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Manimangalam, ..

DEPARTMENT OF
CIVIL ENGINEERING

CE 6511- SOIL MECHANICS LABORATORY

V SEMESTER - R 2013

LABORATORY MANUAL

Name :

Register No. :

Class :

VISION

Dhanalakshmi College of Engineering is committed to provide highly disciplined, conscientious and enterprising professionals conforming to global standards through value based quality education and training.

MISSION

- To provide competent technical manpower capable of meeting requirements of the industry
- To contribute to the promotion of Academic Excellence in pursuit of Technical Education at different levels
- To train the students to sell his brawn and brain to the highest bidder but to never put a price tag on heart and soul

DEPARTMENT OF CIVIL ENGINEERING

VISION

To impart professional education integrated with human values to the younger generation, so as to shape them as proficient and dedicated engineers, capable of providing comprehensive solutions to the challenges in deploying technology for the service of humanity

MISSION

- To educate the students with the state-of-art technologies to meet the growing challenges of the civil industry
- To carry out research through continuous interaction with research institutes and industry, on advances in structural systems
- To provide the students with strong ground rules to facilitate them for systematic learning, innovation and ethical practice

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. FUNDAMENTALS

To provide students with a solid foundation in Mathematics, Science and fundamentals of engineering, enabling them to apply, to find solutions for engineering problems and use this knowledge to acquire higher education

2. CORE COMPETENCE

To train the students in Civil Engineering technologies so that they apply their knowledge and training to compare, and to analyze various engineering industrial problems to find solutions

3. BREADTH

To provide relevant training and experience to bridge the gap between theories and practice this enables them to find solutions for the real time problems in industry, and to design products

4. PROFESSIONALISM

To inculcate professional and effective communication skills, leadership qualities and team spirit in the students to make them multi-faceted personalities and develop their ability to relate engineering issues to broader social context

5. LIFELONG LEARNING/ETHICS

To demonstrate and practice ethical and professional responsibilities in the industry and society in the large, through commitment and lifelong learning needed for successful professional career

PROGRAMME OUTCOMES (POs)

a) To demonstrate and apply knowledge of Mathematics, Science and engineering fundamentals in Civil Engineering field

b) To design a component, a system or a process to meet the specific needs within the realistic constraints such as economics, environment, ethics, health, safety and manufacturability

c) To demonstrate the competency to use software tools for analysis and design of structures

d) To identify, constructional errors and solve Civil Engineering problems

e) To demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks

f) To function as a member or a leader in multidisciplinary activities

g) To communicate in verbal and written form with fellow engineers and society at large

h) To understand the impact of Civil Engineering in the society and demonstrate awareness of contemporary issues and commitment to give solutions exhibiting social responsibility

i) To demonstrate professional & ethical responsibilities

j) To exhibit confidence in self-education and ability for lifelong learning

k) To participate and succeed in competitive exams

CE6511 - SOIL MECHANICS LABORATORY

SYLLABUS

COURSE OBJECTIVES

1. Learn index properties of soils and laboratory methods of soil classification
2. Learn Compaction and hydraulic conductivity tests
3. Learn principles of Consolidation and shear strength and
4. Learn to design and analyze a custom experiment

LIST OF EXPERIMENTS

1. Specific gravity of soil solids
2. Specific gravity of soil solids
3. Grain size distribution Hydrometer analysis
4. Liquid limit and Plastic limit tests
5. Shrinkage limit and Differential free swell tests
6. Field density Test (Sand replacement method)
7. Determination of moisture – density relationship using standard Proctor compaction test.
8. Permeability determination (constant head and falling head methods)
9. One dimensional consolidation test (Determination of co-efficient of consolidation only)
10. Direct shear test in cohesion-less soil
11. Unconfined compression test in cohesive soil
12. Laboratory vane Shear test in cohesive soil
13. Tri-axial compression test in cohesion-less soil (Demonstration only)
14. California Bearing Ratio Test

COURSE OUTCOMES

1. An ability to design and conduct experiments, as well as to analyze and interpret data.
2. Gain the ability to use modern soil testing equipment to find out properties of soil.
3. Understood the basic principle and techniques about soil mechanics.
4. Gain knowledge related to various properties of soil

CONTENTS

Expt.No.01 SPECIFIC GRAVITY OF SOIL SOLIDS

Aim:

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

Apparatus Required:

1. Pycnometer (either a Pycnometer jar with conical top or a stoppered bottle having a capacity of at least 50ml)
2. 4.75mm sieve
3. Weighing balance
4. Oven
5. Glass rod
6. Distilled water

Theory:

Specific gravity G is defined as the ratio of the weight of an equal volume of soil solids at a given temperature to the weight of an equal volume of distilled water at that temperature, both weights being taken in air. The Indian Standard specifies 27oC as the standard temperature for reporting the specific gravity.

Procedure:

1. Clean and dry the Pycnometer
2. Weigh the empty Pycnometer with its cap (W1)
3. Take about 200gmof oven dried soil passing through 4.75mm sieve into the Pycnometer and weigh again (W2)
4. Add sufficient de-aired water to cover the soil and screw on the cap
5. Shake the Pycnometer well and remove entrapped air if any
6. Fill the Pycnometer with water completely
7. Dry the Pycnometer from outside and weigh it (W3)
8. Clean the Pycnometer by washing thoroughly
9. Fill the cleaned Pycnometer completely with water up to its top with cap screw on
10. Weigh the Pycnometer after drying it on the outside thoroughly (W4)
11. Repeat the procedure for three samples and obtain the average value of specific gravity.

Calculations:

Calculate the specific gravity of the soil, as follows,

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

Where,

Weight of empty Pyconometer,	W1 =
Weight of Pyconometer + soil sample,	W2 =
Weight of Pyconometer + soil sample + water,	W3 =
Weight of Pyconometer + water,	W4 =

Result:

The specific gravity of the test sample =

Outcome:

Gained knowledge related to various properties of soil (Specific gravity).

Viva - voce

1. What is meant by Soil?
2. What is soil mechanics?
3. What are main types of soils?
4. What is empirical correlation between PSD and permeability?
5. What is meant by degree of saturation?
6. What are the principles of direct shear test?
7. What is the effect of pore pressure on shear strength of soil?
8. How will you find the shear strength of cohesion less soil?
9. What are the types of shear tests based on drainage?
10. What is meant by shear strength and failure envelope?
11. What are the shear strength parameters?
12. What is cohesion and stress path?
13. What is angle of internal friction?
14. What are the various methods of determination of shear strength in the laboratory?
15. What is the differential equation of deflection of a bent beam?
16. What are the disadvantages of direct shear test?
17. What are the types of tri-axial test based on drainage conditions?
18. What is meant by plastic index, saturated mass density?
19. Distinguish between relative density, relative compaction.

Applications

1. To calculate the weight properties of soil like void ratio, degree of saturation and density properties.
2. Used for calculation of Mix design of concrete for construction.

Expt.No.02 GRAIN SIZE DISTRIBUTION – SIEVE ANALYSIS

Aim:

To determine the grain size distribution of the given soil sample using I.S sieves

Apparatus Required:

1. Balance (Sensitivity – 0.1%)
2. I.S sieves (I.S 460 – 1962) (4.75mm to 75 microns)
3. Mechanical seive shaker

Theory:

The grain size analysis is widely used in classification of soils. The data obtained from grain size distribution curves is used in the design of filters for earth dams and to determine suitability of soil for road construction, air field etc. Information obtained from grain size analysis can be used to predict soil water movement although permeability tests are more generally used. The grain size analysis is an attempt to determine the relative proportions of different grain sizes which make up a given soil mass

Procedure:

1. Take about 500g of soil sample.
2. Check all the sieves and remove any particles sticking to the sieve mesh.
3. Arrange sieves are in the descending order of their sizes with a pan at bottom.
4. To keep the sample moving continuously over the sieve surface
5. The soil particles shall not be turned or manipulated through the sieves by hand.
6. Sieving shall be continued until not more than 1 percent by mass of the residue passes any sieve during 60 seconds.
7. Remove the sieves from the sieve shaker and carefully weigh the soil retained an each sieve.
8. Remove the particles sticking to the sieve mesh and should be included to the weight retained.
9. Tabulate the data and calculate the percentage passing as shown in the following mass of the sample:

Observation:

