LAB MANUAL

SESSION: 2020-21

SUBJECT CODE: KCE 552
GEOTECHNICAL ENGINEERING LAB
BRANCH –CIVIL ENGINEERING
FACULTY INCHARGE- MS. NIDHI SINGH
LAB INSTRUCTOR- MR. MR. DHIRENDRA KUMAR RAI

INDEX

LIST OF EXPERIMENTS

EXPERIMENT NO. 1

Object: Grain size distribution of the soils by Sieve analysis

Theory: having particles larger than 0.075mm size are termed as coarse grained soils. In these soils more than 50% of the total material by mass is larger than 75 micron. Coarse grained soil may have boulder cobble, gravel and sand.

<u>Following sizes:</u>
Boulder - more than 300 mm dia.
Cobble - smaller than 300 mm and larger than 80mm dia.
Gravel (G) - smaller than 80mm and larger than 4.75mm.
Coarse gravel- 20mm to 4.75mm
Sand (S) - smaller than 4.75 mm and larger than 0.075mm
Coarse: 4.75mm to 2mm
Medium: 2.0mm to 425 micron
Fine: 425 micron to 75 micron

Apparatus
Special:
1. 1st set sieves of sizes 300 mm, 80 mm, 40 mm, 20 mm, 10 mm, and 4.75 mm.
2. 2nd set of sieves of sizes 2 mm, 1mm 850µ, 425µ, 150µ, and 75 µ.
3. Sodium hexa meta phosphate (for cohesive soils)
4. Mechanical shaker (optional)
5. Brush
6. Rubber pestle and Motor

General**:-**
1. Balances (one of accuracy=1.0 gm. Other of accuracy=0.1 gm)
2. Weights and weight box
3. Oven
4. Desiccator
5. Drying crucibles
6. Tray/bucket
7. Water

Procedure:-
1. Take suitable quantity of oven-dry soil for analysis and weigh it.

Sieving for coarser than 4.75 mm size
2. Sieve the soil first through IS sieves.
3. Clean the set of sieve and pan with brush
4. Sieve the soil first through I.S. sieves of first set i.e. 100mm,80 mm, 40 mm, 10mm and4.75 mm manually or using a mechanical shaker for 5-10 minutes.
5. Weigh the material retained on each sieve to 1.0 gm.

Sieving for soil passing from 4.75mm size
6. Clean the sieve and pan with brush and weigh to 0.1gm.
7. Sieve the soil through 2nd set of sieves i.e., 2mm, 600µ, 425µ, 150µ and 75µ using a mechanical shaker for 10 mins.

8. Weigh to 0.1 gm each sieve and pan with soil retained on them. The sum of the retained soil mass is checked against the original mass of soil taken.

Precautions:

1. While drying the temperature of the oven should not be more than 105°C because higher temperature may cause some permanent change in the -75 μ materials.
2. During shaking, sample soil should not be allowed to come out.
3. In wet analysis, all cohesive soil adhering to large size particles should be removed by water.
4. For plotting, per cent finer should be determined with respect to the total soil taken for initial analysis.

Observations and Calculations:

Soil Sample No
(Soil passing from 4.75mm Sieve and retained on 75μ Sieve)
i) Weight of total soil sample taken for analysis (g) =
ii) % of soil sample passing from 4.75mm sieve =
iii) Weight of soil sample taken for this analysis (g) =…….

S.No	Sieve No. (1)	Mass of soil retained gm (2)	Cumulative mass of soil retained (gm) **(3)**	Cumulative % of soil retained (gm) (4)	% finer w.r.t. 4.75mm (passing) (5)	Combined% Finer w.r.t. total soil sample (5) x (ii) (6)

Draw Graph sheet – Grain Size Analysis

Result
1. Coefficient of Curvature, Cc= …………
2. Uniformity Coefficient, Cu= …………

EXPERIMENT NO. 2

Object:

(a) To determine the specific gravity of soil by pycnometer.

(b) to determine the water content of a soil sample whose specific gravity by pycnometer is known and check it with oven drying method.

