MAHABARATHIENGINEERINGCOLLEGE

NH-79,SALEM-CHENNAIHIGHWAY,A.VASUDEVANUR,CHINNASALEM(TK),KALLAKURICHI(DT)606201.

Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

AccreditedbyNAACandRecognizedundersection2(f)&12(B)ofUGC,NewDelhi

www.mbec.ac.in | Ph: 04151-256333, 257333 | E-mail: mbec123@gmail.com

DEPARTMENTOFCIVILENGINEERING

Academicyear2024-2025(ODDSEM)

CE3413-SOIL MECHANICSLABORATORYMANUAL

(REGULATION 2021)

NAME	:	
DEPARTMENT	:	
SUBJECT CODE/NAME	:	
YEAR	:	
BATCH	:	

PREPAREDBY	VERIFIEDBY
Mr.S.SELVAKUMARM.E.,	Mr. P. ASHOK M.E.,
ASST.PROFESSOR/ CIVIL	HOD/ CIVIL

CE3413 SOILMECHANICSLABORATORY LT PC

0 031.5

OBJECTIVE

To develop skills to test the soils for their index and engineering properties and to characterize the soilbased ontheirproperties

EXERCISES

1. DETERMINATIONOFINDEXPROPERTIES

a. Specificgravity ofsoil solids
b. Grainsizedistribution –sieveanalysis
c. Grainsizedistribution –hydrometeranalysis
d. Liquidlimitand plasticlimittests
e. Shrinkagelimitanddifferentialfreeswelltests

2. DETERMINATIONOFINSITUDENSITYANDCOMPACTION CHARACTERISTICS

a. Fielddensitytests(sandreplacementmethodandcorecutter method)
b. Determinationofmoisture–densityrelationshipusing standardproctor compactiontests

3. DETERMINATIONOFENGINEERINGPROPERTIES

a. Permeabilitydetermination(constantheadandfallingheadmethods)
b. Onedimensionalconsolidationtest(deyterminationofcoefficientof consolidationonly)
c. Directsheartestincohesionlesssoil
d. Unconfinedcompressiontestincohesivesoil
e. Laboratoryvanesheartest incohesivesoil
f. Triaxial compression test in cohesionless soil (demonstration only)Californiabearing ratio test.

4.TESTONGEOSYNTHETICS(Demonstrationonly)

a. Determinationoftensile strengthandinterfacialfrictionangle.
b. Determinationofapparentopeningsizesand permeability.

TOTAL:45 PERIODS

OUTCOME:

- On completion of the course, the student is expected toCO1Conducttests todeterminetheindexpropertiesofsoilsCO2Det erminetheinsitudensityandcompactioncharacteristics.

CO3 Conduct tests to determine the compressibility, permeability and shear strength of soils.CO4Understand the various tests on Geosynthetics.

LABORATORYSAFETYPROCEDURES

DO'S

- Know the potential hazards of the materials used in the laboratory.
- Wear personal protective apparel when working.
- Wash skin promptly if contacted by any chemical.
- Handle Heavy Equipment with utmost care.
- Be cautious when working with electricity.
- Shoes must cover the entire foot. Open toed shoes and sandals are inappropriate footwear in laboratories.
- Restrain and confine long hair and loose clothing. Pony tails and scarves used to control hair must not present a loose tail that could get caught in moving parts of machinery.
- Clean all the apparatus before and after the experiment.
- Wash your hands thoroughly once you complete the experiments.

DON'T

- Don't Eat, drink, chew gum, or apply cosmetics in laboratory.
- Don't handle heavy weights carelessly.
- Don't use Golden Ornaments While Handling Mercury.

CONTENTS

Ex.No:1

Date: **Determination of Specific gravity of soil solids**

AIM

To determine the specific gravity of soil solids.

THEORY

Specific gravity of soil solids is the ratio of weight, in air of a given volume; of dry soil solids to the weight of equal volume of water at 4°C.Specific gravity of soil grains gives the property of the formation of soil mass and is independent of particle size. Specific gravity of soil grains is used in calculating void ratio, porosity and degree of saturation, by knowing moisture content and density. The value of specific gravity helps in identifying and classifying the soil type.

APPARATUS REQUIRED

1. Pycnometer
2. 450 mm sieve
3. Weighing balance
4. Oven
5. Glass rod
6. Distilled water

PROCEDURE

1. Dry the pycnometer and weigh it with its cap. (W_1)
2. Take about 200gmof oven dried soil passing through 4.75mm sieve into the pycnometer and weigh again (W_2).
3. Add sufficient de-aired water to cover the soil and screw on the cap.
4. Shake the pycnometer well and remove entrapped air if any.
5. After the air has been removed, fill the pycnometer with water completely.
6. Thoroughly dry the pycnometer from out side and weigh it (W_3).
7. Clean the pycnometer by washing thoroughly.
8. Fill the cleaned pycnometer completely with water up to its top with cap screw on.
9. Weigh the pycnometer after drying it on the outside thoroughly (W_4).

10. Repeat the procedure for three samples and obtain the average value of specific gravity.

OBSERVATIONS AND CALCULATIONS

Determine the specific gravity of soil grains (G) using the following equation

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

Where

W1 = Empty weight of pycnometer.

W2 = Weight of pycnometer + oven dry soil

W3 = Weight of pycnometer + oven dry soil+ water

W4 = Weight of pycnometer + water

OBSERVATION FOR SPECIFIC GRAVITY DETERMINATION			
	TRIAL1	**TRIAL2**	**TRIAL3**
Empty weight of pycnometer **W1 in gms**			
Weight of pycnometer + oven dry soil **W2 in gms**			
Weight of pycnometer + oven dry soil+ water **W3 in gms**			
Weight of pycnometer + water **W4 in gms**			
Specific Gravity, G (No Unit)			

RESULT

Average specific gravity of soil solids G =

Specific Gravity and Moisture Content of soil solids

1. What is meant by Specific Gravity?

   The ratio of unit weight of Soil solids to the unit weight of the water is called specific gravity of soil solids.

2. What are the different types of specific gravity?

   Specific Gravity of Soil Solids

   Apparent Specific Gravity

3. What is meant by Apparent specific gravity?

   The ratio of Bulk unit weight of soil to the unit weight of the water is called Apparent gravity of soil solids

4. What are the Different methods to find Specific Gravity?

   Pycnometer Method

   Density Bottle Method

5. Different name of Specific Gravity of Soil Solids?

   True specific Gravity

6. Different name of Bulk Specific Gravity?

   Apparent Specific Gravity

7. Range of Specific Gravity of Soil Solids

   It range from 2.65 to 2.70 for soil

8. Range of Specific Gravity of Soil Solids

   It range from 1.25 to 1.50 for soil.

9. What is meant by capillary water?

   The water which move up / down due to the surface tension is called as capillary water.

10. What is meant by Hygroscopic water?

    The water which bind/held around the soil particle is known as Hygroscopic water.

11. What is meant by Water Content?

    The ratio of Mass of water to the mass of soil solid is called Water content

12. What are the different methods to find water content?

Calcium Carbide Method

Torsion Balance Method

Sand Bath Method

Hot Air Oven Method

13. How the water content measured from Oven Method?

The wet soil is kept in oven at the temperature on 105 degree for 24 hours. The weight of water and the weight of dry weight observed. With that water content to be found.

14. Explain Calcium Carbide Method?

In this method, the wet sample is kept in the flask with calcium carbide chemical. The closed flask to be shake and the carbon dioxide will form and the pressure due to formed gas is measured with pressure gauge attached with flask.

15. Explain Calcium Carbide Method?

In this method, the wet soil if weighed and fried in the hot pan. After few minutes the dry weight to be found. With this water content to be found

16. What are the different types of soil water?

Free water

Structural Water

Capillary water

Hygroscopic water

17. What is meant by free water?

The water which flow under gravity between the voids is called free water.

18. What is structural water?

The water present inside the structure of the soil which cant dry with oven is called structural water

19. What is meant by capillary water?

The water which move up / down due to the surface tension is called as capillary water.

Ex.No:2

Date: **Determination of Grain Size Distribution (Sieve Analysis)**

AIM

To conduct sieve analysis of soil to classify the given coarse grained soil.

THEORY

Grain size analysis is used in the engineering classification of soils. Particularly coarse grained soils. Part of suitability criteria of soils for road, airfield, levee, dam and other embankment construction is based on the grain size analysis. Information obtained from the grain size analysis can be used to predict soil water movement. Soils are broadly classified as coarse grained soils and fine grained soils. Further classification of coarse grained soils depends mainly on grain size distribution and the fine grained soils are further classified based on their plasticity properties. The grain size distribution of coarse grained soil is studied by conducting sieve analysis.

APPARATUS REQUIRED

1. A set of Sieves 4.75 mm, 2.36 mm ,1.18 mm ,0.60mm, 0.425 mm, 0.30 mm 0.15 mm 0.075mm including lid and pan
2. Tray
3. Weighing Balance
4. Sieve Shaker
5. Brush