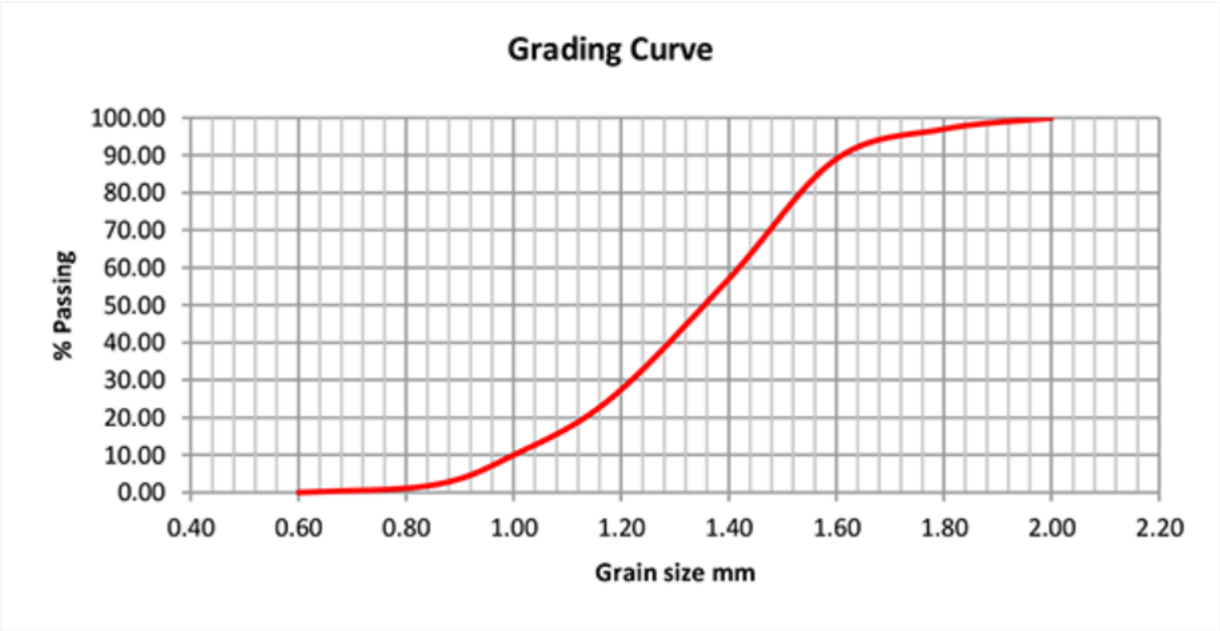
I.S sieve size or number (mm)	Mass retained in sieve (gm)	% retained = (mass retained / total mass)*100	Cumulative % retained	Cumulative % finer (N)
4.75				
4.00				
3.36				
2.40				
1.46				
1.20				
0.60				
0.30				
0.15				
0.075				
Pan				

Graph:

Gradation curve is obtained by plotting percentage passing on y-axis and log of sieve size on x-axis using a semi-log paper. Gradation curves are the best representation of soil nature i.e. it is well graded uniformly graded or poorly graded soil. Uniformity coefficient (CU) and Coefficient of gradation (Cg) can also give us an idea of soil nature.

$$C_U = \frac{D_{60}}{D_{10}} \qquad C_g = \frac{(D_{30})^2}{(D_{10})(D_{60})}$$

Where, D10, D30 and D60 are diameters for 10%, 30% and 60% passing respectively.



Result:

The gradation curve for the given soil sample is obtained.

Outcome :

Understood the grain size distribution of the given soil sample using I.S sieves.

Viva - voce

1. What is meant by void ratio
2. What is meant by specific gravity?
3. What is meant by water content?
4. What is meant by density?
5. What are the factors that affect hydraulic conductivity?
6. What are the classification systems of soil?
7. How to find dry density of soils?
8. What is meant by Soil mechanics?
9. What is meant by plastic index, saturated mass density?
10. Distinguish between relative density, relative compaction.
11. Distinguish between discharge velocity seepage velocities
12. Can liquid limit of any soil be more than 100% substance?
13. Differentiate b/w density and unit weight of soil.
14. What is meant by liquidity index of the soil?
15. What is meant by consistency index?
16. What do you understand by consistency test on soil?

Applications

1. It is used to classifying the soil into various categories to understand its practical uses in the field.
2. It gives the sizes of soil particles in the field which will be used for foundation design.

Expt.No.03 GRAIN SIZE DISTRIBUTION – HYDROMETER ANALYSIS

Aim:

To determine the grain size distribution of the given soil sample by hydrometer test

Apparatus Required:

1. Density Hydrometer (Conforming to I.S 3104 – 1965)
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
3. Thermometer (To cover the range 0 to 50^{o}C with an accuracy of 0.5^{o}C)
4. Water bath
5. Stirring apparatus
6. I.S sieves apparatus
7. Balance (accurate to 0.01 gm)
8. Oven (105 to 110)
9. Stop watch
10. Desiccators
11. Centimeter scale
12. Porcelain evaporating dish
13. Wide mouth conical flask or conical beaker of 1000 ml capacity
14. Thick funnel (about 10 cm in diameter)
15. Filter flask (to take the funnel)
16. Measuring cylinder100 ml capacity
17. Wash bottle (containing distilled water)
18. Filter papers
19. Glass rod (about 15 to 20 cm long and 4 to 5 mm in diameter)
20. Hydrogen peroxide (20 volume solution)
21. Hydrochloric acid N solution 89ml of concentrated hydrochloric acid (specific gravity 1.18) diluted with distilled water one litre of solution
22. Sodium hexametaphosphate solution dissolve 33 g of sodium hexametaphosphate and 7 gm of sodium carbonate in distilled water to make one litre of solution.

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.

Procedure:

Calibration of hydrometer

Volume

1. 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.
2. 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.
3. 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

1. 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.
2. Place the hydrometer on the paper and sketch it. On the sketch note the lowest and highest readings which are on the hydrometer and also mark the neck of the bulb. Mark the center of the bulb which is half of the distance between neck of the bulb and tip of the bulb.
3. The distance from the lowest reading to the center of the bulb is (Rh) shall be recorded (Rh = HL + L/2).
4. The distance from the highest hydrometer reading to the center of the bulb shall be measured and recorded.

5. Draw graph, hydrometer readings vs Hh and Rh. A straight line is obtained. This calibration curve is used to calibrate the hydrometer readings which are taken within 2 minutes.
6. 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.
7. Correction applied to the Rh and Hh
8. From these two corrected readings draw graph (straight line)

Test Procedure

1. Take 50 g of dry soil in an evaporating dish, add 100 ml of dispersing agent, and prepare a suspension.
2. Transfer the suspension into the cup of a mechanical stirrer, add more distilled water, and operate the stirrer for three minutes.
3. Wash the soil slurry into a cylinder, and add distilled water to bring up the level to the 1000 ml mark.
4. Cover the open end of the cylinder with a stopper and hold it securely with the palm of the hand. Then turn the cylinder upside down and back upright repeatedly for one minute.
5. Place the cylinder down and remove the stopper. Insert a hydrometer and start a stop-watch simultaneously. To minimize bobbing of the hydrometer, it should be released close to the reading depth. This requires some amount of rehearsal and practice.
6. Take hydrometer readings on the upper rim of the meniscus formed by the suspension and the hydrometer stem after time intervals of periods of 0.5, 1, 2 and 4 minutes, .
7. After the 4 minutes reading, remove the hydrometer slowly, and float it in a second cylinder containing 100 ml dispersing agent and distilled water up to 1000 ml mark.
8. Take further readings after elapsed time periods of 8, 15 and 30 minutes and also after 1, 2, 4, 8 and 24 hours. Insert the hydrometer only just before the reading and withdraw immediately after the reading.
9. Observe and keep recording the temperature of the soil suspension.
10. Shake the solution in the second cylinder thoroughly. Insert the hydrometer and note the meniscus correction, which is the reading difference between the top of the meniscus and the level of the solution in the cylinder when observed along the hydrometer stem.

11. The composite correction is the difference between the top meniscus reading and value of 1.000 corresponding to the usual hydrometer calibration temperature of 27°C. This may be positive or negative.
12. Calibrate the hydrometer to establish a relation between any reading and its corresponding effective depth, and obtain a calibration plot. The effective depth is the distance from the surface of the soil suspension to the level at which the density of the suspension is being measured.

Observation:

Mass of dry soil taken (passing 75micron) W (g) :

Specific gravity of soil grains, G_S :

Meniscus correction, C_m :

Elapsed time, t (min)	Actual hydrometer reading, R_h	Temp. T (ºC)	Corrected hydrometer reading, $R_{C1} = R_h + C_m$	Effective depth, h (cm)	√h/√t	Viscosity, H (gsec/cm²)	Factor, M	Particle size, D (mm)	$R_{C2} = R_h \pm C$	Factor, N	% Finer w.r.t. mass taken, F	% Finer w.r.t. total mass

Calculations

For Liquid Limit:

Calculation of Particle Size:

1. Enter hydrometer readings. Add meniscus correction and obtain corrected hydrometer readings Rc1.
2. From calibration plot, obtain effective depth h corresponding to Rc1.
3. Calculate value of

4. Obtain viscosity value h corresponding to temperature T. Calculate factor

5. Calculate particle size D by multiplying M and

Calculation of Percentage Finer:

1. Add the composite correction C to the hydrometer reading to get another corrected hydrometer reading Rc2.

2. Calculate factor

3. Calculate percentage finer F by multiplying Rc2 and N.

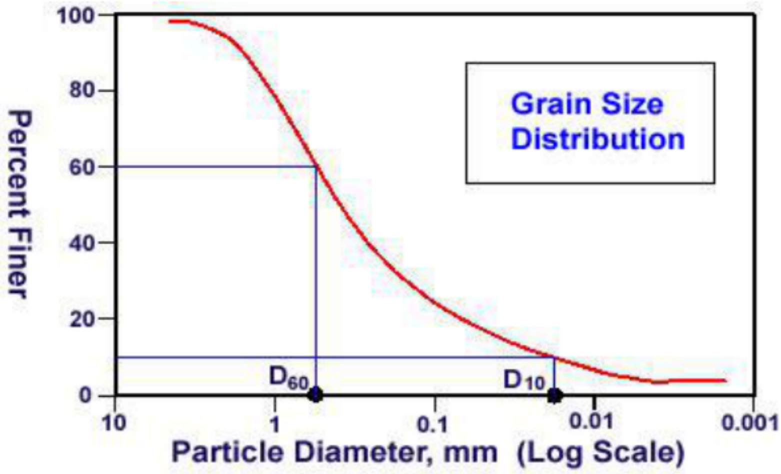
$$N = \frac{G_s}{(G_s - 1)} x \frac{100}{W}$$

4. Calculate percentage finer with respect to total mass of soil taken for sieve analysis and hydrometer analysis.

Total percent finer = F x fine-grained percent in the total soil mass.