A. Determine of specific gravity

Apparatus: A pycnometer, balance, glass rod or some stirrer, oven.

Theory: The specific gravity G of the soil solids is the ratio of the unit weight of soil solids to that of water at a given temperature.

$G=\rho_S/\rho_w$

Where; ρ_s= unit wt. of soil solid

ρ_w= unit wt. of water

Procedure:

1. Weight the dry and empty pycnometer. Let this be W_1.
2. Take about 200 gm oven dried soil and put it in pycnometer. The pycnometer and sand W_2.
3. Add some water in it and mix it thoroughly with glass rod. Add some more water and stir it. Fill the pycnometer by water upto the hole of conical cap, dry the pycnometer from outside and weight it W_3.
4. Empty the pycnometer, clean it thoroughly and fill it with distilled water to the hole of conical cap and weight it W_4.
5. Repeat the steps from 2 to 4 for two or three readings and find the average specific gravity.

Observations:

S. No.		1	2	3
1	Wt. of pycnometer (W_1 gm)			
2	Wt. of pyc + dry soil (W_2 gm)			
3	Wt. of pyc + soil + water (W_3 gm)			
4	Wt. of pyc + water (W_4 gm)			
5	Sp. Gravity			
6	Av. Sp. gravity			

Result: The average specific gravity =

B. Determination of water content

Theory: The water content of any soil sample can be determined by pycnometer if soil solid specific gravity (G) is known.

Derivation:

$$w=\left\{\left(\frac{W2-W1}{W3-W4}\right)\left(\frac{G-1}{G}\right)-1\right\}\times 100$$

Where: W_1 = wt. of empty pycnometer

W_2 = wt. of pyc + soil

W_3 = wt. of pyc + water + soil

W_4 = wt. of pyc + water

Procedure:

1. Add some known quantity of water in oven dried soil whose widht is known. Mix the soil with water thoroughly.
2. Repeat the steps from 1 to 4 of part (a) of this experiment. Put the values of W and G in formula and find out the value of w.
3. Take some representative of soil. First weigh the empty container then put the sample in it and weigh it. The values are U_1, U_2 respectively.
4. Now put the container in an oven to dry the sample. After 24 hours weigh the container with dry soil in it. Mark it with U_3.
   The water content is $w = \frac{U2-U3}{U3-U1}$
   Compare with the value obtained by pycnometer method.
5. For more than one water content values repeat the steps from 1 to 4 of this experiment and compare the value obtained by different methods for a value of w.

Observations:

For water content

S. No		1	2	3
1	Wt. of pyc (W_1 gm)			
2	Wt. of pyc + wet soil (W_2 gm)			
3	Wt. of pyc + wet soil water (W_3 gm)			
4	Wt. of pyc + water (W_4 gm)			

Container No

S. No		1	2	3
1	Wt. of container (U_1 gm)			
2	Wt. of container + wet soil sample (U_2 gm)			
3	Wt. of container + dry soil sample (U_3 gm)			

Result:

Water content =

EXPERIMENT NO- 3
Hydrometer Analysis

Object: Determination of complete grain size distribution of a given soil sample by sedimentation analysis

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

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

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

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

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

(6) Set the cylinder down and record the time. Remove the stopper from the cylinder. After an elapsed time of one minute and forty seconds, very slowly and carefully insert the hydrometer for the first reading.

(**Note:** It should take about ten seconds to insert or remove the hydrometer to minimize any disturbance, and the release of the hydrometer should be made as close to the reading depth as possible to avoid excessive bobbing).

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

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

Data Analysis:

Hydrometer Analysis:

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

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

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

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

D = K x Sq. root Of (L/T)
Where t is in minutes, and D is given in mm.

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

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

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

(8) Calculate percent finer as follows:
P = (Rc ×a ×100)/ WS

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

(9) Adjusted percent fines as follows: = P xF200/100.
F200 = % finer of #200 sieve as a percent

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

EXPERIMENT NO- 4

Object: To determine the liquid limit and plastic limit of the soil.