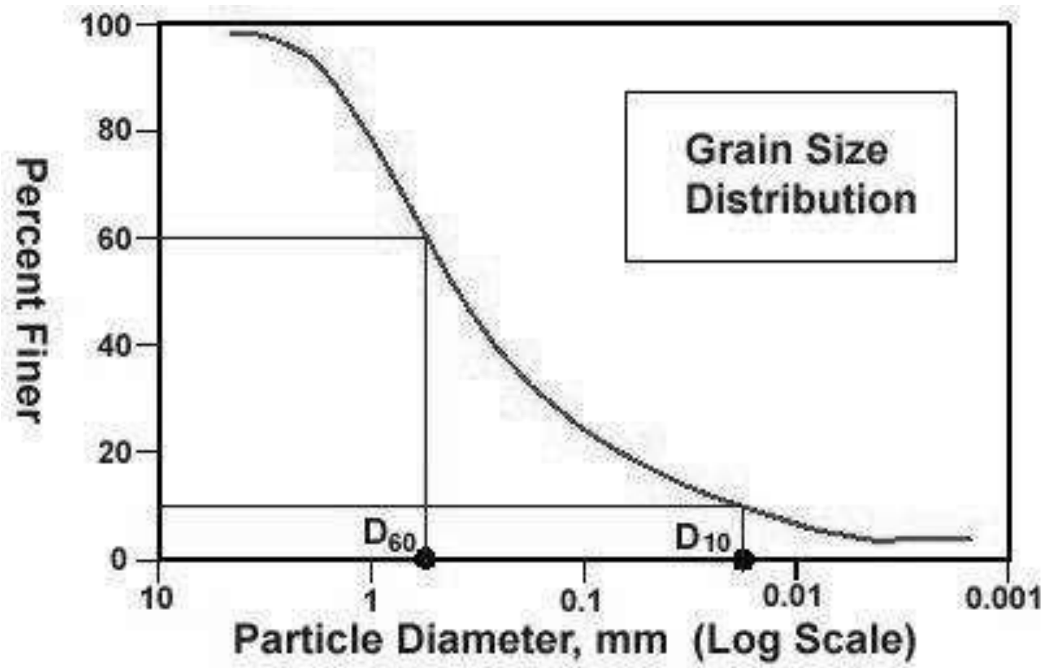
PROCEDURE

1. Weigh 500gms of soil sample, of which grain size distribution has to be studied.
2. Clean the sieve set so that no soil particles were struck in them.
3. Arrange the sieves in order such that coarse sieve is kept at the top and the fine sieve is at the bottom. Place the closed pan below the finest sieve.
4. Take the soil obtained into the top sieve and keep the lid to close the top sieve.
5. Position the sieve set in the sieve shaker and sieve the sample for a period of 10minutes.
6. Separate the sieves and weigh carefully the amount of soil retained on each sieve, This is usually done by transferring the soil retained on each sieve on a separate sieve of paper and weighing the soil with the paper.
7. Enter the observations in the Table and calculate the cumulative percentage of soil retained on each sieve.

8.Draw the grain size distribution curve between grain size on log scale on the abscissa and the percentage finer on the ordinate.

OBSERVATIONS&CALCULATIONS					
Weight of the soil taken for testing (W) =					
Sl.No	Aperture size of sieve in mm	Weight of soil retained (gm)	% Weight Retained	Cumulative Percentage Retained	Percentage Finer
1	4.75mm				
2	2.36mm				
3	1.18mm				
4	0.600mm				
5	0.425mm				
6	0.300mm				
7	0.150mm				
8	0.075mm				

Plot the graph between percentage finer and logarithmic grain size (mm).From the graph, obtain the percentage of coarse, medium and fine sands.



Uniformity coefficient $C_u = D_{60} / D_{10}$

Coefficient of Curvature $C_c = (D_{30})^2 / D_{60} \times D_{10}$

RESULT

Percentage of gravel (>4.75mm) =

Percentage of coarse sand (4.75mm – 2.00 mm) =

Percentage of medium sand (2.00mm – 0.425 mm) =

Percentage of fine sand (0.425mm – 0.0.075 mm) =

Percentage of fines (<0.075 mm) =

Uniformity Coefficient C_u =

Coefficient of Curvature C_c =

Ex.No:3

Date: **Determination of Grain Size Distribution (Hydrometer Analysis)**

AIM

To determine the grain size distribution of soil sample containing appreciable amount of fines by hydrometer analysis test.

THEORY

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

APPARATUS REQUIRED

1. Hydrometer
2. Glass measuring cylinder-Two of 1000 ml capacity with ground glass or rubber stoppers about 7 cm diameter and 33 cm high marked at 1000 ml volume. Thermometer- To cover the range 0 to 50° C with an accuracy of 0.5 ° C.
3. Water bath.
4. Stirring apparatus.
5. I.S sieves apparatus.
6. Balance-accurate to 0.01 gm.
7. Oven-105° to 110°.
8. Stop watch.
9. Desiccators
10. Centimeter scale.
11. Porcelain evaporating dish.
12. Wide mouth conical flask or conical beaker of 1000 ml capacity.
13. Thick funnel-about 10 cm in diameter.
14. Filter flask-to take the funnel.
15. Measuring cylinder-100 ml capacity.
16. Wash bottle-containing distilled water.

17. Filter papers.

18. Glass rod-about 15 to 20 cm long and 4 to 5 mm in diameter.

19. Hydrogen peroxide-20 volume solution.

20. Hydrochloric acid N solution-89 ml of concentrated hydrochloric acid.(specific gravity 1.18) diluted with distilled water one litre of solution.

21. Sodium hexametaphosphate solution-dissolve 33 g of sodium hexametaphosphate and 7 gms of sodium carbonate in distilled water to make one litre of solution.

PROCEDURE

Volume

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

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

(b) From the weight of the hydrometer: The hydrometer shall be weighed to the nearest 0.1 gm. The weight in gm shall be recorded as the volume of the bulb plus the volume of the stem below the 1000 ml graduation mark. For practical purposes the error due to the inclusion of this stem may be neglected.

Calibration

(a) The sectional area of the 1000 ml measuring cylinder in which the hydrometer is to used shall be determined by measuring the distance between the graduations. The sectional area is equal to the volume include between the two graduations divided by the measured distance between them.

1. The distance from the lowest reading to the center of the bulb is (R_h) shall be recorded ($R_h = H_L + L/2$).

2. The distance from the highest hydrometer reading to the center of the bulb shall be measured and recorded.

3. Draw a graph hydrometer readings vs H_H and R_H. A straight line is obtained. This calibration curve is used to calibrate the hydrometer readings which are taken with in 2 minutes.

4. From 4 minutes onwards the readings are to be taken by immersing the hydrometer each time. This makes the soil solution to rise, there by rising distance of free fall of the particle. So correction is applied to the hydrometer readings.

5. Correction applied to the R_h and H_H

V_h= Volume of hydrometer bulb in ml.

A=Area of measuring cylinder in cm^2.

From these two corrected readings draw graph (straight line)

Calculation

Total weight of dry soil taken, W =

Specific Gravity of soil, G =

Wt. Of soil gone into solution ,Ws =

Meniscus correction, Cn =

Dispersion agent correction =

Reading in water RW =

Temperature correction =

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

OBSERVATIONS & CALCULATIONS

Elapsed Time in Sec	Hydrometer reading upper Meniscus Rh 1000	Corrected hydrometer Reading (1-lower meniscus Cm)	N(%finer For soil)

RESULT

Grain size distribution of soil is done by Hydrometer Analysis.

Grain Size Distribution:

1. What is meant by Cc?

   Cc if defined as Coefficient of Curvature. It depend on D10, D30 & D60 value from the grain size distribution Curve

2. What is meant by Cu?

   Cc if defined as Coefficient of Uniformity. It depend on D10& D60 value from the grain size distribution Curve

3. What is meant by Grain Size Distribution curve?

   The curve drawn in semi log sheet between the size of particles in X Axis and the % Finer in the Y Axis is called as grain size distribution curve.

4. What are the test to be done for drawing GSD?

   Sieve Analysis

   Sedimentation Analysis

5. What are the classification in sieve analysis?

   Coarse Soil Fraction

   Fine Soil Fraction

6. What are the correction to be carried out in Sedimentation Analysis?

   Correction due to Meniscus, Chemicals and Temperature

7. What to judge from Cc??

   If the value of Cc between 1 to 3 means, the soil is “Well Graded Soil” Else “Poorly Graded Soil”

8. What to judge from Cu?

If the value of Cu > 4 means, the soil is “Well Graded Sand” & Cu > 6 means, the soil is “Well Graded Gravel”. Else “Poorly Graded Soil”

Ex.No:4

Date: **Determination of Liquid Limit and Plastic Limit**

AIM

To determine the liquid limit and plastic limit of the given soil sample

THEORY AND APPLICATION

Liquid limit is significant to know the stress history and general properties of the soil met with construction. From the results of liquid limit the compression index may be estimated. The compression index value will help us in settlement analysis. If the natural moisture content of soil is closer to liquid limit, the soil can be considered as soft if the moisture content is lesser than liquids limit, the soil can be considered as soft if the moisture content is lesser than liquid limit. The soil is brittle and stiffer. The liquid limit is the moisture content at which the groove, formed by a standard tool into the sample of soil taken in the standard cup, closes for 10 mm on being given 25 blows in a standard manner. At this limit the soil possess low shear strength.

The moisture content expressed in percentage at which the soil has the smallest plasticity is called the plastic limit. Just after plastic limit the soil displays the properties of a semi solid. For determination purposes the plastic limit it is defined as the water content at which a soil just begins to crumble when rolled into a thread of 3mm in diameter. The values of liquid limit and plastic limit are directly used for classifying the fine grained soils. Once the soil is classified it helps in understanding the behaviour of soils and selecting the suitable method of design construction and maintenance of the structures made-up or and resting on soils.

APPARATUS REQUIRED:

1) Measuring balance
2) Liquid limit device (Casagrandes)
3) Grooving tool
4) 425 micron sieve
5) Glass plate
6) Spatula

7) Mixingbowl

8) Wash bottle

9) Mositure content bins

10) Drying oven

Procedure for liquid limit:

