930	0.9926
40	0.9922	0.9910	0.9915	0.9911	0.9907	0.9902	0.9898	0.9894	0.9890	0.9885
50	0.9881	0.9876	0.9872	0.9867	0.9862	0.9857	0.9852	0.9848	0.9842	0.9838
60	0.9832	0.9827	0.9822	0.9817	0.9811	0.906	0.9800	0.9795	0.9589	0.9784
70	0.9778	0.9772	0.9767	0.9761	0.9755	0.9749	0.9743	0.9737	0.9731	0.9724
80	0.9718	0.9712	0.9706	0.9699	0.9693	0.9686	0.9680	0.9673	0.9667	0.9660
90	0.9653	0.9647	0.9640	0.9633	0.9626	0.9610	0.9612	0.9605	0.9598	0.9591

TABLE: VISCOSITY OF WATER
(From International Critical Tables)
Values are in millipoises

C°	0	1	2	3	4	5	6	7	8	9
0	17.94	17.32	16.74	16.19	15.68	15.19	14.73	14.29	13.87	13.48
10	13.10	12.74	12.39	12.06	11.75	11.45	11.16	10.88	10.60	10.34
20	10.09	9.34	9.61	9.38	9.16	8.95	8.75	8.55	8.36	8.18
30	8.00	7.88	7.67	7.51	7.36	7.21	7.06	6.92	6.97	6.66
40	6.54	6.42	6.30	6.18	6.08	5.97	5.87	5.77	5.68	5.58
50	5.49	5.40	5.32	5.24	5.15	5.07	4.99	4.92	4.84	4.77
60	4.70	4.63	4.56	4.50	4.43	4.37	4.31	4.24	4.19	4.13
70	4.07	4.02	3.96	3.91	3.86	3.81	3.76	3.71	3.66	3.62
80	3.57	3.53	3.48	3.44	3.40	3.36	3.32	3.28	3.24	3.20
90	3.17	3.13	3.10	3.06	3.03	2.99	2.96	2.93	2.90	2.87
100	2.84	2.82	2.79	2.76	2.73	2.70	2.67	2.64	2.62	2.59

I dyne sec. Per sq.com = I poise
I gram sec.per sq.cm =980.7 poises
I Pound sec.per sq.ft = 478.69 poises