Theory: Liquid limit is the water content at which soil passes from zero strength to an Infinitesimal strength, hence the true value of liquid limit cannot be determined. For determination purpose liquid limit is that water content at which a part of soil, cut by a groove of standard dimensions, will flow together for a distance of 1.25cm under an impact of 25 blows in a standard liquid limit apparatus. The soil at the water content liquid limit apparatus. The soil at the water content has some strength which is about 0.17 N/cm2 (17.6 gm/cm2). At this water content soil just passes from liquid state to plastic state. The moisture content at which soil has the smallest plasticity is called as the plastic limit. Just after the plastic limit the soil displays the properties of a semi- solid. Change in state at these limits.

Apparatus

Special

1. Cassagrande's liquid limit device
2. A.S.T.M. and B.S. grooving tool (Cassagrande's type)
3. Glass plate 20X15cm
4. 425 micron I.S. sieve
5. 3 mm diameter rod

General

Spatula, Basin (300c.c. capacity), Balance (0.01 gm sensitivity), Water content tins or crucibles, Drying oven, Distilled water, Measuring cylinder, Desiccator,

Procedure

(a) Liquid Limit

1. Adjust the cup of the liquid limit apparatus with the help of grooving tool gauge & the adjustment plate to give a drop of exactly 1 cm on the point of contact on base.
2. Take about 120gm of an air dried sample passing 425 μ sieves.
3. Mix it thoroughly with some distilled water to from a uniform paste.
4. Place a portion of the paste in the cup of the liquid limit device, smooth the surface with spatula to a maximum depth of 1cm. Draw the grooving tool through the sample along the symmetrical axis of the cup, holding the tool perpendicular to the cup.
5. Turn the handle at a rate of 2 revolutions per second and count blows until two parts of the soil sample come into contact at the bottom of the soil sample come into contact at the bottom of the groove along a distance of 10mm.
6. Transfer about 15gm of the soil forming the edges of the groove that flowed together to a water content tin and determine the water content by oven drying.
7. Transfer the remaining soil in the cup to the main soil sample in the basin and mix thoroughly after adding a small amount of water

8. Repeat steps 4, 5 and 6. Obtain at least four sets of readings in the range of 10 to 40 blows.

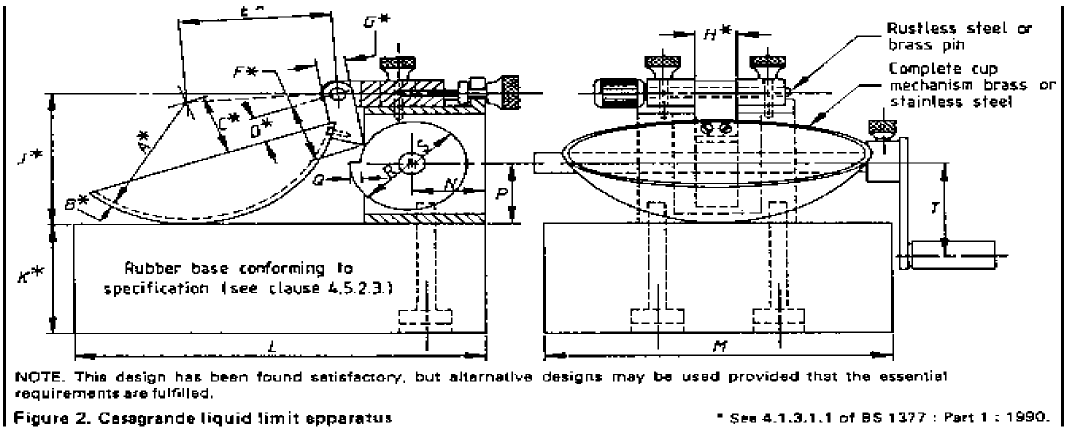


Figure 2. Casagrande liquid limit apparatus

Observation and Calculations
(a) Liquid Limit (L.L. or WL.L)