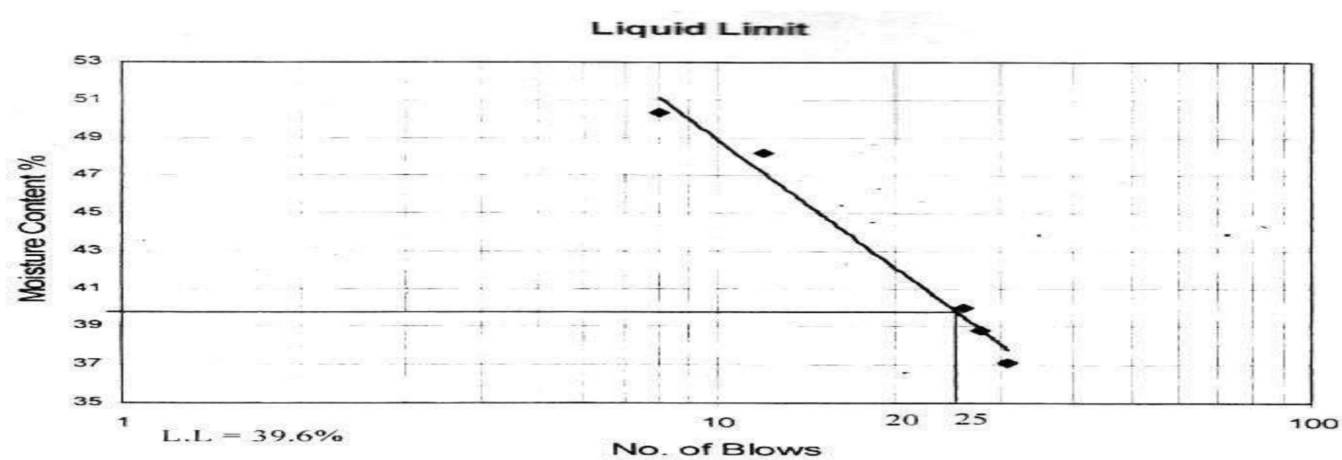
- About 120 gm of air dried soil from thoroughly mixed portion of material passing 425 micron I.S sieve is to be obtained.
- Distilled water is mixed to the soil thus obtained in a mixing disc to form uniform paste. The paste shall have a consistency that would require 30 to 35 drops of cup to cause closer of standard groove for sufficient length.
- A portion of the paste is placed in the cup of LIQUID LIMIT device and spread into portion with few strokes of spatula.
- Trim it to a depth of 1cm at the point of maximum thickness and return excess of soil to the dish.
- The soil in the cup shall be divided by the firm strokes of the grooving tool along the diameter through the centre line of the follower so that clean sharp groove of proper dimension is formed
- Lift and drop the cup by turning crank at the rate of two revolutions per second until the two halves of soil cake come in contact with each other for a length of about 1 cm by flow only.
- The number of blows required to cause the groove close for about 1 cm shall be recorded.
- A representative portion (15gm) of soil is taken from the cup for water content determination by oven drying.
- Repeat the test with different moisture contents at least three more times for blows between 10 and 40.

S.NO	PERCENTAGE OF WATER CONTENT	NO. OF BLOW
1		
2		
3		
4		
5		

S.No	Description	Test1	Test2	Test3
1	Noofblows(N)			
2	Container number			
3	Weight of the container + wet soil			
4	Weight of the container + dry soil			
5	Weight of the water (3–4)			
6	Weight of the container			
7	Weight of the dry soil(4–6)			
8	Moisture content (%), W = {(5 / 7)*100}			

Use the above table for recording number of blows and calculating the moisture content

- Use semi-log graph paper. Take number of blows on log scale (X –Axis) and water content on nominal scale (Y – axis). Plot all the points. (Flow curve)
- Read the water content at 25 blows which is the value of liquid limit.



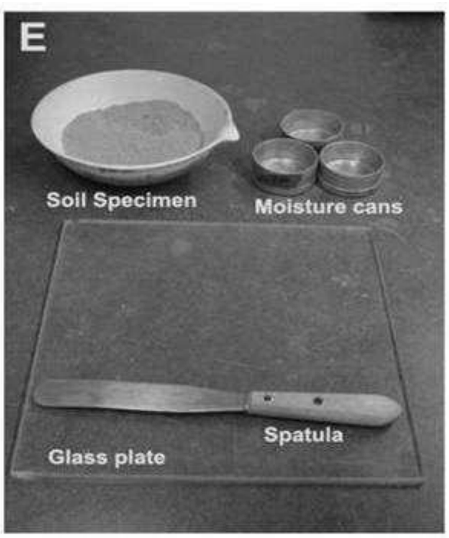
From graph,

Flow Index, IF = (W2 – W1) / log 10 (N2 – N1) =

Liquid Limit (LL) =

Procedure for plasticlimit:

- Take about 20gm of thoroughly mixed portion of the material passing through 425 micron I.S. sieve obtained in accordance with I.S. 2720 (part 1).
- Mix it thoroughly with distilled water in the evaporating dish till the soil mass becomes plastic enough to be easily molded with fingers.
- Allow it to season for sufficient time (for 24 hrs) to allow water to permeate throughout the soil mass
- Take about 10gms of this plastic soil mass and roll it between fingers and glass plate with just sufficient pressure to roll the mass into a threaded of uniform diameter throughout its length. The rate of rolling shall be between 60 and 90 strokes per minute.
- Continue rolling till you get a threaded of 3 mm diameter.
- Kneed the soil together to a uniform mass and reroll.
- Continue the process until the thread crumbles when the diameter is 3 mm.
- Collect the pieces of the crumbled thread in air tight container for moisture content determination.
- Repeat the test to at least 3 times and take the average of the results calculated to the nearest whole number.
- Note: Compare the diameter of thread at intervals with therod.Whenthe diameter reduces to 3 mm, note the surface of the thread for cracks.



S.No	Description	Test1	Test2	Test3
1	Container number			
2	Wt.container+Lid,W1			
3	Wt.container+Lid + Wet sample, W2			
4	Wt.container+Lid + Dry sample, W3			
5	Wt. of dry sample = W3– W1			
6	Wt.of waterinthesoil=W3– W2			
7	Water content (%) = [(W3 – W2) / (W3–W1)]*100			

Calculations for Plastic Limit:

- Collect the pieces of the crumbled thread in air tight container for moisture content determination and record the result as the plastic limit.

  Plastic Limit (PL) =

  Plasticity Index (IP) = (LL - – PL) =

  Toughness Index = (IP / IF) =

Results:

Liquid Limit =

Plastic Limit =

Flow Index =

Plasticity Index =

Toughness Index =

Ex.No:5

Date: **Determination of Shrinkage Limit and Differential Free Swell Index**

AIM:

To determine the shrinkage limit, shrinkage ratio and volumetric shrinkage for the given soil

THEORY:

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

APPARATUS REQUIRED:

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

Procedure:

Preparation of soil paste

- Take about 100 gm of soil sample from a thoroughly mixed portion of the material passing through 425micron I.S. sieve.
- Place about 30 gm the above soil sample in the evaporating dish and thoroughly mixed with distilled water and make a creamy paste.
- Use water content somewhere around the liquid limit

Filling the shrinkage dish

- Coat the inside of the shrinkage dish with a thin layer of Vaseline to prevent the soil sticking to the dish.
- Fill the dish in three layers by placing approximately 1/3 rd of the amount of wet soil with the help of spatula. Tap the dish gently on a firm base until the soil flows over the edges and no apparent air bubbles exist. Repeat this process for 2nd and 3rd layers also till the dish is completely filled with the wet soil.
- Strike off the excess soil and make the top of the dish smooth. Wipe off all the soil adhering to the outside of the dish.
- Weigh immediately, the dish with wet soil and record the weight.
- Air-dry the wet soil cake for 6 to 8hrs, until the colour of the pat turns from dark to light. Then oven dry them to constant weight at 1050C to 1100C say about 12 to 16 hrs.
- Remove the dried disk of the soil from oven. Cool it in a desiccator. Then obtain the weight of the dish with dry sample.
- Determine the weight of the empty dish and record.
- Determine the volume of shrinkage dish which is evidently equal to volume of the wet soil as follows.
- Place the shrinkage dish in an evaporating dish and fill the dish with mercury till it overflows slightly.
- Press it with plain glass plate firmly on its top to remove excess mercury. Pour the mercury from the shrinkage dish into a measuring jar and find the volume of the shrinkage dish directly. Record this volume as the volume of the wet soil pat.
- Volume of the Dry Soil Pat
- Determine the volume of dry soil pat by removing the pat from the shrinkage dish and immersing it in the glass cup full of mercury in the following manner.
- Place the glass cup in a larger one and fill the glass cup to overflowing with mercury. Remove the excess mercury by covering the cup with glass plate with prongs and pressing it. See that no air bubbles are entrapped. Wipe out the outside of the glass cup to remove the adhering mercury. Then, place it in another larger dish, which is, clean and empty carefully.
- Place the dry soil pat on the mercury. It floats submerge it with the pronged glass plate which is again made flush with top of the cup. The mercury spills over into the larger plate. Pour the mercury that is displayed by the soil pat into the measuring jar and find the volume of the soil pat directly.
- Caution: Do not touch the mercury with gold rings.

OBSERVATION

WEIGHT OF CONTAINER, gms	
Wt.Of wet sample + Container, gms	
Wt.Of dry sample + Container, gms	
Wt.Of Water	
Wt.Of wet soil pat	
Wt.Of dry soil pat	
Water content, in %	
Wt.Of mercury container, gms	
Wt.Of mercury displaced, gms	
Volume of displaced mercury = Volume of dry soil pat, Vd cm3	
Volume of container, V cm3	
Shrinkage Limit	
Shrinkage Ratio	

Results:

Shrinkage limit =

Shrinkage ratio =

Volumetric shrinkage =

ATTERBERG’S Limit:

1. What is meant by LL?

   The water content at the boundary limit between the plastic state and the liquid stateiscalledLiquidlimit

2. What is meant by PL?

   The water content at the boundary limit between the Semi solid state and the plastic state is called plastic limit

3. What is meant by SL?

   The water content at the boundary limit between the solid state and the semi solid state is called shrinkage limit

4. What are the methods to find Liquid Limit?

   Casagrande Liquid Limit Test, One Point Method

5. How to find Shrinkage Limit in Lab?

   It is found by using Mercury Displacement Method. Because, SL can’t be find by directly.

6. What are the characteristics of Degree of saturation at different states?

   Degree of Saturation is 0 to 100 % at in Solid State. After that, Degree of saturation is 100%. At LL, PL & SL, Degree of saturation is 100%

7. How to find the consolidation of clay in soil

   Consolidation of clay is found using the Cc value, Initial Void ratio, Effective Vertical Stress over the soil

8. How to Judge the soil based on A Line.

   If soil falls above A Line, it is Inorganic Clay and the Soil falls below A line, soil is Organic Clay.

9. What is the purpose of finding LL, Pl & SL?

   To Classify the fine Grained Soil based on BIS classification. If LL<35%, Soil is Low Compressibility. If LL is between 35 to 50%, soil Medium Compressibility. If the LL > 50%, Soil is High Compressibility.

10. What is meant by A Line?

    In consistency Chart, to classify the soil A Line is needed. A Line equation is

    $I_p = 0.73 (LL - 20)$

Ex.No:6

Date:

Determination of Field Density (Sand Replacement Method)

AIM:

To determine the field density of soil at a given location by sand replacement method.