Result:

The graph represents the plotting particle size vs. percent finer on a semi-logarithmic sheet.



Outcome:

Understood the grain size distribution of the given soil sample by hydrometer test.

Viva - Voce

1. What are assumptions made to derive the equation governing two dimensional steady state seepage?
2. What are the steps in the construction of a flow net? Steps in Drawing a Flow Net
3. What are the factors that affect the permeability of a soil mass?
4. What is immediate settlement?
5. What is primary consolidation settlement?
6. Distinguish between Residual and Transported soil.
7. What are the relation between γ_{sat}, G, γ_w and e?
8. What are all the Atterberg limits for soil and why it is necessary?
9. What is a zero air voids line? Draw a compaction curve and show the zero air voids line.
10. What is porosity of a given soil sample?
11. What is water content in given mass of soil?
12. What are the different types of soil water?
13. What are the methods of drawing flow net?
14. What is meant by total stress, neutral stress and effective stress?
15. What is meant by capillary rise in soil and how it affects the stress level in soils?
16. State and explain Darcy's law.
17. What is quick sand?
18. What is seepage velocity?
19. What is pore pressure?

Applications

1. It is used to classifying the soil at micron levels which we can use in the irrigation fields.
2. Used to find out different sizes of soil paricles in wet condition or saturation condition.

Expt.No.04 LIQUID LIMIT AND PLASTIC LIMIT

Aim:

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

Apparatus Required:

1. Measruing balance
2. Liquid limit device (Casagrandes)
3. Grooving tool
4. 425 micron sieve
5. Glass plate
6. Spatula
7. Mixing bowl
8. Wash bottle
9. Mositure content bins
10. Drying oven

Theory:

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.

Procedure for liquid limit:

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

Procedure for plastic limit:

1. 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).
2. Mix it thoroughly with distilled water in the evaporating dish till the soil mass becomes plastic enough to be easily molded with fingers.
3. Allow it to season for sufficient time (for 24 hrs) to allow water to permeate throughout the soil mass
4. 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.
5. Continue rolling till you get a threaded of 3 mm diameter.
6. Kneed the soil together to a uniform mass and reroll.
7. Continue the process until the thread crumbles when the diameter is 3 mm.
8. Collect the pieces of the crumbled thread in air tight container for moisture content determination.

9. Repeat the test to at least 3 times and take the average of the results calculated to the nearest whole number.

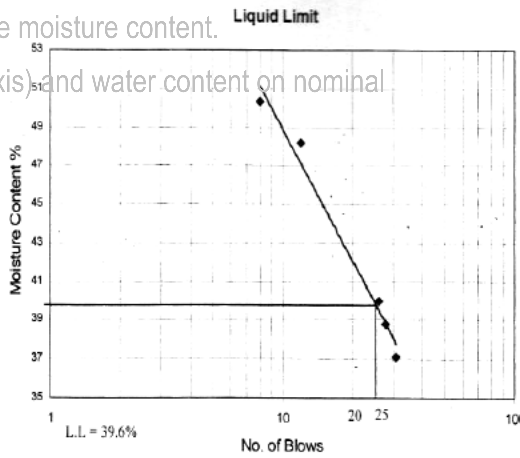
Observation for Liquid Limit:

Natural moisture content: Room temperature:

Sl.No	Description	Test 1	Test 2	Test 3
1	No of blows (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}			

Calculations for Liquid Limit:

1. Use the above table for recording number of blows and calculating the moisture content.
2. 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)
3. Read the water content at 25 blows which is the value of liquid limit.



Observation for Plastic Limit:

Sl.No	Description	Test 1	Test 2	Test 3
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 water in the soil = 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) =

1. From graph,

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

Liquid Limit (LL) =

Result:

Liquid Limit =

Plastic Limit =

Flow Index =

Plasticity Index =

Toughness Index =

Outcome:

Gained the knowledge of the liquid limit and plastic limit of the soil.

Viva - voce

1. What is meant by permeability?
2. What is laminar flow?
3. What is meant by quick sand
4. What is Frost heave?
5. What are the assumptions of Allen Hazens Formula?
6. How can u explain effect of grain size on specific surface how the engineering behavior of soil?
7. What are the different types of soil water?
8. What are The Importance of Effective Stress?
9. What are the uses of flow net?
10. What is surface tension?
11. What is capillary rise?
12. What are the Calculation of total flow?
13. Write down Boussinesque equation for finding out the vertical stress under a single concentrated load.
14. What is meant by normally consolidated clays and over consolidated clays
15. Explain the method of estimating vertical stress using Newark's influence chart.
16. What are the assumptions made in Terzaghi's one dimensional consolidation theory?
17. What is the use of influence chart in soil mechanics?
18. Differentiate between 'Compaction' and 'Consolidation'.
19. What are the uses of influence charts?

Applications

1. It is used to find out the index properties like void ratio, dry density, using this we can find the bearing capacity of soil.
2. Used to find out moisture content of soil depending upon the atmospheric condition.

Expt.No.05 SHRINKAGE LIMIT AND DIFFERENTIAL FREE SWELL TESTS

Aim:

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

Apparatus Required:

1. Evaporating Dish (Porcelain, about 12cm diameter with flat bottom)
2. Spatula
3. Shrinkage Dish (Circular, porcelain or noncorroding metal dish (3 nos) 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. Oventhermostatically 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

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.

Procedure:

<u>Preparation of soil paste</u>

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

Filling the shrinkage dish

1. Coat the inside of the shrinkage dish with a thin layer of Vaseline to prevent the soil sticking to the dish.
2. 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.
3. 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.
4. Weigh immediately, the dish with wet soil and record the weight.
5. 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.
6. Remove the dried disk of the soil from oven. Cool it in a desiccators. Then obtain the weight of the dish with dry sample.
7. Determine the weight of the empty dish and record.
8. Determine the volume of shrinkage dish which is evidently equal to volume of the wet soil as follows.
9. Place the shrinkage dish in an evaporating dish and fill the dish with mercury till it overflows slightly.
10. Press it with plain glass plate firmly on its top to remove excess mercury.

Volume of the Dry Soil Pat

1. 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.
2. 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.
3. 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.

Observation:

Sl.No	Description	Test 1	Test 2	Test 3
1	Wt of dish + wet soil pat (gm)			
2	Wt of dish + dry soil pat (gm)			
3	Wt of water present (R2 – R3)			
4	Wt of shrinkage dish, empty (gm)			
5	Wt of dry soil pat, Wd = (R2 – R4)			
6	Initial water content, W= [(R4/R6)*100]			
7	Wt of weighing dish, empty (gm)			
8	Wt of weighing dish + Mercury			
9	Wt of mercury (R8 – R7)			
10	Volume of wet soil pat, V (R8/13.6) cm3			
11	Wt of weighing dish + displaced mercury			
12	Wt of mercury displaced (R11 – R7)			
13	Volume of dry soil pat, VO (R8/13.6) cm3			
14	Shrinkage limit (WS)			
15	Shrinkage ratio (SR)			
16	Volumetric shrinkage (VS)			

Calculations:

Shrinkage limit,

$$W_S = \left(W - \frac{V - V_O}{W_d}\right) * 100$$

Shrinkage Ratio,

$$SR = \left({}^{W_d}/_{V_O}\right)$$

Volumetric Shrinkage,

$$VS = (W - W_S)\, SR$$

Result:

Shrinkage limit =

Shrinkage ratio =

Volumetric shrinkage =

Outcome:

Gained the knowledge about the shrinkage limit, shrinkage ratio and volumetric shrinkage of the soil

Viva - voce

1. What is Darcy's law?
2. What is meant by seepage?
3. What are the assumptions made in the Laplace's equation?
4. What are the approximate methods of determination of vertical stress under loaded areas?
5. What are isochrones?
6. When a soil mass is said to be homogeneous?
7. What are isobars?
8. Differentiate Consolidation and Compaction.
9. What are the components of settlement in soil?
10. What are the two theories explaining the stress distribution on soil?
11. What is odometer?
12. What is meant by hydrodynamic log?
13. What is meant by dynamic pressure?
14. What is meant by consolidation?
15. What is meant by consolidation?

Applications

1. It is used to find out the shrinking capacity of soil in the field in dry condition.
2. Used to find out volumetric changes in the soil in different conditions like wet and dry conditions.