1. Use table 1 for recording the number of blows and calculating the moisture contents.
2. Use semi log graph paper, take number of blows on semi log scale (x-axis) and water contents on ordinary scale (y-axis). Plot all the points and draw a straight line (flow curve) passing through these points.
3. Read the water content at 25 blows which is the value of liquid limit

Sr. No.	Determination No.	1	2	3
1	No. of blows			
2	Container No.			
3	Mass of container + wet soil (gm)			
4	Mass of container + dry soil ,(gm)			
5	Mass of water (3)-(4) (gm)			
6	Mass of container, (gm)			
7	Mass of dry soil (4)-(6)			
8	Moisture content (5)/ (7) x 100, (%)			

Liquid limit:

(b) Plastic Limit

1. Take about 30gm of air dried sample passing 425 micron sieve.
2. Mix thoroughly with distilled water on the glass plate until it is plastic enough to be shaped into a small ball.
3. Take about 10gm of the plastic soil mass and roll it between the hand and the glass plate to from the soil mass into a thread. If diameter of thread becomes less than 3mm without cracks, it shows that water added in the soil is more than its plastic limit; hence the soil is kneaded further and rolled into thread again.
4. Repeat this rolling and remolding process until the thread starts just crumpling at a diameter of 3mm.

5. If crumpling starts before 3mm diameter thread in step 3, it show the water added in step 2 is less than the plastic limit of the soil, hence some more water should be added and mixed to a uniform mass and rolled again, until the thread starts just crumbling at a diameter of 3mm.
6. Collect the pieces of crumbled soil thread at 3mm diameter in an air tight container and determine moisture content.
7. Repeat this procedure twice more with fresh samples of 10gm each.

Precaution

1. Use distilled water in order to minimize the possibility of iron exchange between the soil and any impurities in the water.
2. Soil used for liquid and plastic limit determinations should not be oven dried prior to testing.
3. In liquid limit test, the groove should be closed by a flow of the soil and not by slippage between soil and the cup.
4. After mixing distilled water to the soil sample, sufficient time should be given to permeate the water throughout the soil mass.
5. Wet soil taken in the container for moisture content determination should not be left open in the air even for some time, the containers with soil samples should either be placed in desiccators or immediately be weighed,
6. For each test, cup and grooving tool, should be clean.

Classification of soil

1. Calculating plasticity index (P.I. or Ip)

Ip **= WL.L - WP.L.**

2. Use plasticity chart for classification of given soil.

Or

Calculate the plasticity the plasticity index of 'A' line

(P.I.) A **= 0.73 (WL.L-- 20)**

Where WL.L is in percentage

If P.I. > (P.I.) A the soil is clay

If P.I. < (P.I.) A the soil is silt

L.L. = 0-35 low Compressibility

35-50 medium Compressibility

> 50 High Compressibility

Toughness Index =Plasticity Index/Flow Index.

Flow index=w1---w2 /Log10 (N1/N2)

w1 = water content in % at N1 Blows

w2 = water content in % at N2 Blows

Observation and Calculations

Sr. No.	**Determination No.**	1	2	3
1	Container No.			
2	Mass of container + wet soil (gm)			
3	Mass of container + dry soil ,(gm)			
4	Mass of water, (2)-(3) (gm			

5	Mass of container (gm)			
6	Mass of dry soil (3)-(5) ,(gm)			
7	Plastic Limit (4)/ (6) x 100,(%)			

Average plastic limit:

RESULT

Liquid limit L.L (%) =
Plastic limit P.L (%) =
Plasticity Index P.I =
Classification =
Flow Index IF =
Toughness Index IT =

EXPERIMENT NO-5

Aim

(a) To determine the shrinkage limit of soil
(b) To calculate shrinkage factors

Theory:

