DEPARTMENT OF CIVIL ENGINEERING

MANUAL
FOR

CIVIL ENGINEERING LAB-II

Sr.No	Name of Experiment
1	DETERMINATION OF MOISTURE CONTENT
2	DETERMINATION OF SPECIFIC GRAVITY
3	SAND REPLACEMENT METHOD
4	SIEVE ANALYSIS
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1. DETERMINATION OF MOISTURE CONTENT

OBJECTIVE

Determine the natural content of the given soil sample.

NEED AND SCOPE OF THE EXPERIMENT

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

DEFINITION

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

APPARATUS REQUIRED

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

PROCEDURE

1. Clean the container with lid dry it and weigh it (W1).
2. Take a specimen of the sample in the container and weigh with lid (W2).
3. Keep the container in the oven with lid removed. Dry the specimen to constant weight maintaining the temperature between 105^0 C to 1100 C for a period varying with the type of soil but usually 16 to 24 hours.
4. Record the final constant weight (W3) of the container with dried soil sample. Peat and other organic soils are to be dried at lower temperature (say 600) possibly for a longer period.

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

OBSERVATIONS AND RECORDING

Data and observation sheet for water content determination

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

RESULT

The natural moisture content of the soil sample is _________

REMARKS

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

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

2.DETERMINATION OF SPECIFIC GRAVITY

OBJECTIVE

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

NEED AND SCOPE

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

DEFINITION

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

APPARATUS REQUIRED

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

PROCEDURE

1. Clean and dry the density bottle

    a. wash the bottle with water and allow it to drain.
    b. Wash it with alcohol and drain it to remove water.
    c. Wash it with ether, to remove alcohol and drain ether.

2. Weigh the empty bottle with stopper (W_1)

3. Take about 10 to 20 gm of oven soil sample which is cooled in a desiccator. Transfer it to the bottle. Find the weight of the bottle and soil (W_2).

4. Put 10ml of distilled water in the bottle to allow the soil to soak completely. Leave it for about 2 hours.

5. Again fill the bottle completely with distilled water put the stopper and keep the bottle under constant temperature water baths (T_x^0).

6. Take the bottle outside and wipe it clean and dry note. Now determine the weight of the bottle and the contents (W_3).

7. Now empty the bottle and thoroughly clean it. Fill the bottle with only disttiled water and weigh it. Let it be W_4 at temperature (T_x^0 C).

8. Repeat the same process for 2 to 3 times, to take the average reading of it.

OBSERVATIONS

S. No.	Observation Number	1	2	3
1	Weight of density bottle (W_1 g)			
2	Weight of density bottle + dry soil (W_2g)			
3	Weight of bottle + dry soil + water (W_3 g)			
4	Weight of bottle + water (W_4 g)			

CALCULATIONS

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

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

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

RESULT: specific gravity of soil **-------------**

Unless or otherwise specified specific gravity values reported shall be based on water at 27^0C.

The specific gravity of the soil particles lie with in the range of 2.65 to 2.85. Soils containing organic matter and porous particles may have specific gravity values below 2 0. Soils having heavy substances may have values above 3.0.

FIELD DENSITY TEST

3. SAND REPLACEMENT METHOD

OBJECTIVE

Determine the in situ density of natural or compacted soils using sand pouring cylinders.

NEED AND SCOPE

The in situ density of natural soil is needed for the determination of bearing capacity of soils, for the purpose of stability analysis of slopes, for the determination of pressures on underlying strata for the calculation of settlement and the design of underground structures.

It is very quality control test, where compaction is required, in the cases like embankment and pavement construction.

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 non-corrodible airtight containers.

10. Thermostatically controlled oven with interior on non-corroding material to maintain the temperature between 105^0C to 110^0C.

11. A dessicator with any desiccating agent other than sulphuric acid.

THEORY

By conducting this test it is possible to determine the field density of the soil. The moisture content is likely to vary from time and hence the field density also. So it is required to report the test result in terms of dry density. The relationship that can be established between the dry density with known moisture content is as follows:

$$\gamma_d = \gamma_b / (1 + w)$$

$$\gamma_d = Dry\ density$$

$$\gamma_b - Bulk\ density$$

$$w = water\ content$$

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. 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

3. Determine the volume (V) of the container be filling it with water to the brim. Check this volume by calculating from the measured internal dimensions of the container.

4. Place the sand poring cylinder centrally on yhe of the calibrating container making sure that constant weight (W_1) is maintained. Open the shutter and permit the sand to run into the container. When no further movement of sand is seen close the shutter, remove the pouring cylinder and find its weight (W_3).

Determination of Dry Density of Soil In Place

5. Approximately 60 sqcm 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). 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).