Expt.No.06 FIELD DENSITY TEST - SAND REPLACEMENT METHOD

Aim:

To determine the in situ density of natural or compacted soils using sand pouring cylinders

Apparatus Required:

1. Sand pouring cylinder of 3 litre/16.5 litre capacity, mounted above a pouring come and separated by a shutter cover plate.
2. Tools for excavating holes; suitable tools such as scraper tool to make a level surface.
3. Cylindrical calibrating container with an internal diameter of 100 mm/200 mm and an internal depth of 150 mm/250 mm fitted with a flange 50 mm/75 mm wide and about 5 mm surrounding the open end.
4. Balance to weigh unto an accuracy of 1g.
5. Metal containers to collect excavated soil.
6. Metal tray with 300 mm/450 mm square and 40 mm/50 mm deep with a 100 mm/200 mm diameter hole in the centre.
7. Glass plate about 450 mm/600 mm square and 10mm thick.
8. Clean, uniformly graded natural sand passing through 1.00 mm I.S.sieve and retained on the 600micron I.S.sieve. It shall be free from organic matter and shall have been oven dried and exposed to atmospheric humidity.
9. Suitable noncorrodible airtight containers.
10. Thermostatically controlled oven with interior on noncorroding material to maintain the temperature between 105^{0}C to 110^{0}C.

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.

Procedure:

Calibration of the Cylinder

1. Fill the sand pouring cylinder with clean sand so that the level of the sand in the cylinder is within about 10 mm from the top. Find out the initial weight of the cylinder plus sand (W_1) and this weight should be maintained constant throughout the test for which the calibration is used.
2. Allow the sand of volume equal to that of the calibrating container to run out of the cylinder by opening the shutter, close the shutter and place the cylinder on the glass sand takes place in the cylinder close the shutter and remove the cylinder carefully. Weigh the sand collected on the glass plate.
3. Its weight (W_2) gives the weight of sand filling the cone portion of the sand pouring cylinder. Repeat this step at least three times and take the mean weight (W_2) Put the sand back into the sand pouring cylinder to have the same initial constant weight (W_1).

Determination of Bulk Density of Soil

1. Determine the volume (V) of the container be filling it with water to the brim.
2. Place the sand poring cylinder centrally on the container making sure that weight (w_1) is maintained.
3. Open the shutter and permit the sand to run into the container.
4. When no further movement of sand is seen close the shutter, remove the cylinder and find its weight (w_3).

Determination of Dry Density of Soil in Place

1. Approximately 60 cm^2 of area of soil to be tested should be trimmed down to a level surface, approximately of the size of the container. Keep the metal tray on the level surface and excavate a circular hole of volume equal to that of the calibrating container. Collect all the excavated soil in the tray and find out the weight of the excavated soil (W_w).
2. Remove the tray, and place the sand pouring cylinder filled to constant weight so that the base of the cylinder covers the hole concentrically. Open the shutter and permit the sand to run into the hole. Close the shutter when no further movement of the sand is seen. Remove the cylinder and determine its weight (W_3).
3. Keep a representative sample of the excavated sample of the soil for water content determination.

Observation

Sl.No	Description	Test 1	Test 2
(a) Determination of mass of sand in the cone			
1	Weight of sand + cylinder before pouring (W_1) (g)		
2	Mean weight of sand in cone (W_2) (g)		
(b) Determination of bulk density of sand			
3	Volume of calibrating container (V) cc		
4	Weight of sand + cylinder after pouring (W3) (g)		
5	Weight of sand to fill calibrating containers, Wa = (W1 – W3 – W2) (g)		
6	Bulk density of sand, ρS = (5/3) (g/cc)		
(c) Bulk density and unit weight of soil			
7	Weight of wet soil from the hole (WW) (g)		
8	Weight of sand + cylinder after pouring in the hole (W4) (g)		
9	Weight of sand in the hole, Wh = (W1 – W4 – W2) (g)		
10	Bulk density of soil, ρ = (WW / Wh)* ρS (g/cm3)		
11	Bulk unit weight of soil, γ = 9.81 * ρ (kN/m3)		
(d) Water content determination			
12	Container Number		

	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 (%)		

Calculations:

Dry density,

$$\rho_d = \left(\frac{\rho}{1+W}\right) \qquad \text{(g/cm3)}$$

Dry unit weight,

$$\gamma_d = \left(\frac{\gamma}{1+W}\right) \qquad \text{(kN/m3)}$$

Result:

Dry density =

Dry unit weight =

Outcome:

The in situ density of natural or compacted soils using sand pouring cylinders is understood.

Viva - Voce

1. What are the reasons for compression of the soil?
2. What are the stages of consolidation?
3. What is a principal plane?
4. What are the limitations of coulomb's theory?
5. Explain Coulomb's shear strength equation.
6. What are the factors affecting the time factors and hence the degree of consolidation?
7. What are the hydrodynamic equations of one-dimensional consolidation?
8. What is meant by Pre consolidation Stress?
9. What are the assumptions of Mohr's-Coulomb failure envelope equation?
10. Why tri-axial shear test is considered better than direct shear test?
11. What are different types of tri-axial compression tests based on drainage conditions?
12. Explain the Mohr–Coulomb failure theory.
13. What are the principles of direct shear test?
14. What is the effect of pore pressure on shear strength of soil?
15. How will you find the shear strength of cohesion less soil?
16. What are the types of shear tests based on drainage?
17. What is shear strength of soil?
18. How will you find the shear strength of cohesive soil?
19. What are the advantages of tri-axial Compression Test?

Applications

1. It is used to find out the densities of soils at various field condition.
2. It is alos used for determining moisture content of soil.

Expt. No.07 DETERMINATION OF MOISTURE – DENSITY RELATIONSHIP

Aim:

To determine Optimum Moisture Content and Maximum dry density for a soil by conducting standard 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.

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. Themoisture 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.

Procedure:

1. Take about 3 kg of air dried soil
2. Sieve the soil through 20mm sieve.Take the soil that passes through the sieve for testing.
3. 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.
4. Clean , dry and grease the mould and base plate .Weigh the mould with base plate. Fit the collar.
5. Compact the wet soil in three equal layers by the rammer with 25 evenly distributed blows in each layer.
6. 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.
7. Clean the outside of the mould and weigh the mould with soil and base plate.
8. Remove the soil from the mould and obtain a representative soil sample from the bottom, middle and top for water content determination
9. 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.
10. 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.

<u>Moisture-Density relationship:</u>

1. The dry density of the soil shall be plotted as ordinates and the corresponding moisture content as abscissas.
2. The moisture content corresponding to the peak of the moisture-density curve is termed the “Optimum Moisture Content” of the soil.
3. The dry density of the soil at optimum moisture content is termed as “Maximum Density”.

Observation

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

Ht. of the mould, H (cm) =

Wt. of the mould, W1 (g) =

Sl.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)				

(b) Water content					
6	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)				

Calculations:

1. Enter all the observations in Table and calculate the wet density.
2. Calculate the dry density by using the equation
3. Plot the moisture content on X axis and dry density on Y axis .Draw a smooth curvepassing through the points called compaction curve.
4. Read the point of maximum dry density and corresponding water content from thecompaction curve.

Dry density,

$$\rho_d = \left(\frac{\rho}{1+W}\right) \text{(g/cm3)}$$

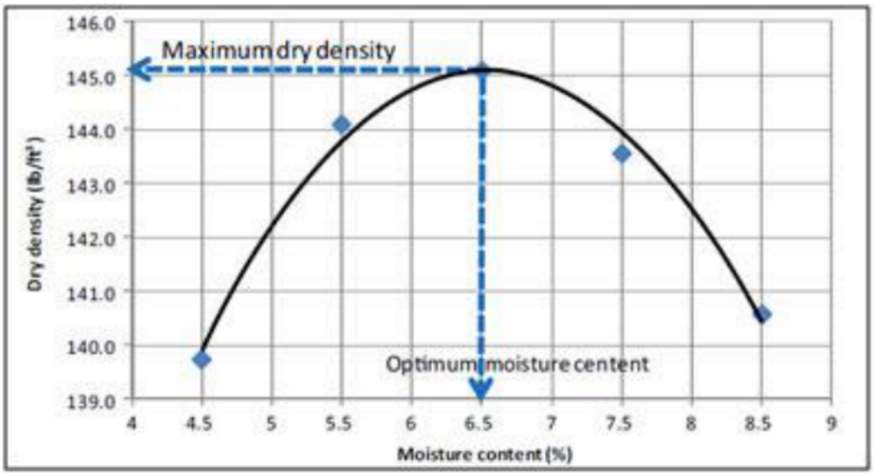
Dry unit weight,

$$\gamma_d = [\rho_d * 9.81] \text{(kN/m3)}$$

Result:

Optimum Moisture Content (OMC) % =

Maximum dry density (g/cc) =



Outcome:

Understoodoptimum moisture content and maximum dry density for a soil by conducting standard proctor compaction test.