Shrinkage limit is the maximum water content at which a reduction in water content does not cause an appreciable decrease in volume of the soil mass. At shrinkage limit, on further reduction in water, air starts to enter into the voids of the soil and keeps the volume of voids constant. Represent the initial soil sample in saturated stage with initial mass W1 and volume V1;
(c) Represent the oven dry sample with mass Ws and volume V2. According to definition, the water content at (b) will be the shrinkage limit.
Mass of water in (a) = W1 - Ws
Loss in water from (a) to (b) = (V1 – V2) γw
Mass of water in (b),
Ws = (W1 - Ws) - (V1 – V2) γw
Water content in (b)
w= (W1 -Ws) --- (V1 – V2) γw/Ws
Shrinkage limit, W.S.L (%) = [w1 - (W1 - Ws) --- (V1 – V2) γw/Ws] x100

Apparatus

Special

1.Three circular shrinkage dish (porcelain/stainless steel/brass with flat bottom about.
4. 5 cm in dia and 1.5 cm high)
2. Three porcelain evaporated dish (two about 12cm large) and one 6cm (small in diameter)
3. One glass plate with three prongs
4. Plain glass plate (7.5 cm X 7 .5 cm).
5. One glass or stainless steel cup (about 5.0 cm in dia and 2.5 cm high with level and smooth ground top rim).
6. Mercury
7. 425micronsieve.

General

8. Spatula
9. Straight edge
10. Oven
11. Desiccators
12. Balance (sensitivity 0.01 gm)

Procedure

1. Mix about 30gm of soil passing 425 micron sieve with distilled water. The water added should be sufficient to make the soil past enough to be readily worked into the shrinkage dish without inclusion of air bubbles.

2. Cost the inside of two shrinkage dish with a thin layer of Vaseline. Place the soil sample in the dish, by giving gentle taps. Strike off the top surface with a straight edge

3. Weight the shrinkage dish immediately full of wet soil. Dry the dish fist in air and then in an oven.
4. Weight the shrinkage dish with dry soil pat.
5. Clean dry the shrinkage dish and determine its empty mass.
6. Also weigh an empty porcelain dish (small size) which will be used for weighing dish.
7. Keep the shrinkage dish in a large porcelain dish, fill it to overflowing with mercury and remove the excess by pressing the plate firmly over the top of the dish. Transfer the contents of the shrinkage dish to the mercury weighing dish and weight.
8. Place the glass cup in a large dish. Fill it to over flowing with mercury; remove the excess by pressing the glass plate with three prongs firmly over the top of the cup.
9. Wipe the outside of the glass cup to remove any adhering mercury, and then place it in another large dish. Place the dry soils pat on the surface of the mercury and submerge it under the mercury by pressing with glass plate with prongs.
10. Transfer the mercury displaced by the dry soil pat to the mercury weighing dish and weigh.
11. Repeat the test at least three times for each soil sample.

Precautions

1. The water content of the soil taken in shrinkage dish should be above liquid limit but within 10% from liquid limit.
2. To prevent the cake from adhering to the shrinkage dish and consequent cracking of the dry soil pat, the inside of the shrinkage dish should be greased with Vaseline.
3. During filling the shrinkage dish with soil paste, sufficient tapping should be done to remove the entrapped air.
4. The dry soil pat should be weighed soon after it has been removed from the air.
5. Test should be repeated at least three times for each soil sample and the average of the results thus obtained reported. If any individual value varies from the average by ± 2%, it should be discarded and test repeated.
6. No air should be entrapped under the dry soil pat when pressing by the glass with prongs is being carried out.

Observation and Calculation

(a) Shrinkage Limit

1. Enter all the observations in the table.

2. Calculate the shrinkage limit using the equation W S.L

Where,

W S.L. = shrinkage limit in % soil pat.
W1 = initial water content of wet soil pat.
V1 = volume of wet soil pat in cc.
V2 = volume of dry soil in cc.
Ws = mass of oven-dry soil pat in gm.
gw = mass density of water in g/cc.