6. Keep a representative sample of the excavated sample of the soil for water content determination.

OBSERVATIONS AND CALCULATIONS

S. No.	Calibration	1	2	3
1.	Weight of sand in cone (of pouring cylinder) W_2 gm			
2.	Volume of calibrating container (V) in cc			
3.	Weight of sand + cylinder before pouring W_3 gm			
4.	Weight of sand + cylinder after pouring W_3 gm			
5.	Weight of sand to fill calibrating containers $W_a = (W_1 - W_3 - W_2)$ gm			
6.	Bulk density of sand $g_s = W_a / V$ gm/cc			

S. No.	Measurement of Soil Density	1	2	3
	Weight of wet soil from hole W_w gm			
1.	Weight of sand + cylinder before pouring W_1 gm			
2.	Weight of sand + cylinder after pouring W_4 gm			
3.	Weight of sand in hole $W_b = (W_1 - W_2 - W_4)$ gm			
4.	Bulk density $g_b = (W_w / W_b)\ g_s$ gm/cc			
5.				
6.	Water content determination			
7.	Container number			
8.	Weight of wet soil			
9.	Weight of dry soil			
10.	Moisture content (%)			
	Dry density $g_d = g_b / (1+w)$ gm/cc			

REMARKS

1. While calibrating the bulk density of sand great care has to be taken.

2. The excavated hole must be equal to the volume of the calibrating container.

4. GRAIN SIZE DISTRIBUTION

I. SIEVE ANALYSIS

OBJECTIVE

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

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

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

NEED AND SCOPE OF EXPERIMEN

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.

Apparatus

1. Balance

2. I.S sieves

3. Rubber pestle and mortar.

4. mechanical Sieve Shaker

The grain size analysis is an attempt to determine the relative proportions of different grain sizes which make up a given soil mass.

KNOWLEDGE OF EQUIPMENT

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

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

PROCEDURE

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

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

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

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

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

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

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

OBSERVATIONS AND RECORDING

Weight of soil sample:

Moisture content:

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

0.30					
0.15					
0.075					

GRAPH

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

CALCULATION

1. The percentage of soil retained on each sieve shall be calculated on the basis of total weight of soil sample taken.
2. Cumulative percentage of soil retained on successive sieve is found.

5. HYDROMETER ANALYSIS

OBJECTIVE

Grain size analysis of soils by hydrometer analysis test.

SPECIFIC OBJECTIVE

1. To determine the grain size distribution of soil sample containing appreciable amount of fines.

2. To draw a grain size distribution curve.

NEED AND SCOPE OF THE EXPERIMENT

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

APPARATUS

1. Hydrometer

2. Glass measuring cylinder-Two of 1000 ml capacity with ground glass or rubber stoppers about 7 cm diameter and 33 cm high marked at 1000 ml volume.

3. Thermometer- To cover the range 0 to 50° C with an accuracy of 0.5 $^{\circ}$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 cylinder-100 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-89 ml 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 gms of sodium carbonate in distilled water to make one litre of solution.

CALIBRATION OF HYDROMETER

Volume

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

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

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

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

Calibration

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

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.

(b) The distance from the lowest reading to the center of the bulb is (R_h) shall be recorded

($R_h = H_L + L/2$).

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

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

(e) 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.

(f) Correction applied to the R_h and H_H

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

V_h= Volume of hydrometer bulb in ml.

A=Area of measuring cylinder in cm^2.

From these two corrected readings draw graph (straight line)

Calculation

Date:

Sample No:

Total weight of dry soil taken, W =

Specific Gravity of soil, G =

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

Meniscus correction, C_n =Dispersion agent correction =

Reading in water RW =

Temperature correction =

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

Date	Time	Elapsed Time in Sec	Hydrometer reading upper Meniscus R_h 1000	Corrected hydrometer Reading (1- lower meniscus C_m)	Z_r	Velocity Cms/sec V=Zr/K or Z_r/ t	Equivalent dia. Of Particle D_{mm}	R	N(%finer Thanfor soil)	REMARKS

6. DETERMINATION OF LIQUID LIMIT

OBJECTIVE

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

NEED AND SCOPE

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

THEORY

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

APPARATUS REQUIRED

1. Balance 2. Liquid limit device (Casagrendes) 3. Grooving tool 4. Mixing dishes

5. Spatula 6. Electrical Oven

PROCEDURE

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

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

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

4. Trim it to a depth of 1cm at the point of maximum thickness and return excess of soil to the dish.
5. The soil in the cup shall be divided by the firm strokes of the grooving tool along the diameter through the centre line of the follower so that clean sharp groove of proper dimension is formed.
6. Lift and drop the cup by turning crank at the rate of two revolutions per second until the two halves of soil cake come in contact with each other for a length of about 1 cm by flow only.
7. The number of blows required to cause the groove close for about 1 cm shall be recorded.
8. A representative portion of soil is taken from the cup for water content determination.
9. Repeat the test with different moisture contents at least three more times for blows between 10 and 40.