Viva - voce

1. What is unconsolidated undrained condition?
2. What is consolidated undrained condition?
3. What is the main cause of slope failure?
4. What are the factors affecting permeability tests?
5. What is meant by effective stress?
6. What is meant by angle of repose of soil?
7. Explain coulomb's law.
8. What are the merits and demerits of direct shear test?
9. What are the different types of failure of a triaxcal compression test specimen?
10. What do you mean by stress-path?
11. What is peak shear strength? West out the factors it depends on?
12. What is Rohr's circle? What are the characteristics of Rohr's circle?
13. What are the type of triaxial test?
14. What are the advantages of triaxial test?
15. What is compaction of the soil?
16. What is the Relationship between the Dry Density - Water Content?
17. What is meant by voids line?
18. How to differentiate finite slope and infinite slope?
19. How do u explain factor of safety of an infinite slope in case of cohesion less soil?

Applications

1. It is used to find out the densities of soils at various field condition.
2. It is alos used for determining moisture content of soil.

Expt. No.08 PERMEABILITY DETERMINATION (CONSTANT HEAD)

Aim:

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

Apparatus Required:

1. Permeameter mould of noncorrodible material having a capacity of 1000 ml, with an internal diameter of 100 mm and internal effective height of 127.3 mm.
2. The mould shall be fitted with a detachable base plate and removable extension counter.
3. Compacting equipment: 50 mm diameter circular face, weight 2.76 kg and height of fall 310 mm as specified in I.S 2720 part VII 1965.
4. Drainage bade: A bade with a porous disc, 12 mm thick which has the permeability 10 times the expected permeability of soil.
5. Drainage cap: A porous disc of 12 mm thick having a fitting for connection to water inlet or outlet.
6. Constant head tank: A suitable water reservoir capable of supplying water to the permeameter under constant head.
7. Graduated glass cylinder to receive the discharge.
8. Stop watch to note the time.
9. A meter scale to measure the head differences and length of specimen.

Theory:

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

Procedure:

Preparation of specimen for testing undisturbed soil sample

1. Note down the sample number, bore hole number and it depth at which the sample was taken.
2. Remove the protective cover (paraffin wax) from the sampling tube.

3. Place the sampling tube in the sample extraction frame, and push the plunger to get a cylindrical form sample not longer than 35 mm in diameter and having height equal to that of mould.
4. Place the specimen shall be centrally over the porous disc to the drainage base.
5. Fill the angular space shall be with an impervious material such as cement slurry or wax, to provide sealing between the soil specimen and the mould against leakage from the sides.
6. Fix the drainage cap over the top of the mould.
7. Now the specimen is ready for the test.

Disturbed Soil Sample

1. A 2.5 kg sample shall be taken from a thoroughly mixed air dried or oven dried material.
2. The initial moisture content of the 2.5 kg sample shall be determined. Then the soil shall be placed in the air tight container.
3. Add required quantity of water to get the desired moisture content.
4. Mix the soil thoroughly. Weigh the empty permeameter mould.
5. After greasing the inside slightly, clamp it between the compaction base plate and extension collar.
6. Place the assembly on a solid base and fill it with sample and compact it.
7. After completion of a compaction the collar and excess soil are removed.
8. Find the weight of mould with sample.
9. Place the mould with sample in the permeameter, with drainage base and cap having discs that are properly saturated.

Test Procedure

1. Connect the specimen through the top inlet to the constant head reservoir.
2. Open the bottom outlet.
3. Establish steady flow of water.
4. CollectThe quantity of flow for a convenient time interval.
5. Repeat three times for the same interval.

Observation:

The coefficient of permeability is reported in cm/sec at 27^{O}C. The dry density, the void ratio and the degree of saturation shall be reported.

Dia. of the specimen, D (cm) :

Specific gravity of soil, G :

Volume of the specimen, V (cm^3) :

Weight of the dry specimen, W_S (g) :

Moisture content, (%) :

S.No	Description	Test 1	Test 2	Test 3
1	Length of the specimen, L (cm)			
2	Area of the specimen, A (cm2)			
3	Time, t (sec)			
4	Discharge (Qty. of water collected), Q (ml)			
5	Hydraulic head, h (cm)			
6	Test temperature (OC)			

Calculations:

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

Coefficient of permeability for a constant head test is given by,

$$K = \frac{Q}{t}\frac{L}{h}\frac{1}{A}$$

Permeability at 27^oC is calculated by the formual,

$$K_{27} = \frac{K_t * V_t}{V_{27}}$$

Where,

K_{27} = coefficient of permeability at 27^oC

K_t = coefficient of permability at t^oC

V_t = coefficient of viscosity at t^oC

V_{27} = coefficient of viscosity at 27^oC

Void ratio is given by,

$$e = \frac{G*\gamma_w - \gamma_d}{\gamma_d}$$

$$\gamma_d = \frac{W_d}{V}$$

Where,

V = volume of the specimen in cm^3

G = specific gravity of the specimen

W_d = weight of dry specimen

γ_w = unit weight of water

γ_d = dry unit weight of soil sample

Degree of Saturation is given by,

$$S = \frac{w\,G}{e}$$

Where,

S = degree of saturation

w = moisture content

e = void ratio

Result:

Coefficient of permeability (cm/sec), K =

Permeability at 27OC (cm/sec), K27 =

Void ratio, e =

Degree of saturation (%), S =

Outcome:

Understoodproperties of soil(coefficient of permeability) by conducting constant head method.

Viva - voce

1. What is meant by water content and compaction
2. What are the laboratory methods of determination of water content?
3. What is meant by degree of saturation and shrinkage ratio
4. What is meant by specific gravity and density index
5. What do understand from grain size distribution?
6. What are consistency limits of soil?
7. Explain any two slope protection methods.
8. What do you mean by Tension crack?
9. What do you meant by critical surface of failure.
10. What are different factors of safety used in the stability of slopes?
11. What is a stability number? What are the uses of stability charts?
12. What are the two basic types of failure occurring in finite slopes.
13. What is a slide?
14. What are the different types of Slope failure?
15. What do you mean by slide?
16. Why does a slope be analyzed?
17. What is meant stability number?
18. What is the Factor of safety used in stability Analysis of slopes?
19. How do you calculate factor of safety with respect to cohesion?
20. How do you calculate factor of safety with respect to friction?

Applications

1. It is used to find out the voids in the soil paricles then only the compaction required to the soil can calculated.
2. It is used to determine the permeability nature of soil during the rainy seasons, we can find out the strom run off.

Expt. No.08 PERMEABILITY DETERMINATION (FALLING HEAD)

Aim:

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

Apparatus Required:

1. Permeameter mould of noncorrodible material having a capacity of 1000 ml, with an internal diameter of 100 mm and internal effective height of 127.3 mm.
2. The mould shall be fitted with a detachable base plate and removable extension counter.
3. Compacting equipment: 50 mm diameter circular face, weight 2.76 kg and height of fall 310 mm as specified in I.S 2720 part VII 1965.
4. Drainage bade: A bade with a porous disc, 12 mm thick which has the permeability 10 times the expected permeability of soil.
5. Drainage cap: A porous disc of 12 mm thick having a fitting for connection to water inlet or outlet.
6. Constant head tank: A suitable water reservoir capable of supplying water to the permeameter under constant head.
7. Graduated glass cylinder to receive the discharge.
8. Stop watch to note the time.
9. A meter scale to measure the head differences and length of specimen.

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.

Procedure:

1. Compact the soil into the mould at a given dry density and moisture content by a suitable device.
2. Place the specimen centrally over the bottom porous disc and filter paper.
3. Place a filter paper, porous stone and washer on top of the soil sample and fix the top collar.
4. Connect the stand pipe to the inlet of the top plate. Fill the stand pipe with water.
5. 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.

6. Open the air valve at the top and allow the water to flow out so that the air in the cylinder is removed.
7. Fix the height h1 and h2 on the pipe from the top of water level in the reservoir.
8. 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.
9. Record the time required for the water head to fall from h1 to h2.
10. Change the height h1 and h2 and record the time required for the fall of head.

Observation:

The coefficient of permeability is reported in cm/sec at 27OC.

The test result should be tabulated as below:

Sl.No.	Description	Test 1	Test 2	Test 3
1	Length of the sample, L (cm)			
2	Area of the stand pipe, a (cm2)			
3	C/s area of the soil sample, A (cm2)			
4	Initial head, h1 (cm)			
5	Final head, h2 (cm)			
6	Time interval, t (sec)			
7	Coefficient of permeability at test temp (cm/sec)			
8	Test temperature (OC)			
9	Permeability at 27OC (cm/sec)			

Calculations:

For cohesive soils falling head method is suitable.

Coefficient of permeability for a falling head test is given by,

$$K = 2.3 \frac{a\,L}{A\,t} \log_{10} \frac{h_1}{h_2}$$

Permeability at 27ºC is calculated by the formual,

$$K_{27} = \frac{K_t * V_t}{V_{27}}$$

Where,

K_{27} = coefficient of permeability at 27ºC

K_t = coefficient of permability at tºC

V_t = coefficient of viscosity at tºC

V_{27} = coefficient of viscosity at 27ºC

Result:

Coefficient of permeability (cm/sec), K =

Permeability at 27OC (cm/sec), K27 =

Outcome:

Gained the knowledge about properties of soil (coefficient of permeability) by conducting falling head method.