THEORY:

In core cutter method the unit weight of soil obtained from direct measurement of weight and volume of soil obtained from field. Particularly for sandy soils the core cutter method is not possible. In such situations the sand replacement method is employed to determine the unit weight. In sand replacement method a small cylindrical pit is excavated and the weight of the soil excavated from the pit is measured. Sand, whose density is known, is filled into the pit. By measuring the weight of sand required to fill the pit and knowing the density of soil , volume of the pit is calculated .Knowing the weight of soil excavated from the pit and the volume of pit the density of soil is calculated. Therefore in this experiment there are two stages (1) Calibration of sand density and (2) Measurement of soil density.

APPARATUS

1. Moisture content cups
2. Sand pouring Cylinder
3. Calibrating can
4. Metal tray with a central hole
5. Dry sand (Passing through 600 micron sieve)
6. Balance
7. Metal tray
8. Scraper tool
9. Glass plate

PROCEDURE

CALIBRATION OF SAND DENSITY

- Measure the internal dimensions diameter (d) and height (h) of the calibrating can and compute its internal volume V.
- Fill the sand pouring cylinder (SPC) with sand with 1 cm top clearance to avoid any spillover during operation and find its weight (W1)

- Place the SPC on a glass plate, open the slit above the cone by operating the valve and allow the sand to run down. The sand will freely run down till it fills the conical portion. When there is no further downward movement of sandin the SPC, close the slit.
- Find the weight of the SPC along with the sand remaining after filling the cone (W2)
- Place the SPC concentrically on top of the calibrating can. Open the slit to allow the sand to rundown until the sand flow stops by itself. This operation will fill the calibrating can and the conical portion of the SPC. Now close thes lit and find the weight of the SPC with the remaining sand(W3)

MEASUREMENT OF SOIL DENSITY

- Clean and level the ground surface where the field density is to be determined.
- Place the tray with a central hole over the portion of the soil to be tested.
- Excavate a pit into the ground, through the hole in the plate , approximately 12cm deep (Close the height of the calibrating can) The hole in the tray will guide the diameter of the pit to be made in the ground.
- Collect the excavated soil into the tray and weigh the soil (W)
- Determine the moisture content of the excavated soil.
- Place the SPC, with sand having the latest weight of W3, over the pit so that the base of the cylinder covers the pit concentrically.
- Open the slit of the SPC and allow the sand to run into the pit freely, till there is no downward movement of sand level in the SPC and then close the slit.
- Find the weight of the SPC with the remaining sand W4.

OBSERVATION – SAND REPLACEMENT METHOD

S.No	Description	Test 1
	CALIBERATION OF APPARATUS	
1	Weight of sand + cylinder before pouring (W1) (g)	
2	Mean weight of sand pouring cylinder with remaining sand after fillingin cone (W2)	
3	Volume of calibrating container (V) cc	

4	Mean weight of sand pouring cylinder with remaining sand after fillingin cone and	
5	Weight of sand filling calibrating containers, W_a = (W_1– W_3– W_2)(g)	
6	Calibrated Bulk density of sand, ρ_S = (5/3) (g/cc)	
	MEASUREMENT OF INSITU SOIL DENSITY	
7	Weight of wet soil from the hole or Wt. of excavated Soil (W_s or W_W) (g)	
8	Weight of sand + cylinder after pouring in the holeand cone (W_4) (g)	
9	Weight of sand in the hole, W_h = (W_1– W_4 – W_2)(g)	
10	Bulk density of soil, ρ W / Wh)* ρS (g/cm3)	
11	Bulk unit weight of soil, γ 9.8 * ρ kN/m3)	
12	Container Number	
13	Weight of container + wet soil (g)	
14	Weight of container + dry soil (g)	
15	Weight of container (g)	
16	Weight of dry soil (g)	
17	Weight of water (g)	
18	Water content, W = (R17/R16)*100 (%)	

RESULT

1. **Dry unit weight of the soil =**
2. **Wet unit weight of the soil =**
3. **Void ratio of the soil =**
4. **Porosity of the soil =**
5. **Degree of saturation =**

Ex.No:7

Date: **Determination of Moisture Density Relationship (Proctor Compaction)**

AIM:

To determine Optimum Moisture Content and Maximum dry density for a soil by conducting standard proctor compaction test

THEORY:

Compaction is the process of densification of soil mass, by reducing air voids under dynamic loading. On the other hand though consolidation is also a process of densification of soil mass but it is due to the expulsion of water under the action of continuously acting static load over a long period.The degree of compaction of a soil is measured in terms of its dry density. The degree of compaction mainly depends upon its moisture content during compaction, compaction energy and the type of soil. For a given compaction energy, every soil attains the maximum dry density at a particular water content which is known as optimum moisture content (OMC).Compaction of soil increases its dry density, shear strength and bearing capacity. The compaction of soil decreases its void ratio permeability and settlements. The results of this test are useful in studying the stability earthen structures like earthen dams, embankments roads and airfields. In such constructions the soils are compacted. The moisture content at which the soils are to be compacted in the field is estimated by the value of optimum moisture content determined by the Proctor compaction test.

APPARATUS REQUIRED:

1) Proctor mould having a capacity of 1000 cc with an internal diameter of 100 mm and a height of 127.3 mm. The mould shall have a detachable collar assembly and a detachable base plate.

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

3) Sample extruder.

4) A balance of 15 kg capacity.

5) Sensitive balance.

6) Straight edge.

7) Graduated cylinder.

8) Mixing tools such as mixing pan, spoon, towel, spatula etc.

9) Moisture tins.

PROCEDURE:

- Take about 3 kg of air dried soil
- Sieve the soil through 20mm sieve.Take the soil that passes through the sieve for testing.
- Take 2.5 kg of the soil and add water to ti to bring its moisture content to about 4% in coarse grained soils and 8% in case of fine grained soils.
- Clean , dry and grease the mould and base plate .Weigh the mould with base plate. Fit the collar.
- Compact the wet soil in three equal layers by the rammer with 25 evenly distributed blows in each layer.
- Remove the collar and trim off the soil flush with the top of the mould. In removing the collar rotate it to break the bond between it and the soil before lifting it off the mould.
- Clean the outside of the mould and weigh the mould with soil and base plate.
- Remove the soil from the mould and obtain a representative soil sample from the bottom, middle and top for water content determination
- Repeat the above procedure with 8,12,16 and 210 % of water contents for coarse grained soil and 14,18,22 and 26 % for fine grained soil samples approximately.
- The above moisture contents are given only for guidance. However, the moisture contents may be selected based on experience so that, the dry density of soil shows the increase in moisture content.Each trial should be performed on a fresh sample.

OBSERVATION

Dia. of the mould, D (cm) =

Ht. of the mould, H (cm) =

Vol. of the mould, V (cm^3) =

Wt. of the mould, W1 (g) =

S.No	Description	Test 1	Test 2	Test 3	Test 4
(a) Density					
1	Weight of the mould+ compacted soil (W2) (g)				
2	Weight of mould (W1)(g)				
3	Weight of compacted soil, W (W2–W1)(g)				
4	Bulk density (g/cm^3)				
5	Dry density (g/cm^3)				

6	Water content %,w				
	Zero void ratio (Gsϒw)/(1+ (wGs/100))				
	Void ratio, e=((Gsϒw)/(ϒd))-1				
(b) Water content					
	Container number				
7	Empty weight of container (g)				
8	Weight of container+ wet soil (g)				
9	Weight of container+ dry soil (g)				
10	Weight of dry soil (R8-R7)(g)				
11	Weight of wet soil (R9-R7)(g)				
12	Weight of water (R8-R9)(g)				
13	Moisture content, W[(R12 / R10)*100](%)				

Results:

Optimum Moisture Content (OMC) % =

Maximum dry density (g/cc) =

Field Density Test

1. What is meant by Density of soil?

   The Ratio of Mass of the soil to the volume of the soil is called as density of soil.

2. What are the different forms of Density of soil?

   Dry Density

   Wet / Bulk Density

   Saturated Density

   Submerged Density

3. What are the methods to find Field Density of Soil?

   Sand Replacement Method

   Core Cutter Method

4. What are the importances of finding field density?

   To confirm the achievement of compaction during sub grade preparation.

5. What are the different Field Methods to compact the soil?

   Rollers, Tampers ,Vibrators ,Terra Probe method

6. What are the Disadvantages of Core Cutter Test?

   While taking out the core cutter from the ground, the soil present at the bottom portion may get collapse and fall down

7. What are the disadvantages of sand replacement test?

   Generally, it gives good results. But if the calibration of clean sand gets error, final finding also will be error

8. What is the range of Permeability for Course sand?

   More Than 10-3 mm/sec

9. How to classify the permeability of soil?

   High, Medium, Low, Very Low & Impervious

10. What is meant by Permeability?

    The flow of water inside the soil pores is called as Permeability

Ex.No:8

Date: Determination of Relative Density of Cohesion less Soils (Demonstration)

AIM:

To determine the relative density of cohesion less soil.

THEORY

Relative density is also known as density index. It is defined as the ratio of difference between the void ratio of cohesion less soil in the loosest state and any given void ratio to the difference between its void ratios in the loosest and in the densest states. The concept of density index gives a practically useful measure of compactness of such soils. The compactive characteristics of cohesion less soils and the related properties of such soils are dependent on factors like grain size distribution and shape of individual particles. The compactive characteristics of cohesion less soils s and the related properties of such soils are dependent on factors like grain size distribution and shape of individual particles. Relative density is also effected by these factors and serves as a parameter to correlate properties of soils. Various soil properties such as penetration resistance, compressibility, compaction , friction angle , permeability and CBR has been found to have simple relationships with relative density.

APPARATUS REQUIRED

1. Vibratory table: A steel table with cushioned steel vibrating deck about 75 x 75 cm. The vibrator should have a net weight of over 45 kg. The vibrator should have frequency of 3600 vibrations per minute, a vibrator amplitude variable between 0.05 and 0.65 mm under a115 kg load.

2. Moulds: Cylindrical metal density moulds of 3000cc 150mm dia and 169.77 mm high.

3. One guide sleeve: With clamp assembly should be provided with lock nuts.

4. Surcharge base plate: 10mm thick with handle for each mould.

5. One dial gauge holder

6. Dial gauge: A dial gauge with 50mm travel and 0.02 mm least count.

7. Pouring devices : Consisting of funnels 12mm and 25 mm in diameter and 150 mm long with cylindrical spots and lipped brims for attaching to 150mm and 300 mm high metal cans.