OBSERVATIONS

Details of the sample:.......

Natural moisture content:........ Room temperature:..............

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

CALCULATION

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

RESULT Liquid limit = --------------------------

7. PLASTIC LIMIT TEST

NEED AND SCOPE

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

APPARATUS REQUIRED

1. Porcelain dish.
2. Glass plate for rolling the specimen.
3. Air tight containers to determine the moisture content.
4. Balance of capacity 200gm and sensitive to 0.01gm
5. Oven thermostatically controlled with interior of non-corroding material to maintain the temperature around 105^0 and 110^0C.

PROCEDURE

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 re-roll.

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 atleast 3 times and take the average of the results calculated to the nearest whole number.

OBSERVATION AND REPORTING

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

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

Average Plastic Limit=...............

Plasticity Index(Ip) = (LL - PL)=............ Toughness Index =I_p/I_F

8. SHRINKAGE LIMIT TEST

OBJECTIVE

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

THEORY

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

NEED AND SCOPE

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

A shrinkage limit test should be performed on a soil.

1. To obtain a quantitative indication of how much change in moisture can occur before any appreciable volume changes occurs
2. To obtain an indication of change in volume.

The shrinkage limit is useful in areas where soils undergo large volume changes when going through wet and dry cycles (as in case of earth dams)

APPARATUS

1. Evaporating Dish. Porcelain, about 12cm diameter with flat bottom.
2. Spatula
3. Shrinkage Dish. Circular, porcelain or non-corroding metal dish (3 nos) having a flat bottom and 45 mm in diameter and 15 mm in height internally.
4. Straight Edge. Steel, 15 cmm 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 × 75 mm one plate shall be of plain glass and the other shall have prongs.

7. Sieves. 2mm and 425- micron IS sieves.

8. Oven-thermostatically controlled.

9. Graduate-Glass, having a capacity of 25 ml and graduated to 0.2 ml and 100 cc one mark flask.

10.Balance-Sensitive to 0.01 g minimum.

11.Mercury. Clean, sufficient to fill the glass cup to over flowing.

12.Wash bottle containing distilled water.

PROCEDURE

Preparation of soil paste

1. Take about 100 gm of soil sample from a thoroughly mixed portion of the material passing through 425-micron I.S. sieve.

2. Place about 30 gm the above soil sample in the evaporating dish and thoroughly mixed with distilled water and make a creamy paste.

Use water content some where around the liquid limit.

Filling the shrinkage dish

3. Coat the inside of the shrinkage dish with a thin layer of Vaseline to prevent the soil sticking to the dish.

4. Fill the dish in three layers by placing approximately 1/3 rd of the amount of wet soil with the help of spatula. Tap the dish gently on a firm base until the soil flows over the edges and no apparent air bubbles exist. Repeat this process for 2nd and 3rd

layers also till the dish is completely filled with the wet soil. Strike off the excess soil and make the top of the dish smooth. Wipe off all the soil adhering to the outside of the dish.

5. Weigh immediately, the dish with wet soil and record the weight.

6. Air- dry the wet soil cake for 6 to 8hrs, until the colour of the pat turns from dark to light. Then oven-dry the to constant weight at 105^0C to 110^0C say about 12 to 16 hrs.

7. Remove the dried disk of the soil from oven. Cool it in a desiccator. Then obtain the weight of the dish with dry sample.

8. Determine the weight of the empty dish and record.

9. Determine the volume of shrinkage dish which is evidently equal to volume of the wet soil as follows. Place the shrinkage dish in an evaporating dish and fill the dish with mercury till it overflows slightly. Press it with plain glass plate firmly on its top to remove excess mercury. Pour the mercury from the shrinkage dish into a measuring jar and find the volume of the shrinkage dish directly. Record this volume as the volume of the wet soil pat.

Volume of the Dry Soil Pat

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

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

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

CALCULATION

First determine the moisture content

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

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

V = Volume of wet soil pat in cm3

$V0$ = Volume of dry soil pat in cm3

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

Do not touch the mercury with gold rings.

TABULATION AND RESULTS

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

9. DIRECT SHEAR TEST

OBJECTIVE

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

NEED AND SCOPE

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

PLANNING AND ORGANIZATION

Apparatus

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

KNOWLEDGE OF EQUIPMENT:

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

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

PROCEDURE

1. Check the inner dimension of the soil container.

2. Put the parts of the soil container together.

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

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

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

6. Make the surface of the soil plane.

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

8. Measure the thickness of soil specimen.

9. Apply the desired normal load.

10.Remove the shear pin.