Sr.No.	Determination No.	1	2	3
1	Shrinkage dish no. (gm)			
2	Mass of dish+ wet soil pat (gm)			
3	Mass of dish+ dry soil pat (gm)			
4	Mass of water,(2)-(3) (gm)			
5	Mass of shrinkage dish empty (gm)			
6	Mass of shrinkage dish empty (gm)			
7	Initial water content (%)			
8	Mass of weighing dish +mercury (filling shrinkage dish)			
9	Mass of weighing dish empty (gm)			
10	Mass of mercury (8)-(9) (gm)			
11	Vol. wet soil pat (cc)			
12	Mass of weighing dish+ displaced mercury (by dry pat)			
13	Mass of mercury displaced (12) – (9)			
14	Volume of dry soil packed			

(b) OTHER SHRINKAGE FACTORS:-

1. Shrinkage ratio
SR = (Ws/V2) X (1/γw)

Where Ws= mass of oven-dry soil pat in gm.

V2 = volume of oven-dry soil in cc

2. Volumetric Shrinkage VS = (W1 – W S.L.)

Where,
W1 = given moisture content in %
WS.L = shrinkage limit in %
S. R. = shrinkage ratio
Where VS = Volumetric shrinkage

Result:
(a) Shrinkage Limit:
(b) Shrinkage ratio:
(c) Volumetric Shrinkage:
(d) Linear Shrinkage:

EXPERIMENT NO-6

Aim:

(i) To determine the optimum moisture content and maximum dry density of a soil by proctor test.

(ii) To plot the cure of zero air void.

Theory:

Compaction is the process of densification of soil mass by reducing air voids. This process should not be confused with consolidation which is also a process be confused with consolidation which is also a process of densification of soil mass but 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, compaction energy and type of soil. For a given compaction mainly depends upon soil. For a given compaction energy every soil attains the maximum dry density at a particular water content. In the dry side, water acts as a lubricant and helps in the closer packing of soil grains. In the wet side, water starts to occupy the space of soil grains and hinders in the closer packing of grains.

Apparatus

Special

1. Cylindrical mould (capacity 1000 cc, internal dia 100 mm. effective height 127.3 mm) Cylindrical mould (capacity 2250cc, internal dia 150 mm. effective height 127.30m.m)
2. Rammer for light compaction (face diameter 50 mm mass of 2.6 kg free drop 310 mm) or Rammer for heavy compaction (face diameter 50 mm mass of 4.89 kg free drop 450 mm) .
3. Mould accessories (detachable base plate removable collar)
4. I.S. serves (20 mm, 4.75mm)

General

1. Balance (capacity 10kg, sensitivity 1gm)
2. Balance (capacity 200kg, sensitivity 0.01gm)
3. Drying oven (temperature 1000 C to 110 C)
4. Desiccators
5. Drying crucibles
6. Graduated jars
7. Straight edge
8. Large mixing pan
9. Spatula
10. Scoop

Procedure

1. Take about 20 kg for 100cc mould or 45 kg for 2250 cc mould of air dried and mixed soil.
2. Sieve this through 20mm and 4.75 mm sieves.
3. Calculate the percentage retained on 20 mm and 4.75mm sieves and passing from 4.75 mm sieve. Do not use the soil retained on 20 mm sieve.
4. Use a mould of 10 cm diameter if percentage retained on 4.75mm sieve is less than 20 or use a mould of 15cm diameter if percentage retained on 4.75 mm sieve more than 20.
5. Mix the soil retained on 4.75 mm sieve and passing from 4.75 mm sieve thoroughly in the proportion obtained in step3