Viva - voce

1. What is meant by degree of saturation and shrinkage ratio?
2. What is meant by gravity and density index?
3. What do understand from grain size distribution?
4. What are consistency limits of soil?
5. How do you explain plasticity index, flow index and liquidity index?
6. What are the methods available for determination of in-situ density?
7. What is the function of A-line Chart in soil classification?
8. What are the soil classifications as per Indian Standard Classification System?
9. What are the types of slopes in soil?
10. What is meant by stability number?
11. What are the three forces acting in circular failure while analysis through friction circles method?
12. What do you mean by slide?
13. What do you meant by slope failure factors?
14. What is meant by slope stability analyses
15. What is infinite slope analysis?
16. What is meant by brush layering?

Applications

1. It is used to find out the voids in the soil paricles then only the compaction required to the soil can calculated.
2. It is used to determine the permeability nature of soil during the rainy seasons, we can find out the strom run off.

Expt. No.09 ONE DIMENSIONAL CONSOLIDATION TEST

Aim:

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

Apparatus Required:

1. Consolidometer consisting essentially
2. A ring of diameter = 60mm and height = 20 mm
3. Two porous plates or stones of silicon carbide, aluminum oxide or porous metal
4. Guide ring
5. Outer ring
6. Water jacket with base
7. Pressure pad
8. Rubber basket
9. Loading device consisting of frame, lever system, loading yoke dial gauge fixing device and weights
10. Dial gauge to read to an accuracy of 0.002mm
11. Thermostatically controlled oven
12. Stopwatch to read seconds
13. Sample extractor
14. Miscellaneous items like balance, soil trimming tools, spatula, filter papers, sample containers.

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. Themagnitude 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. Consolidation properties are required in estimating the settlement of a foundation. They provide the maximum amount of settlements under a given load and the time required for it to occur. Many times the design of foundations is carried out based on the limiting settlements. The amount of consolidation will be more in clay soils. Further due to low permeability, the rate of settlement in clay soil is very low. That means the time required for the total settlement in clay soils is very high. Hence the study of consolidation properties is important for foundation resting on clay soil.

Procedure:

1. Saturate two porous stones either by boiling in distilled water about 15 minute or by keeping them submerged in the distilled water for 4 to 8 hrs. Wipe away excess water. Fittings of the consolidometer which is to be enclosed shall be moistened.
2. Assemble the consolidometer, with the soil specimen and porous stones at top and bottom of specimen, providing a filter paper between the soil specimen and porous stone.
3. Position the pressure pad centrally on the top porous stone.
4. Mount the mould assembly on the loading frame, and center it such that the load applied is axial.
5. Position the dial gauge to measure the vertical compression of the specimen. The dial gauge holder should be set so that the dial gauge is in the begging of its releases run, allowing sufficient margin for the swelling of the soil, if any.
6. Connect the mould assembly to the water reservoir and the sample is allowed to saturate. The level of the water in the reservoir should be at about the same level as the soil specimen.
7. Apply an initial load to the assembly. The magnitude of this load should be chosen by trial, such that there is no swelling. It should be not less than 50 g/cm3 for ordinary soils & 25 g/cm2 for very soft soils. The load should be allowed to stand until there is no change in dial gauge readings for two consecutive hours or for a maximum of 24 hours.
8. Note the final dial reading under the initial load. Apply first load of intensity 0.1 kg/cm2 start the stop watch simultaneously. Record the dial gauge readings at various time intervals. The dial gauge readings are taken until 90% consolidation is reached. Primary consolidation is gradually reached within 24 hrs.
9. At the end of the period, specified above take the dial reading and time reading. Double the load intensity and take the dial readings at various time intervals. Repeat this procedure fir successive load increments. The usual loading intensity are as follows: a. 0.1, 0.2, 0.5, 1, 2, 4 and 8 kg/cm^2.
10. After the last loading is completed, reduce the load to the value of the last load and allow it to stand for 24 hrs. Reduce the load further in steps of the previous intensity till an intensity of 0.1kg/cm^2 is reached. Take the final reading of the dial gauge.
11. Reduce the load to the initial load, keep it for 24 hrs and note the final readings of the dial gauge.

12. Quickly dismantle the specimen assembly and remove the excess water on the soil specimen in oven, note the dry weight of it.
13. In the log fitting method, a plot is made between dial readings and logarithmic of time, the time corresponding to 50% consolidation is determined.
14. In the square root fitting method, a plot is made between dial readings and square root of time and the time corresponding to 90% consolidation is determined. The values of C_v are recorded in table.2

Observation:

For consolidation test

Depth of the sample (m) : Description of soil :

Empty weight of ring (g) : Area of ring (cm2) :

Diameter of ring (cm) : Volume of ring (cm3) :

Height of ring (cm) : Specific gravity of soil sample :

Dial gauge (Least Count):

(Table 1: Pressure, Compression and Time)

Pressure intensity (kN/m^2)		10	20	50	100	200	400	800
Elapsed time (min)	√t	Dial gauge readings						
0	0							
0.25	0.5							
1	1							
2.25	1.5							
4	2							
6.25	2.5							
9	3							
12.25	3.5							
16	4							
20.25	4.5							
25	5							
36	6							

49	7							
64	8							
81	9							
100	10							
121	11							
144	12							

(Table 2: Coefficient of consolidation)

Applied pressure σ' (kN/m2)	Final dial reading	Dial change ΔH	Specimen height H = H1 + ΔH	Drainage path d = 0.25 (H1 + H)	Fitting time		CV (cm2/min)	
					t50	t90	0.197*d2/t50	0.848*d2/t90
10								
20								
50								
100								
200								
400								
800								

Calculations:

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

a. $C_v = 0.197*d^2/t_{50}$ (Log fitting method)

b. $C_v = 0.848*d^2/t_{90}$ (Square fitting method)

Result:

Coefficient of consolidation of the given soil sample, Cv =

Outcome:

Gained knowledge about the settlements due to primary consolidation of soil by conducting one dimensional test.

Viva - voce

1. How do you define shear.
2. What is creep?
3. What is meant by plastic limit?
4. What is meant by Liquid limit?
5. What are methods available for determination of k for a soil sample?
6. Why tri-axial shear test is considered better than direct shear test?
7. What are different types of tri-axial compression tests based on drainage conditions?
8. Explain the Mohr–Coulomb failure theory.
9. State the principles of direct shear test.
10. What is the effect of pore pressure on shear strength of soil?
11. How will you find the shear strength of cohesion less soil?
12. What are the types of shear tests based on drainage?
13. What are the different types of soil water
14. What are the methods of drawing flow net?
15. What is meant by total stress, neutral stress and effective stress?
16. What is meant by capillary rise in soil and how it affects the stress level in soils?
17. Write any two engineering classification system of soil.
18. What is meant by plasticity index, flow index and liquidity index?
19. Differentiate standard proctor from modified proctor test.
20. What is capillary rise?

Applications

1. It is used to determine the settlement of soil so that strength of soil can easily understood.
2. It is used to find out the consolidation characteristics of soil in wet conditioin.

Ex. No.10 DIRECT SHEAR TEST IN COHESION-LESS SOIL

Aim:

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

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

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 :

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

τ_f = shear strength of the soil

C = Cohesion

σ = normal stress on the failure plane

φ = Angle of internal friction

Shear parameters are used in the design of earthen dams and embankments. The stability of the failure wedges depends on the shear resistance of the soil along the failure plane. The strength parameters C and φ are used in calculating the bearing capacity of soil foundation systems. Further shear parameters help in estimating the earth pressures behind the retaining walls.

Procedure:

1. Check the inner dimension of the soil container.
2. Put the parts of the soil container together.
3. Calculate the volume of the container. Weigh the container.
4. Place the soil in smooth layers (approximately 10 mm thick). If a dense sample is desired tamp the soil.
5. Weigh the soil container, the difference of these two is the weight of the soil. Calculate the density of the soil.
6. Make the surface of the soil plane.
7. Put the upper grating on stone and loading block on top of soil.
8. Measure the thickness of soil specimen.
9. Apply the desired normal load.
10. Remove the shear pin.
11. Attach the dial gauge which measures the change of volume.
12. Record the initial reading of the dial gauge and calibration values.
13. Before proceeding to test check all adjustments to see that there is no connection between two parts except sand/soil.
14. Start the motor. Take the reading of the shear force and record the reading.
15. Take volume change readings till failure.
16. Add 5 kg normal stress 0.5 kg/cm^2 and continue the experiment till failure.
17. Record carefully all the readings. Set the dial gauges zero, before starting the experiment.

Observation: for Direct Shear Test

Least count of the dial : Proving ring constant :

(Table 1: Normal stress 0.5 kg/cm^2)

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 reading (6)	Vertical deformation = div. In col. (6) X L.C of dial gauge (7)	Proving reading Initial reading (8)	Shear stress = div. Col. (8) X Proving ring constant area of the specimen (kg/cm2) (9)
0								
25								
50								
75								
100								
125								
150								
175								
200								
250								

(Table 2: Normal stress 1.0 kg/cm2)

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 reading (6)	Vertical deformation = div. In col. (6) X L.C of dial gauge (7)	Proving reading Initial reading (8)	Shear stress = div. Col. (8) X Proving ring constant area of the specimen (kg/cm2) (9)
0								
25								
50								
75								
100								
125								
150								
175								
200								
250								

Calculations:

Least count of the dial : Proving ring constant :

Calibrarion factor : Leverage factor :

Dimension of shear box : Empty weight of shear box :

Least count of dial gauge: Volume change :

(Table 3: Normal stress 1.5 kg/cm2)

S.No	Normal load (kg)	Normal stress (kg/cm2) (Load * Leverage / Load)	Shear stress (kg/cm2) (Proving Ring reading * calibration / Area of container)
1			
2			
3			
4			

Results:

The shear strength parameters of the given soil sample,

τf =

C =

σ =

φ =

Outcome:

Student were gained the knowledge about the shearing strength of the soil.