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

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

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

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

15.Take volume change readings till failure.

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

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

OBSERVATION AND RECORDING

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

S.No	Normal load (kg)	Normal stress(kg/cm^2)	Normal stress(kg/cm^2)	Remark
1 2 3				

REMARKS

1. In the shear box test, the specimen is not failing along its weakest plane but along a predetermined or induced failure plane i.e. horizontal plane separating the two halves of the shear box. This is the main draw back of this test. Moreover, during loading, the state of stress cannot be evaluated. It can be evaluated only at failure condition i.e Mohrs circle can be drawn at the failure condition only. Also failure is progressive.

2. Direct shear test is simple and faster to operate. As thinner specimens are used in shear box, they facilitate drainage of pore water from a saturated sample in less time. This test is also useful to study friction between two materials one material in lower half of box and another material in the upper half of box.

3. The angle of shearing resistance of sands depends on state of compaction, coarseness of grains, particle shape and roughness of grain surface and grading. It varies between 28^o(uniformly graded sands with round grains in very loose state) to 46^o(well graded sand with angular grains in dense state).

4. The volume change in sandy soil is a complex phenomenon depending on gradation, particle shape, state and type of packing, orientation of principal planes, principal stress ratio, stress history, magnitude of minor principal stress, type of apparatus, test procedure, method of preparing specimen etc. In general loose sands expand and dense sands contract in volume on shearing. There is a void ratio at which either expansion contraction in volume takes place. This void ratio is called critical void ratio. Expansion or contraction can be inferred from the movement of vertical dial gauge during shearing.

5. The friction between sand particle is due to sliding and rolling friction and interlocking action.

10. PROCTOR TEST

SCOPE

This method covers the determination of the relationship between the moisture content and density of soils compacted in a mould of a given size with a 2.5 kg rammer dropped from a height of 30 cm.

APPARATUS

1. Proctor mould having a capacity of 944 cc with an internal diameter of 10.2 cm and a height of 11.6 cm. The mould shall have a detachable collar assembly and a detachable base plate.
2. Rammer: A mechanical operated metal rammer having a 5.08 cm diameter face and a weight of 2.5 kg. The rammer shall be equipped with a suitable arrangement to control the height of drop to a free fall of 30 cm.
3. Sample extruder.
4. A balance of 15 kg capacity.
5. Sensitive balance.
6. Straight edge.
7. Graduated cylinder.
8. Mixing tools such as mixing pan, spoon, towel, spatula etc.
9. Moisture tins.

PROCEDURE

Take a representative oven-dried sample, approximately 5 kg in the given pan. Thoroughly mix the sample with sufficient water to dampen it to approximately four to six percentage points below optimum moisture content

Weigh the proctor mould without base plate and collar. Fix the collar and base plate. Place the soil in the Proctor mould and compact it in 3 layers giving 25 blows per layer with the 2.5 kg rammer falling through.

Remove the collar, trim the compacted soil even with the top of the mould by means of the straight edge and weigh.

Divide the weight of the compacted specimen by 944 cc and record the result as the wet weight γ_{wet} in grams per cubic centimeter of the compacted soil.

Remove the sample from the mould and slice vertically through and obtain a small sample for moisture determination.

Thoroughly break up the remainder of the material until it will pass a no.4 sieve as judged by the eye. Add water in sufficient amounts to increase the moisture content of the soil sample by one or two percentage points and repeat the above procedure for each increment of water added. Continue this series of determination until there is either a decrease or no change in the wet unit weight of the compacted soil.

CALCULATION

Wet density gm/cc =weight of compacted soil / 944.

Dry density = wet density/(1+w)

Where w is the moisture content of the soil.

Plot the dry density against moisture content and find out the maximum dry density and optimum moisture for the soil.

OBSERVATIONS

Cylinder diameter cm.

height cm.

volume cc

weight of cylinder gm

Density					
Determination No.					
Water to be added (percent)					
Weight of water to be added (gm)					
Weight of cylinder + compacted soil					
Weight of compacted soil					

(gms)					
Average moisture content (percent)					
Wet density (gm /cc)					
Dry density (gm/cc)					
Water content					
Container No.					
Wt. Of container + wet soil gms.					
Wt. Of container + dry soil gms					
Wt of container alone gms.					
Wt. Of water gm					
Wt. Of dry soil gms.					
Percentage of water Content					

RESULT

1. Maximum dry density=_____________
2. Optimum moisture content =__________