8. Mixing pans: Two mixing pans

`

PROCEDURE

The test procedure to determine the relative density of soil involves the measurement of density of soil in its loosest possible state ( ) and densest possible state ( ) .Knowing the specific gravity of soil solids (G) the void ratios of the soil in its loosest (emax) and densest state (emin) are computed. The density of soil in the field () (natural state) is used to compute void ratio (e) in the field. After obtaining the three void ratios the relative density is computed. For 4.75mm size particles 3000cc mould is used. Moulds are first calibrated, Then the densities of the soil are obtained.

CALIBRATION OF MOULDS

To calibrate the mould should be filled with water and a glass plate should be slide carefully over the top surface of the mould in such a manner as to ensure that the mould is completely filled with water. The volume of the mould should be calculated in cc by dividing the weight of water in the mould by the unit weight of water.

PREPARATION OF SOIL SAMPLE

A representative sample of soil should be selected. The weight of soil sample to be taken depends upon the maximum size of particles in the soil .The soil sample should be dried in an oven at a temperature of 105^{o}c to 110^{o}c .The soil sample should be pulverized without breaking the individual soil particles and sieved through the required sieve.

PROCEDURE FOR THE DETERMINATION OF MINIMUM DENSITY

1. The pouring device and mould should be selected according to the maximum size of particle. The mould should be weighed and weight recorded. Oven dry soil should be used.

2. Soil containing particles smaller than 10mm should be placed as loosely as possible in the mould by pouring the soil through the spout in a steady stream. The spout should be adjusted so that the height of free fall of the soils always 25mm.While pouring the soil the pouring device should be moved in a spiral motion from the outside towards the centre to form a soil layer of uniform thickness without segregation. The mould should be filled approximately 25mm above the top and leveled with the top by making one continuous pass with steel straight edge. If all excess material is not removed an additional continuous pass should be made. Great care shall be exercised to avoid jarring during the entire pouring and trimming operation.

3. The mould and the soil should be weighed and the weight recorded.

4. Soil containing particles larger than 10mm should be placed by means of a large scoop held as close as possible to and just above the soil surface to cause the material to slide rather than fall into the previously placed soil. If necessary large particles may be held by hand to prevent them from rolling offs the scoop.

5. The mould should be filled to overflowing but not more than 25mm above the top. The surface of the soil should be leveled with the top of the mould using the steel straight edge in such a way that any slight projections of the larger particles above the top of the mould shall approximately balance the large voids in the surface below the top of the mould.

6. The mould and the soil should be weighed and the weight recorded.

OBSERVATION:

Weigh of the mould =

Volume of the mould =

Sl.No	Description	Trial1	Trial2	Trial3
1	Weight of the mould ,gms			
2	Weight of the soil+mould gms			
3	Weight of the soil W gms			
4	Calibrated volume of mould V_c			
5	Minimum density			

RESULT

Minimum density =

Ex.No:9

Date:

Determination of Permeability of Soil (Constant Head Method)

AIM:

To determine the coefficient of permeability of the soil by conducting constant head method.

THEORY

The property of the soil which permits water to percolate through its continuously connected voids is called its permeability .Water flowing through the soil exerts considerable seepage forces which has direct effect on the safety of hydraulic structures. The quantity of water escaping through and beneath and earthen dam depends on the permeability of the embankment and the foundation soil respectively. The rate of settlement of foundation depends on the permeability properties of the foundation soil.

APPARATUS REQUIRED

1. Permeability apparatus with accessories
2. Stop watch
3. Measuring jar

PROCEDURE – Constant Head Method

- Compact the soil into the mould at a given dry density and moisture content by a suitable device. Place the specimen centrally over the bottom porous disc and filter paper.
- Place a filter paper, porous stone and washer on top of the soil sample and fix the top collar.
- Connect the stand pipe to the inlet of the top plate.Fill the stand pipe with water.
- Connect the reservoir with water to the outlet at the bottom of the mould and allow the water to flow through and ensure complete saturation of the sample.
- Open the air valve at the top and allow the water to flow out so that the air in the cylinder is removed.
- When steady flow is reached, collect the water in a measuring flask for a convenient time intervals by keeping the head constant. The constant head of flow is provided with the help of constant head reservoir
- Repeat the for three more different time intervals

OBSERVATIONS AND CALCULATIONS – Constant Head Method

Calculate the coefficient of permeability of soil using the equation

$$K = QL / Ath$$

Where

K = Coefficient of permeability

Q = Quantity of water collected in time t sec (cc)

t = Time required (sec)

A = Cross sectional area of the soil sample (sq.cm)

h = Constant hydraulic head (cm)

L = Length of soil sample (cm)

DIA OF SPECIMEN , D=
Length of Specimen L =
Head =
Area of specimen =

S.no.	Time, t sec	Quantity of discharge, Q cm^3	K_T cm/sec

RESULT:

Coefficient of permeability of the given soil sample by

Constant Head Method =

Ex.No:10

Date:

Determination of Permeability of Soil
(Variable Head Method)

AIM:

To determine the coefficient of permeability of the soil by conducting falling head method.

THEORY

The property of the soil which permits water to percolate through its continuously connected voids is called its permeability .Water flowing through the soil exerts considerable seepage forces which has direct effect on the safety of hydraulic structures. The quantity of water escaping through and beneath and earthen dam depends on the permeability of the embankment and the foundation soil respectively. The rate of settlement of foundation depends on the permeability properties of the foundation soil.

APPARATUS REQUIRED

1. Permeability apparatus with accessories
2. Stop watch
3. Measuring jar

PROCEDURE – Falling Head Method

- Compact the soil into the mould at a given dry density and moisture content by a suitable device. Place the specimen centrally over the bottom porous disc and filter paper.
- Place a filter paper, porous stone and washer on top of the soil sample and fix the top collar.
- Connect the stand pipe to the inlet of the top plate. Fill the stand pipe with water.
- Connect the reservoir with water to the outlet at the bottom of the mould and allow the water to flow through and ensure complete saturation of the sample.
- Open the air valve at the top and allow the water to flow out so that the air in the cylinder is removed.
- Fix the height h1 and h2 on the pipe from the top of water level in the reservoir
- When all the air has escaped, close the air valve and allow the water from the pipe to flow through the soil and establish a steady flow.
- Record the time required for the water head to fall from h1 to h2.
- Change the height h1 and h2 and record the time required for the fall of head.

OBSERVATIONS AND CALCULATIONS – Variable Head Method

Calculate the coefficient of permeability of soil using the equation.

$$K = 2.303 Al / At \log_{10}(h1/h2)$$

Where

K = Coefficient of permeability

a = Area of stand pipe (sq.cm)

t = Time required for the head to fall from h1 to h2 (sec)

A = Cross sectional area of the soil sample (sq.cm)

L = Length of soil sample (cm)

h1 = Initial head of water in the stand pipe above the water level in the reservoir (cm)

h2 = final head of water in the stand pipe above the water level in the reservoir (cm)

(i) Diameter of the stand pipe (cm) =

(ii) Cross sectional area of stand pipe (sq.cm) =

(iii) Length of soil sample (cm) =

(iv) Area of soil sample (sq.cm) =

S.no.	Time, t sec	Initial head , h1 cm	Final head , h2 cm	$\log_{10}$ h1/h2	K_T cm/sec

RESULT:

Coefficient of permeability of the given soil sample by

Falling Head Method =

Co-efficient of Permeability:

1. What is meant by Permeability?

   The flow of water inside the soil pores is called as Permeability.

2. What are the methods to find Permeability?

   Direct Method

   Constant Head Permeability Test Method

   Falling Head Permeability Test Method

   Pumping Out Test

   Pumping In Test

   Indirect Method

   Found using Soil Particle Size

3. Which method is suitable for Sandy Soil?

   For Sandy soil, the Constant Head permeability Test to be adopted

4. Which method is suitable for Clayey Soil?

   For Clayey soil, the Variable Head permeability Test to be adopted

5. What is the range of Permeability for Clay?

   Less Than 10^{-9} mm/sec.

6. What is the range of Permeability for Silt?

   10^{-7} mm/sec to 10^{-9} mm/sec

7. What is the range of Permeability for Fine Clay?

   10^{-5} mm/sec to 10^{-7} mm/sec

8. What is the range of Permeability for Clean Sand?

   10-^{3} mm/sec to 10^{-5} mm/sec

9. What is the range of Permeability for Course sand?

   More Than 10^{-3} mm/sec

10. How to classify the permeability of soil?

    High, Medium, Low, Very Low & Impervious

Ex.No:11

Date: **Determination of Coefficient of Consolidation**

AIM

To determine the coefficient of consolidation of a given clay soil.

THEORY

When a load is applied on a saturated soil, the load will initially be transferred to the water in pores of the soil .This results in development of pressure in pore water which results in the escape of water from voids and brings the soil particles together. The process of escape of water under applied load, leads to reduction in volume of voids and hence the volume of soil. The process of reduction of volume of voids due to expulsion of water under sustained static load is known as consolidation. The magnitude of consolidation depends on the amount of voids or void ratio of the soil. The rate of consolidation depends on the permeability properties of soil. The two important consolidation properties of soil are (i) co-efficient of consolidation (Cv) and (ii) Compression index (Cc). The coefficient of consolidation reflects the behaviour of soil with respect to time under a given load intensity. Compression index explains the behaviour of soils under increased loads.

APPARATUS REQUIRED

1. Consolidometer consisting of specimen ring.
2. Guide ring
3. Porous stones
4. Dial gauges
5. Stop watch

PROCEDURE

Preparation of specimen

Sufficient thickness of the soil specimen is cut from undisturbed sample. The consolidation ring is gradually inserted into the sample. The consolidation ring is gradually inserted into the sample by pressing and carefully removing the material around it. The specimen should be trimmed smooth and flush to the ends of the ring. Any voids in the specimen caused due to removal of gravel or limestone pieces should be filled back by pressing completely the loose soil in the voids. The ring should be wiped clean and weighed again with the soil. Place wet filter paper on top and bottom faces of the sample and two porous stones covering it should be in place. Place this whole assembly in the loading frame. Over the porous stone a perforated plate with loading ball is placed

The sample is put for saturation both from top and bottom. After allowing time for saturation the load is applied through the loading frame. The settlement in sample is measured using a dial gauge. The stepwise procedure for observing reading is as follows:

1.Apply the requiredloadintensity (stress) at which Cvis to be determined.