Viva - Voce

1. What are the different types of soil water?
2. What are the methods of drawing flow net?
3. What is meant by total stress, neutral stress and effective stress?
4. What is meant by capillary rise in soil and how it affects the stress level in soils?
5. State and explain Darcy's law.
6. Explain plasticity index, flow index and liquidity index
7. What are the methods available for determination of in-situ density?
8. What is the function of A-line Chart in soil classification?
9. What are the major soil classifications as per Indian Standard Classification System?
10. Explain any two slope protection measures.

Applications

1. It is used to find out the shear values of soilsby having this we can predict the land slides in hilly areas.
2. It is determine shear angle to control the sliding.

Expt.No.11 UNCONFINED COMPRESSION TEST IN COHESIVE SOIL

Aim:

To determine the shearing strength of the cohesive soil.

Apparatus Required:

1. Loading frame of capacity of 2 t, with constant rate of movement.
2. Proving ring of 0.01 kg sensitivity for soft soils; 0.05 kg for stiff soils
3. Soil trimmer
4. Frictionless end plates of 75 mm diameter (Perspex plate with silicon grease coating)
5. Evaporating dish (Aluminum container)
6. Soil sample of 75 mm length
7. Dial gauge (0.01 mm accuracy)
8. Balance of capacity 200 g and sensitivity to weigh 0.01 g
9. Sample extractor and split sampler
10. Dial gauge (sensitivity 0.01mm)
11. Vernier calipers

Theory:

The unconfined compression test is a special case of triaxial compression test in which $\sigma_2 = \sigma_3 = 0$. The cell pressure in the triaxial 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 soi is subjected to major principal stress σ_1 till the specimen fails due to shearing along a critical plane of failure.

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

<u>Undisturbed specimen</u>

1. Note down the sample number, bore hole number and the depth at which the sample was taken.
2. Remove the protective cover (paraffin wax) from the sampling tube.
3. Place the sampling tube extractor and push the plunger till a small length of sample moves out.
4. Trim the projected sample using a wire saw.

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

Moulded sample

1. Calculate the weight of the dry soil W_s required for preparing a specimen of 3.8 cm dia and 7.5 cm long.
2. Add required quantity of water Ww to this soil.
3. $W_w = W_S * W/100$ gm
4. Mix the soil thoroughly with water.
5. Place the wet soil in a tight thick polythene bag in a humidity chamber
6. place the soil in a constant volume mould, having an internal height of 7.5 cm and internal dia of 3.8 cm.
7. After 24 hours take the soil from the humidity chamber and place the soil in a constant volume mould,
8. Place the lubricated moulded with plungers in position in the load frame.
9. Apply the compressive load till the specimen is compacted to a height of 7.5 cm.
10. Eject the specimen from the constant volume mould.
11. Record the correct height, weight and diameter of the specimen.

Test procedure

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

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 :

Sl.No.	Elapsed time (min)	Axial load, P (kg)	Compression dial reading, ΔL (mm)	Strain, ϵ (%)	Area, A (cm2)	Compressive stress, σ (kg/cm2)
1						
2						
3						
4						

Calculations:

The axial strain, ϵ is determined by,

$\epsilon = (\Delta L/LO)*100$

The average c/s area, A at particular strain is determined by,

$A = (AO/[1-\epsilon])$

Compressive stress, σ is determine by,

$\sigma = (P/A)$

A 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.

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

Results:

Unconfined compression strength of the soil, q_u =

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

Sensitivity =

Outcome:

Gained the knowledge about the shearing strength of the cohesive soil.

Viva - Voce

1. What is capillary rise?
2. What is surface tension?
3. What are the different forms of soil water?
4. Write down the uses of flow net?
5. What is meant by neutral stress?
6. What is seepage?
7. What is meant byseepage velocity?
8. What are the classification of types of soil water?
9. What is meant by capillarity and permeability
10. What is surface tension?
11. What is meant by capillary siphoning?
12. How do you define soil mechanics?
13. What is the function of A-line Chart in soil classification?
14. What are the major soil classifications as per Indian Standard Classification System?
15. Differentiate standard proctor from modified proctor test.

Applications

1. It is used to find out the compression values of soils.
2. It is determine the void ratios.

Expt.No.12 LABORATORY VANE SHEAR TEST IN COHESIVE SOIL

Aim:

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

Apparatus Required:

1. Vane shear apparatus

   A typical laboratory vane is 20mm high and 12mm in diameter with blade thickness from 0.5mm to 1mm (the blades being made of high tensile steel).The field shear vane is from 10cm to 20cm in height and from 5cm to 10cm in diameter, with blade thickness of about 2.5mm
2. Specimen
3. Specimen container
4. Callipers

Theory:

Vane shear test is a quick test, used either in the laboratory or in the field, to detremine 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 1^{o} 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.

Procedure:

1. Prepare two or three specimens of the soil sample of dimensions of at least 37.5 mm diameter and 75 mm length in specimen.(L/D ratio 2 or 3).
2. Mount the specimen container with the specimen on the base of the vane shear apparatus. If the specimen container is closed at one end, it should be provided with a hole of about 1 mm diameter at the bottom.
3. Gently lower the shear vanes into the specimen to their full length without disturbing the soil specimen.
4. The top of the vanes should be atleast 10 mm below the top of the specimen. Note the readings of the angle of twist.

5. Rotate the vanes at an uniform rate say 0.1°/s by suitable operating the torque application handle until the specimen fails.
6. Note the final reading of the angle of twist.
7. Find the value of blade height in cm.
8. Find the value of blade width in cm.

Observation:

For VS test

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

Calculations:

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

$$\tau_f = \frac{T}{\pi d^2 \left[\frac{H}{2} + \frac{d}{6}\right]}$$

Results:

Un drained Shear strength of the given cohesive soil sample =

Outcome:

Understood the undrained shear strength of the cohesive soil and usage of vane shear appartus.

Viva - voce

1. What are the different forms of soil water?
2. What is meant by neutral stress?
3. What is surface tension?
4. What are methods of determination of permeability in the field?
5. What is the function of A-line Chart in soil classification?
6. What are the major soil classifications as per Indian Standard Classification System.
7. Differentiate standard proctor from modified proctor test.
8. Explain sieve analysis and sedimentation analysis and what is the necessity of these two analyses?
9. What are the main types of soils?
10. Can you explain empirical correlation between PSD and permeability?
11. What is meant by degree of saturation?
12. State the principles of direct shear test.
13. What is the effect of pore pressure on shear strength of soil?
14. How will you find the shear strength of cohesion less soil?
15. What are the types of shear tests based on drainage?
16. How do you explain shear strength and failure envelope?

Applications

1. It is used to find out the shear values of soilsby having this we can predict the land slides in hilly areas.
2. It is determine shear angle to control the sliding.

Expt.No13TRI-AXIAL COMPRESSION TEST IN COHESIONLESS SOIL

Aim:

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

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

Apparatus for preparation of the sample:

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

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 σ_1 is applied in the vertical direction, and the other two principal stresses σ_2 and σ_3 ($\sigma_2 = \sigma_3$) are applied in the horizontal direction by the fluid pressure round the specimen.

Procedure:

1. The sample is placed in the compression machine and a pressure plate is placed on the top. Care must be taken to prevent any part of the machine or cell from jogging the sample while it is being setup, for example, by knocking against this bottom of the loading piston. The probable strength of the sample is estimated and a suitable proving ring selected and fitted to the machine.
2. The cell must be properly set up and uniformly clamped down to prevent leakage of pressure during the test, making sure first that the sample is properly sealed with its end caps and rings (rubber) in position and that the sealing rings for the cell are also correctly placed.
3. When the sample is setup water is admitted and the cell is fitted under water escapes from the beed valve, at the top, which is closed. If the sample is to be tested at zero lateral pressure water is not required.
4. The air pressure in the reservoir is then increased to raise the hydrostatic pressure in the required amount. The pressure gauge must be watched during the test and any necessary adjustments must be made to keep the pressure constant.
5. The handle wheel of the screw jack is rotated until the under side of the hemispherical seating of the proving ring, through which the loading is applied, just touches the cell piston.
6. The piston is then removed down by handle until it is just in touch with the pressure plate on the top of the sample, and the proving ring seating is again brought into contact for the begging of the test.

Observation:

The machine is set in motion 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.

Height :
Area :
Volume :
Diameter :
Initial mass :
Initial water content :
Final mass :
Final water content :
Cell pressure (σ_3) kg/cm^2 :

Load gauge reading 1	Strain 2	Proving ring reading 3	Load on sample (kg) 4	Corrected area (cm2) 5	Vertical stress (σ1) (R4/R5) 6	Deviator stress (σd) (R6 – σ3) 7

Calculations:

The shear parameters are obtained from a plot of Mohr circles for which purpose peak value of principal stress difference ($\sigma1 – \sigma3$) or principal stress-ratio ($\sigma1/\sigma3$) or the ultimate value as desired may be used.

Results:

Shear parameter of the given soil sample =

Outcome:

Understood the characterestics ofthe cohesive soil using vane shear.

Viva - Voce

1. What is the use of influence chart in soil mechanics?
2. Differentiate between 'Compaction' and 'Consolidation'.
3. Can you discuss the use of influence charts?
4. What are isochrones?
5. When a soil mass is said to be homogeneous?
6. What are isobars?
7. Differentiate Consolidation and Compaction.
8. What are the components of settlement in soil?
9. What are the two theories explaining the stress distribution on soil?
10. What is geostatic stress and pre-consolidation pressure?
11. What are the applications of Boussinesque equation?
12. What is meant by seepage pressure and flow net?
13. What is quick sand condition?
14. What are the different forms of soil water?
15. What is meant by neutral stress?
16. What is surface tension?
17. What are methods of determination of permeability in the field?

Applications

1. Fundamental material parameters about the sample.
2. To predict how the material will behave in a larger-scale engineering application.

Expt. No.14 CALIFORNIA BEARING RATIO TEST

Aim:

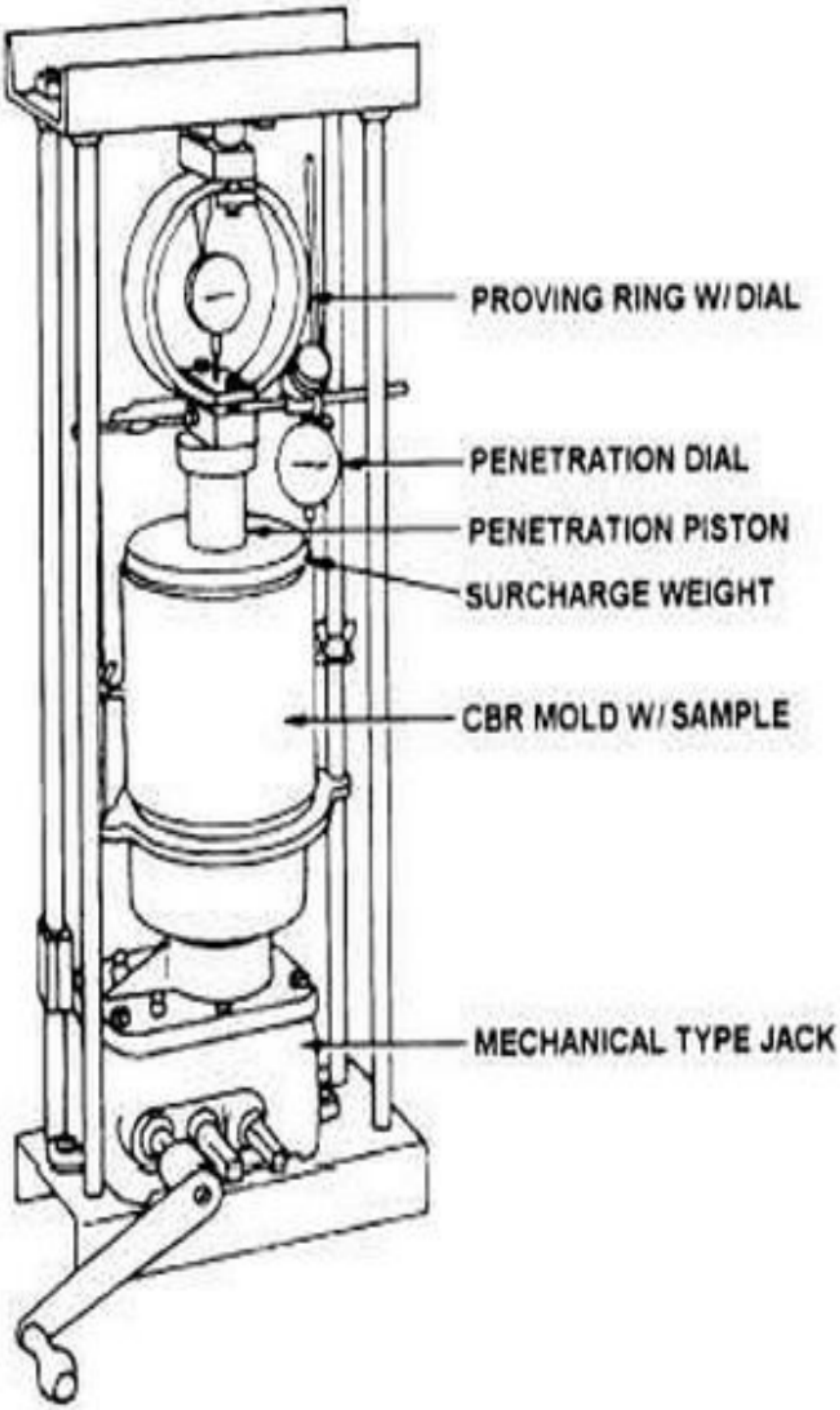
To determine the California bearing ratio by conducting a load penetration test in the laboratory.

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 10 mm thick
2. Spacer disc 148 mm in dia and 47.7 mm in height along with handle
3. Metal rammers. Weight 2.6 kg with a drop of 310 mm (or) weight 4.89 kg a drop 450 mm
4. Weights. One annular metal weight and several slotted weights weighing 2.5 kg each, 147 mm in dia, with a central hole 53 mm in diameter
5. Loading machine. With a capacity of atleast 5000 kg and equipped with a movable head or base that travels at an uniform rate of 1.25 mm/min. Complete with load indicating device
6. Metal penetration piston 50 mm dia and minimum of 100 mm in length
7. Two dial gauges reading to 0.01 mm
8. Sieves. 4.75 mm and 20 mm I.S. Sieves
9. Miscellaneous apparatus, such as a mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers

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 3in^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.


PROVING RING W/ DIAL
PENETRATION DIAL
PENETRATION PISTON
SURCHARGE WEIGHT
CBR MOLD W/ SAMPLE
MECHANICAL TYPE JACK

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.

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.

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

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

1. Take about 4.5 to 5.5 kg of soil and mix thoroughly with the required water.
2. 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.
3. 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.
4. For heavy compaction compact the soil in 5 layers, 56 blows to each layer by the 4.89 kg rammer.
5. Remove the collar and trim off soil.
6. Turn the mould upside down and remove the base plate and the displacer disc.
7. Weigh the mould with compacted soil and determine the bulk density and dry density.
8. Put filter paper on the top of the compacted soil (collar side) and clamp the perforated base plate on to it.

Static compaction

1. 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

   w = desired water content

   V = volume of the specimen in the mould = 2250 cm3 (as per the mould available in laboratory)
2. Take the weight W (calculated as above) of the mix soil and place it in the mould.
3. Place a filter paper and the displacer disc on the top of soil.
4. Keep the mould assembly in static loading frame and compact by pressing the displacer disc
5. Keep the load for some time and then release the load. Remove the displacer disc.
6. The test may be conducted for both soaked as well as unsoaked conditions.
7. If the sample is to be soaked, in both cases of compaction, put a filter paper on the top of the soil
8. place the adjustable stem and perforated plate on the top of filter paper.

9. 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.
10. Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Remove the mould from tank.
11. Note the consolidation of the specimen.

Procedure for Penetration Test

1. Place the mould assembly with the surcharge weights on the penetration test machine.
2. 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.
3. 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.
4. 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.
5. 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:

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 (cm^3) :

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)

Results:

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

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

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

Outcome:

After completing the experiment,student were capable to calculate California bearing ratio by conducting a load penetration test.

Viva - Voce

1. What is meant by shear strength and failure envelope
2. What are the shear strength parameters?
3. How do you explain cohesion and stress path.
4. What is angle of internal friction?
5. What are the various methods of determination of shear strength in the laboratory?
6. Write the differential equation of deflection of a bent beam?
7. What are the disadvantages of direct shear test?
8. What are the types of tri-axial test based on drainage conditions?
9. Can you define plastic index, saturated mass density?
10. Distinguish between relative density, relative compaction.
11. Distinguish between discharge velocity seepage velocities
12. Can liquid limit of any soil be more than 100%substance?
13. Why tri-axial shear test is considered better than direct shear test?
14. What are different types of tri-axial compression tests based on drainage conditions?
15. Explain the Mohr–Coulomb failure theory.

Applications

1. For the evaluation of subgrade strength of roads and pavements.
2. To determine the thickness of pavement and its component layers in construction of pavements.

LIST OF PROJECTS

1. Experimental investiogation on Stability of high rise buildings in clayey soils.
2. Field investigation on Soil Liquefaction in irrigation land.
3. Ready mix concrete plants on settleable soils.
4. Pile foundation on weak soil.
5. Improvement of bearing capacity of sandy soil by grouting.
6. Ground improvement technique by geotextiles.
7. Investigation of use of plastic as soil stabilizer.
8. Erosion control in slope areas.
9. Model of different types of soil stratum invarious field condition.
10. Properties and safe bearing capacity of different types of soil.