2. As the loading is applied, the stop watch should be started.

3. Take the readings of the dial gauge at different time interval from the time of loading and record them in the table.

OBSERVATION AND CALCULATIONS

(a) Square root method

1. Record the dial gauge readings at different time interval from the point of loading in Table.

2. Plot a graph between $\sqrt{t}$ on X axis and dial gauge reading on Y axis .Where t is time in minutes.

3. The curve drawn reflects three components of settlement (i) Immediate settlement or elastic compression. This will be reflected in the form of steep settlements in a small time interval and a nearly vertical line at the initial portion of the curve represents it. This is followed by (ii) Primary consolidation curve, which will be nearly a straight line with a reduced sloe. The majority of consolidation will be in this zone. After primary consolidation (iii) Secondary consolidation takes place that is marked by a curve nearly parallel to time axis.

4. Draw a straight line through a primary consolidation zone. Identification of primary consolidation zone depends on experience and eye judgement. Extent the straight line to meet Y- axis at Oc. Oc is the corrected zero.

5. Draw another straight line through Oc , with a slope equal to 1.15 times the slope of the earlier straight line.

6. The Straight line so drawn (with 1.15 times the slope of primary consolidation line will intersect the originally plotted curve at a point. The X co ordinate of this point will give $\sqrt{t90}$. Where t90 is the time required for 90% consolidation (in minutes)

7. The coefficient of consolidation is calculated as follows

$$Cv = 0.848\ H2 / (t90 \times 60)\ \ cm^2/sec.$$

Where H = length of dra[illegible]

H = half thickness of soil sample for double drainage and H = thickness of soil sample for single drainage

t90 = time required for 90% consolidation in minutes.

(b) Log - method

1. The compression dial readings should be plotted against the log of time and a smooth curve drawn to pass through the points.

2. The two straight portions of the curve should be extended to intersect at a point , the ordinate of which gives d100 corresponding to 100% primary compression.

3. The corrected zero point ds shall be located by the laying of above point in the neighbourhood of 0.1 minute a distance equal to the vertical distance between this point and one at a time which is four times this value

4. The 50% compression point which is halfway between the corrected zero point and the 100% compression point, shall be marked on the curve and the readings on the time axis corresponding to this point t50, time to 50% primary compression, shall be noted. The readings on the dial gauge reading axis, corresponding to 100% compression gives d100.

5. Coefficient of consolidation is calculated as follows

$$Cv = 0.197\ H2/\ t50.$$

TABULATION

Dimensions of sample: Diameter = Thickness =

Unit weight of soil =

Elapsed time In minutes,t	√t	Dial gauge reading
1	2	3
0		
0.25		
2.25		
4.00		
6.25		

9.00		
12.25		
16.00		
20.25		
25.00		
36.00		
49.00		
64.00		
81.00		
100.00		
121.00		
144.00		
169.00		
225.00		
256.00		

RESULT

Co efficient of Consolidation of the given soil sample C_v =

Ex.No:12

Date: **Direct shear test in cohesion-less soil**

AIM:

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

THEORY:

Shear strength of a soil is its maximum resistance to shearing stresses. It is equal to the shear stress at failure on the failure plane. Shear strength is composed of (i) internal frictions, which is the resistance due to the friction between the individual particles at their contact points and inter locking of particles. (ii) cohesion which is the resistance due to inter particle forces which tend to hold the particles together in a soil mass. Coulomb has represented the shear strength of the soil by the equation :

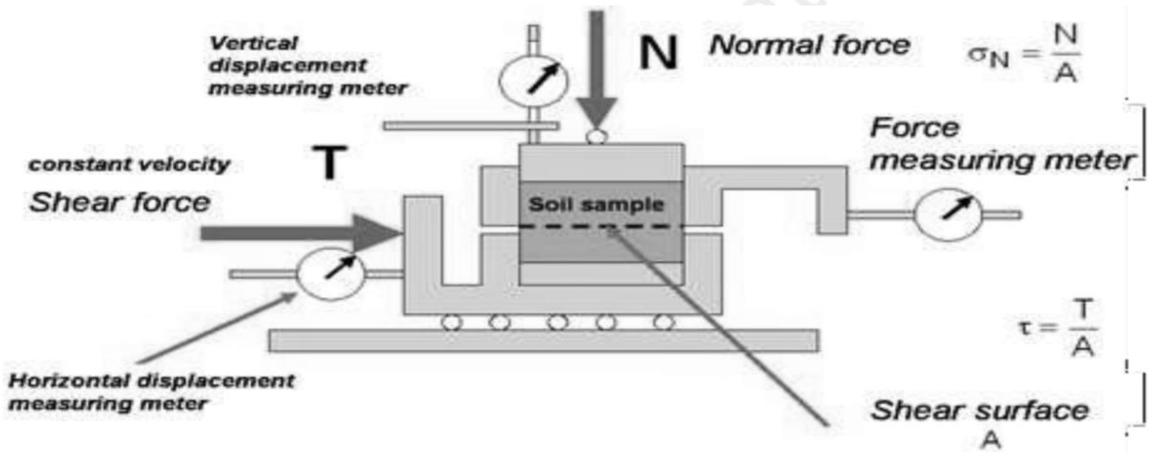
APPARATUS REQUIRED:

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.

PROCEDURE:

- Check the inner dimension of the soil container.
- Put the parts of the soil container together.
- Calculate the volume of the container. Weigh the container.
- Place the soil in smooth layers (approximately 10 mm thick). If a dense sample is desired tamp the soil.
- Weigh the soil container, the difference of these two is the weight of the soil. Calculate the density of the soil.
- Make the surface of the soil plane.
- Put the upper grating on stone and loading block on top of soil.
- Measure the thickness of soil specimen.
- Apply the desired normal load.

- Remove the shear pin.
- Attach the dial gauge which measures the change of volume.
- Record the initial reading of the dial gauge and calibration values.
- Before proceeding to test check all adjustments to see that there is no connection between two parts except sand/soil.
- Start the motor. Take the reading of the shear force and record the reading.
- Take volume change readings till failure.
- Add 5 kg normal stress 0.5 kg/cm2 and continue the experiment till failure.
- Record carefully all the readings. Set the dial gauges zero, before starting the experiment



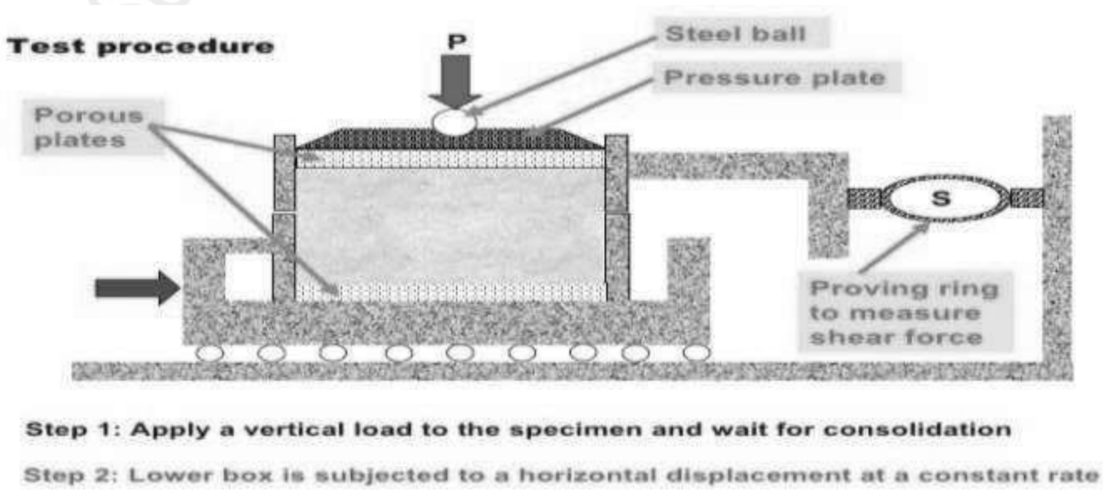


Table:Observation for Direct Shear test (Table1:Normal stress 0.5 kg/cm^2)

Least count of the dial : Proving ring constant :

Horizontal Gauge reading (1)	Vertical dial gauge reading (2)	Proving ring reading (3)	Hor. Dial gauge reading Initial reading div. Gauge (4)	Shear deformation col. (4) X Least count of dial (5)	Vertical gauge reading Initial ing (6)	Vertical deformation= div.In (6) XL.C of dial gauge (7)	Proving reading Initial ing (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								

Table:Observation for Direct Shear test (Table1:Normalstress1kg/cm^2)

Least count of the dial : Proving ring constant :

Horizontal Gauge reading (1)	Vertical dial gauge reading (2)	Proving ring reading (3)	Hor. Dial gauge reading Initial ing div. Gauge (4)	Shear deformation col. (4) X Least count of dial (5)	Vertical gauge reading Initial ing (6)	Vertical deformation= div.In (6) XL.C of dial gauge (7)	Proving reading Initial ing (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								

Table:Observation for Direct Shear test (Table1:Normalstress1.5kg/cm^2)

Least count of the dial : Proving ring constant :

Horizontal Gauge reading (1)	Vertical dial gauge reading (2)	Proving ring reading (3)	Hor. Dial gauge reading Initialing div. Gauge (4)	Shear deformation col. (4) X Least count of dial (5)	Vertical gauge reading Initialing (6)	Vertical deformation= div.In (6) XL.C of dial gauge (7)	Proving reading Initialing (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								

Calculations:

Sample Size =

Area of sample , Ao =

Volume of sample, V =

Weight of sample, w =

Density of sample =

S.NO	PROVING RING READING		SHEAR FORCE, Pn,kg	Applied Load ,kg	Normal force, Pv	Normal Stress	Shear stress , T = Pn/ A
	Initial Div	Final Div					
1							
2							
3							

RESULT

The shear strength parameters of the given soil sample,

$\tau =$

Ex.No:13

Date: **Determination of Unconfined Compression in Cohesive Soil**

AIM

To determine the shearing strength of the cohesive soil.

THEORY:

The unconfined compression test is a special case of tri axial compression test in which σ2, σ3 = 0. The cell pressure in the tri axial cell is also called the confining pressure. Due to the absence of such a confining pressure, the uniaxial test is called the unconfined compression test. The cylindrical specimen of soil is subjected to major principal stress σ1 till the specimen fails due to shearing along a critical plane of failure.

APPARATUS REQUIRED:

1) Loading frame of capacity of 2 t, with constant rate of movement.
2) Proving ring.
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 noncorroding 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 to find out the diameter and length of the specimen.

PROCEDURE:

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

Preparation of specimen for testing

A. Undisturbed specimen

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

B. Moulded sample

- 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.
- Add required quantity of water Ww to this soil.
- Ww = WS * W/100 gm
- Mix the soil thoroughly with water.
- 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.
- 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.
- Place the lubricated moulded with plungers in position in the load frame.
- Apply the compressive load till the specimen is compacted to a height of 7.5 cm.
- Eject the specimen from the constant volume mould.
- Record the correct height, weight and diameter of the specimen.

TEST PROCEDURE

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

- Continue loading till failure is complete.
- Draw the sketch of the failure pattern in the specimen.

Table:Observation for UCC test

Specific gravity, G : Bulk density (Initial) :

Initial water content : Degree of saturation :

Initial diameter of the specimen (D_O) cm :

Initial Length of the specimen (L_O) mm :

Initial area of cross section (A_O) cm^2 :

S.No	Elapsed time (min)	load,P (kg)	Compression dial reading, ΔL(mm)	Strain,ϵ (%)	Area, (cm^2)	Compressive stress, σ (kg/cm^2)
1						
2						
3						
4						

Calculations:

The axial strain, ϵ is determined by, ϵ Δ / O)*100

The average c/s area, A at particular strain is determined by, A = (A_O/[1-ϵ])

Plot is made between σ and ϵ. The maximum stress from this curve gives the values of the unconfined compressive strength qu. Where no maximum occurs, the unconfined compressive strength is taken as the stress at 20% axial strain.

RESULTS:

Unconfined compression strength of the soil, qu =

Shear strength of the soil, qu/2 =

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

Ex.No:14

Date: **Laboratory Vane Shear Test in Cohesive Soil**

AIM

To determine the undrained shear strength of the cohesive soil using vane shear.

THEORY:

Vane shear test is a quick test, used either in the laboratory or in the field, to determine the undrained shear strength of cohesive soil. The vane shear tester consists of four thin steel plates, called vanes, welded orthogonally to a steel rod. A torque measuring arrangement, such as a calibrated torsion spring, is attached to the rod which is rotated by a worm gear and worm wheel arrangment, After pushing the vanes gently into the soil, the torque rod is rotated at a uniform speed (usually at 1O per minute). The rotation of the vane shears the soil along a cylindrical surface. The rotation of the spring in degrees is indicated by a pointer moving on a graduated dial attached to the worm wheel shaft. The torque T is the calculated by multiplying the dial reading with the spring constant.

APPARATUS REQUIRED:

1) Vane shear apparatus.
2) Specimen.
3) Specimen container.
4) Callipers.

PROCEDURE:

- 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).
- 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.
- 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.
- Rotate the vanes at an uniform rate say 0.1O/s by suitable operating the torque application handle until the specimen fails.
- Note the final reading of the angle of twist.
- Find the value of blade height and width in cm.

OBSERVATION

S.No	Initial reading (Deg)	Final reading (Deg)	Difference (Deg)	Spring constant (kg – cm)	T = (Spring constant/180) X Difference (kg – cm)	Shear strength, τ_f(kg – cm²)
1						
2						
3						
4						
5						

CALCULATIONS:

The shear strength of the soil sample using vane apparatus is given by formula,

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

Where S = shear strength of soil in kg/cm2

T = torque in cm kg

D = overall diameter of vane in cm

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

RESULT:

Undrained Shear strength of the given cohesive soil sample is

Ex.No:14

Date: **Tri-axial compression test in cohesion-less soil (Demonstration Only)**

AIM:

To determine the undrained shear strength of the cohesive soil using vane shear.

THEORY:

The strength test more commonly used in a research laboratory today is the triaxial compression test, first introduced in the U.S.A. by A. Casagrande and Karl Terzaghi in 1936 – 37. The soil specimen, cylindrical in shape, is subjected to direct stresses acting in three mututally perpendicular directions. In the common solid cylindrical specimen test, the major principal stress σ1 is applied in the vertical direction, and the other two principal stresses σ2 and σ3 σ2 σ3) are applied in the horizontal direction by the fluid pressure round the specimen

APPARATUS REQUIRED:

KNOWLEDGE OF EQUIPMENT

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

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.

2) 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 nonferrous metal top and base connected by tension rods and with walls formed of perspex.

Apparatus for preparation of the sample:

1) 3.8 cm (1.5 inch) internal diameter 12.5 cm (5 inches) long sample tubes.

2) Rubber ring.

3) An open ended cylindrical section former, 3.8 cm inside dia, fitted with a small rubber tube in its side.

4) Stop clock.

5) Moisture content test apparatus.

6) A balance of 250 gm capacity and accurate to 0.01 gm.

PROCEDURE:

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

- The cell must be properly set up and uniformly clamped down to prevent leakage of pressure during the test, making sure first that the sample is properly sealed with its end caps and rings (rubber) in position and that the sealing rings for the cell are also correctly placed.

- When the sample is setup water is admitted and the cell is fitted under water escapes from the beed valve, at the top, which is closed. If the sample is to be tested at zero lateral pressure water is not required.

- The air pressure in the reservoir is then increased to raise the hydrostatic pressure in the required amount. The pressure gauge must be watched during the test and any necessary adjustments must be made to keep the pressure constant.

- The handle wheel of the screw jack is rotated until the under side of the hemispherical seating of the proving ring, through which the loading is applied, just touches the cell piston.

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

TABLE: 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.

Soil specimen measurement:

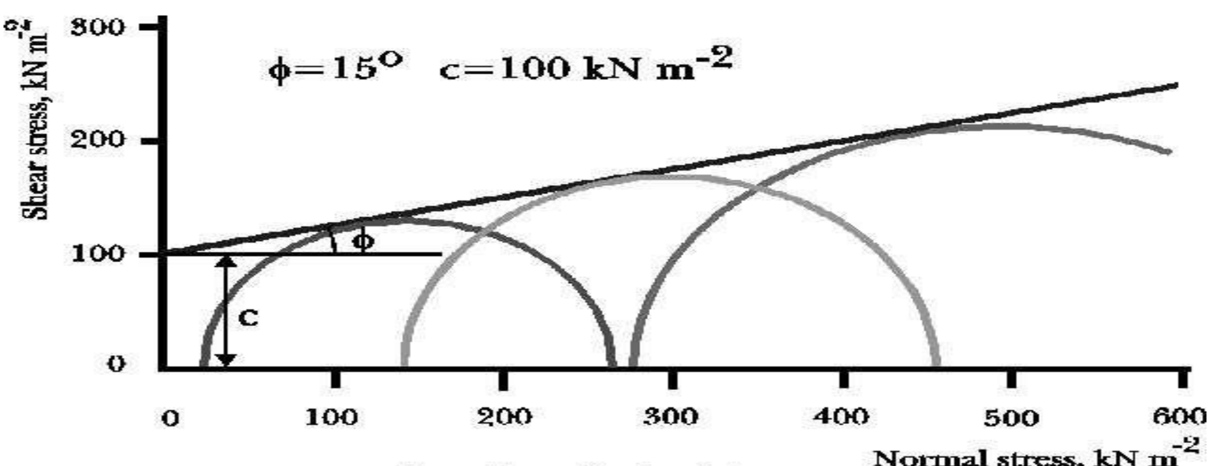
Height	:	Area	:
Volume	:	Diameter	:
Initial mass	:	Initial water content	:
Final mass	:	Final water content	:

Cell pressure σ3) kg/cm^2 :

Load gauge reading 1	Strain 2	Proving ring reading 3	Load on sample (kg) 4	Corrected area (cm^2) 5	Vertical stress σ_1) (R4/R5) 6	Deviator stress σ_d) (R6 – σ_3) 7

CALCULATIONS:

The shear parameters are obtained from a plot of Mohr circles for which purpose peak value of principal stress difference σ1 – σ3) or principal stress-ratio σ1/σ3) or the ultimate value as desired may be used.



Results of triaxial tests

RESULT:

Shear parameter of the given soil sample is

Ex.No:15

Date: **California Bearing Ratio Test**

AIM

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

THEORY:

This method was originally devised by O.J. Porter, the of the California State Highway Department, but it has since been developed and modified by other authorities in U.S.A., notably the U.S. Corps of Engineers. The method combines a load penetration test perfomed in the laboratory or in-situ with the empirical design charts to determine the thickness of pavement and of its constituent layers. This is probably the most widely used method for the design of flexible pavement. The thickness of the different elements comprising a pavement is determine by CBR values. The CBR test is a small scale penetration test in which a cylindrical plunger of 3 in 2 c/s area is penetrated into a soil mass at the rate of 0.05 in. per minute (1.25mm/min).The CBR is defined as the ratio of the test load to the standard load, expressed as percentage, for a given penetration of the plunger, CBR = (Test load/Standard load)*100

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

APPARATUS 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 10mmthick.
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 450mm.
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 mixingbowl, straight edge, scales soaking or pan, drying oven, filter paper and containers.

PROCEDURE:

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. 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 cm3 (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.
- 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

1. Compaction characteristics:

   (a) Dynamic compaction:

      Optimum water content (%):

      Weight of mould + compacted specimen (g):

      Weight of empty mould (g) :

      Weight of compacted specimen (g) :

      Volume of specimen (cm3):

      Bulk density (g/cc) :

      Dry density (g/cc) :

(b) Static compaction:

Dry density (g/cc) :

Moulding water content (%):

Wet weight of compacted specimen, W (g) :

2. Penetration test:

Surcharge weight used (g) :

Water content after penetration test :

Penetration dial		Load dial		Corrected load (kg)
Readings	Penetration (mm)	Readings	Load (kg)	
	0			
	0.5			
	1.0			
	1.5			
	2.0			
	2.5			
	3.0			
	4.0			
	5.0			
	7.5			
	10.0			
	12.5			

CALCULATIONS:

1. Expansion ratio:

The expansion ratio may be calculated as follows,

Expansion ratio = {(df – di)/h}*100 df = final dial gauge reading (mm) di = initial gauge reading (mm) h=initial height of specimen (mm)

2. LOAD PENETRATION:

Plot the load penetrating curve. 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. Find and record the correct load reading corresponding to each penetration.

Corresponding to the penetration value at which the C.B.R. is desired, correct load values are found from the curve and C.B.R. is calculated as follows;

C.B.R. = (PT/PS) * 100 Where,

PT = Corrected test load corresponding to the chosen penetration from the load penetration curve.

PS = Standard load for the same penetration taken from the table below.

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

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

RESULT:

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

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

Engineering Properties of Soil

1. What is meant Unconfined in UCC Test?

   There will no Confining Pressure given to make the soil to fail. Minor Principal Stress is Zero

2. What are the called Shear strength parameters?

   Cohesion

   Angle of Internal Friction

3. How to classify the soil based on shear strength parameters?

   Purely Cohesive soil

   Cohesive soil

   Cohesion less Soil

4. What are the tests available to find shear strength parameters?

   Direct Shear Test

   Triaxial Compression Test

   Unconfined Compression Test

   Vane shear Test.

5. What are the different Drainage Condition to be consider in Triaxial Test?

   CD Test (consolideted drained Test)

   CU Test (consolideted Undrained Test)

   UU Test (Unconsolideted Undrained Test)

6. What are the advantages of UCC Test?

   This test is most applicable for clayey soil. It will give accurate result shear strength

7. What is meant by Unconfined cohesion?

   It is represented by Cu. Half of the Unconfined Compression Strength Qu is called as Unconfined Cohesion

8. What is the disadvantages of UCS test?

   Soil must be free from fissures and there should not presence of silt content

9.What is meant by Angle of failure plane?

Angle of failure plane (α) = 45 + Ø/2. The angle made by failure plane depends on angle of internal friction Ø.

10. What is meant by Principal Plane and principal stress?

The plane at which shear stress is Zero is called as Principal Plane and the stress acts on the principal plane is called as principal stress

11. What is meant by Dilation?

Dilation Occurs in Dense sand, there will be volume change in soil under shear. The phenomenon at which the volume initially decreases and then increases after the certain strain for dense soil is called Dilation.

12. What are the advantages of Direct Shear Test?

The Test is Simple and Convenient for sandy soil

13. What are the disadvantages of Triaxial Compression Test?

The Test is Elabrate, Time Consuming and Skilled person to be take care.

14. How to arrive Angle of internal friction from test?

The observed value of Shear load for applied Normal load for different trial is drawn in Graph. The angle of the line connecting all failure points gives angle of internal friction.

15. What is the advantages of Direct Shear test?

This test is suitable for all types of soil. Can measure the pore water pressure at any time. It gives most accurate results

16. What is the disadvantages of Direct Shear test?

Failure plane is predefined as Horizontal. It will be suitable only for cohesionless soil

17. What is meant by Angle of failure plane?

Angle of failure plane (α) = 45 + Ø/2.

The angle made by failure plane depends on angle of internal friction Ø.

18. What is meant by Principal Plane and principal stress?

The plane at which shear stress is Zero is called as Principal Plane and the stress acts on the principal plane is called as principal stress.

19. What are the different types of settlement?

Primary Settlement (Immediate Settlement)

Consolidation Settlement

Tertiary Settlement

20. What is the purpose of consolidation?

    To Calculate the Future settlement of the Building or any other structure

21. What is meant by Degree of Consolidation?

    The ratio of the settlement at the time to the final settlement of soil is called Degree of Consolidation.

22. What are the methods to find coefficient of consolidation?

    Log T Method

    Root T Method

23. What are the disadvantages of Triaxial Compression Test?

    The Test is Elaborate, Time Consuming and Skilled person to be take care.

24. How to arrive Angle of internal friction from test?

    The observed value of Minor principal stress and Major Principal stress for different trial to be drawn as mohr circles. The angle of the common tangent line touching all mohr's circle.

25. What is the advantages of Direct Shear test?

    This test is suitable for all types of soil. Can measure the pore water pressure at any time. It gives most accurate results

TOPIC BEYOND SYLLABUS

Ex.No:16

Date: **Determination of Moisture Content of Soil**

AIM

To determine the moisture content (water content) of a given soil sample.

THEORY

A soil is an aggregate of soil particles having a porous structure. The pores may havewaterand/orair.Theporesarealsoknownasvoids.Ifvoidsarefullyfilledwithwater.Thesoil iscalledsaturated soil and if voids have only air, the soil is called dry.

Moisture content is defined as the ratio of the mass/weight of water to the mass/weight of soilsolids

$$W = W_w / W_s$$

Where, W=water content

W_w=Weight/mass of water

W_s =Weight/mass of soil solids (mass of oven dry soil)

The temperature at which only pore water is evaporated. This temperature was standardized105^{0}C to110^{0}C.Soils having gypsum are dried at 600ºC to800ºC.

The quantity of soil sample needed for the determination of moisture content depends on the gradation and the maximum size of particles. Following quantities are recommended.

S.No.	Soil	Max. quantity used(gm)
01	Coarse gravel	1000to2000
02	Finegravel	300to500
03	Coarse sand	200
04	Mediumsand	50
05	Finesand	25
06	Siltandclays	10to25

The methodstodeterminemoisture content in the laboratory are oven-drying, pycnometer, infrared lamp with torsion balance moisture meter. The approximate methods are alcohol burning method and calcium carbide method.

APPARATUSREQUIRED

1. Containers
2. Balance of sufficient sensitivity.
3. Hot Oven
4. Desiccators.

PROCEDURE

- Clean, dry and weigh the container with lid.
- Take the required quantity of the soil specimen in the container and weigh with lid.
- Maintain the temperature of the oven between105ºC to110ºC for normal soils and 600ºC to 800ºC for soils having loosely bound hydration water or/and Organic matter.
- Dry the sample in the oven till its mass becomes constant. In normal conditions the sample is kept in the oven for not more than24hours.
- After drying remove the container from the oven, replace the lid and cool in the desiccators.
- Weigh the dry soil in the container with lid.

OBSERVATIONS

S.No.	DeterminationNo.	1	2	3
1	ContainerNo.			
2	Mass of container withlid.W_1(gm)			
3	Mass of containerwithlid+wetsoil,W_2(gm)			
4	Mass of containerwithlid+drysoil,W_3(gm)			
5	Mass of water,$W_w=W_2-W_3$(gm)			
6	Mass of dry soil,$W_s=W_3-W_1$(gm)			
7	Moisture content, $W=W_2-W_3/W_3-W_1 x100$,(%)			

RESULT:

The moisture content of the given soil sample =

TOPIC BEYOND SYLLABUS

Ex.No:17

Date: **Determination of Specific Gravity Using Density Bottle**

AIM:

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

THEORY:

The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc.Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air.

APPARATUS REQUIRED

1. Density bottle of 50 ml with stopper having capillary hole.
2. Balance to weigh the materials (accuracy 10gm).
3. Wash bottle with distilled water.
4. Alcohol and ether.

PROCEDURE

- Clean and dry the density bottle
- wash the bottle with water and allow it to drain.
- Wash it with alcohol and drain it to remove water.
- Wash it with ether, to remove alcohol and drain ether.
- Weigh the empty bottle with stopper (W1)
- Take about 10 to 20 gm of oven soil sample which is cooled in a desiccator. Transfer it to the bottle. Find the weight of the bottle and soil (W2).
- Put 10ml of distilled water in the bottle to allow the soil to soak completely. Leave it for about 2 hours.
- Again fill the bottle completely with distilled water put the stopper and keep the bottle under constant temperature water baths.
- Take the bottle outside and wipe it clean and dry note. Now determine the weight of the bottle and the contents (W3).
- Now empty the bottle and thoroughly clean it. Fill the bottle with only distilled water and weigh it. Let it be W4.
- Repeat the same process for 2 to 3 times, to take the average reading of it.

OBSERVATIONS

SNo.	Observation Number	1	2	3
1	Weight of density bottle (W1 g)			
2	Weight of density bottle + dry soil(W2 g)			
3	Weight of bottle + dry soil + water(W3 g)			
4	Weight of bottle + water (W4 g)			
5	Specific Gravity			

CALCULATIONS

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

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

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

Unless or otherwise specified specific gravity values reported shall be based on water at 27ºC.

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

RESULT:

Specific gravity of soil =

Ex.No:19

Date: **Determination of Field Density-Core Cutter Method**

AIM:

To determine the field density of soil at a given location by core cutter method

THEORY:

In core cutter method the unit weight of soil obtained from direct measurement of weight and volume of soil obtained from field. Particularly for sandy soils the core cutter method is not possible. In such situations the sand replacement method is employed to determine the unit weight. In sand replacement method a small cylindrical pit is excavated and the weight of the soil excavated from the pit is measured. Sand, whose density is known, is filled into the pit. By measuring the weight of sand required to fill the pit and knowing the density of soil , volume of the pit is calculated .Knowing the weight of soil excavated from the pit and the volume of pit the density of soil is calculated. Therefore in this experiment there are two stages (1) Calibration of sand density and (2) Measurement of soil density.

APPARATUS

1. Cylindrical core cutter
2. Steel rammer
3. Steel dolly
4. Balance
5. Moisture content cups

PROCEDURE

CORE CUTTER

- Measure the height (h) and internal diameter (d) of the core cutter and apply grease to the inside of the core cutter.
- Weigh the empty core cutter (W1).
- Clean and level the place where density is to be determined.
- Drive the core cutter, with a steel dolly on its top in to the soil to its full depth with the help of a steel rammer.
- Excavate the soil around the cutter with a crow bar and gently lift the cutter without disturbing the soil in it.
- Trim the top and bottom surfaces of the sample and clean the outside surface of the cutter.

- Weigh the core cutter with soil(W2).
- Remove the soil from the core cutter , using a sample ejector and take a representative soil sample from it to determine the moisture content (w).

OBSERVATIONS - CORE CUTTER METHOD

Internal diameter of the core cutter (d)

Height of the core cutter (h)

Volume of the core cutter (V)

Specific gravity of solids (G)

RESULT

1. **Dry unit weight of the soil =**
2. **Wet unit weight of the soil =**
3. **Void ratio of the soil =**
4. **Porosity of the soil =**
5. **Degree of saturation =**