6. Take about 2.5kg of the soil for 1000 cc mould or take about 2.8 kg or the soil for 1000 cc mould or 6.5kg for 2250 cc mould for heavy compaction.
7. Add water to it bring its moisture content to about 4% in coarse grained soils and 8% in fine grained soils
8. Clean, dry and grease lightly the mould and base plate. Weigh the mould with base plate.
9. Fit the collar and place the mould on a solid base.
10. For light compaction, compact wet soil in three equal layers by the rammer of mass 2.6 kg and free fall 31 cm with 25 evenly distributed blows in each layer for 10 cm diameter mould and 56 blows for 15cm diameter mould. Alternatively for heavy compaction compact the soils using the rammer of mass 4.89 kg and free fall 45 cm in five layers. Each layer being given 25 blows for 10 cm diameter mould and 56 blows for 15 cm diameter mould.
11. 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.
12. Clean the outside of the mould and base plate, weigh the mould with soil and base plate.
13. Remove the soil from the mould and obtain a representative soil sample from the bottom middle and top for water content determination.
14. Weigh the drying crucible with samples and put samples and put in the drying oven at temperature 1050c to 1100 c or 24 hours.
15. Repeat the above procedure with 7,10,13,16,19,22% of water contents on coarse grained fresh soil samples and 11,14,17,20,23 and 26% of water contents of fine grained fresh soil samples approximately.
16. Next day first weigh the crucibles with dry soil samples and then the empty crucibles.

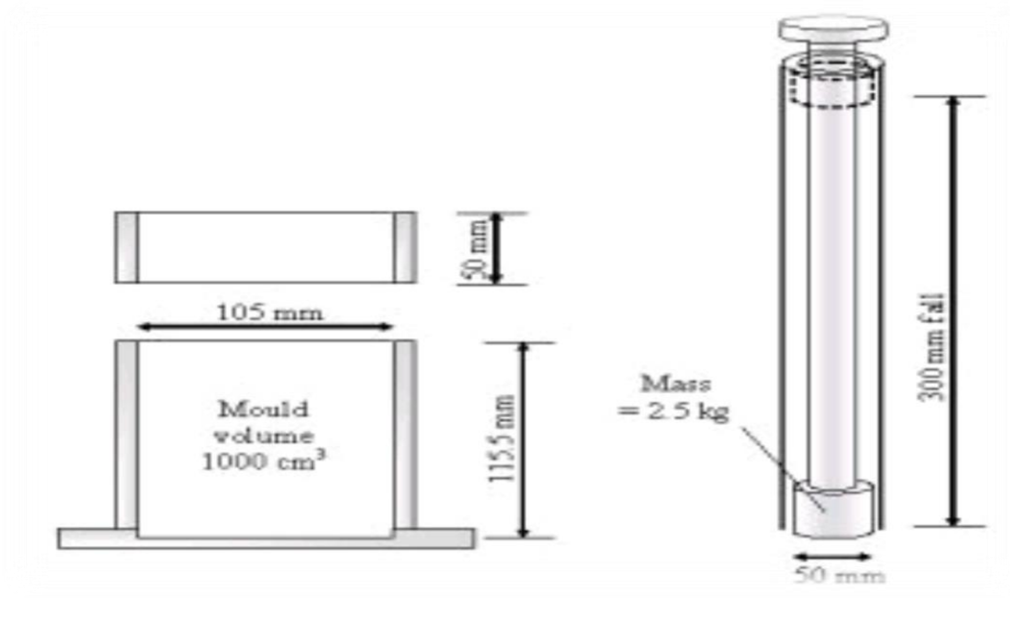


Fig - Compaction mould

Precautions

1. Adequate period is allowed for mixing the water with soil before compaction
2. The blows should be uniformly distributed over the surface of each layer.
3. Each layer of compacted soil is scored with a spatula before placing the soil for the succeeding layer.
4. The amount of soil used be just sufficient to fill the mould i.e. at the last layer the Surface of the soil should be slightly (5mm) above the top rim of the mould.
5. Mould should be placed on a solid foundation during compaction.

Observations and Calculation

1. Enter all observations in table 1 and calculate the wet density.
2. Calculate the dry density by using the equation

$$\rho_d = (\rho_b/1+w)$$

Where ρ_d = dry density (g/cc) ρ_b = wet density (g/cc); w = water content

3. Plot the water content on X-axis and dry density on Y-axis draw the smooth curve, called the compaction curve.
4. Calculate the dry density at 100% saturation.
5. Plot the 100% saturation or Zero Air Voids curve on the same graph.
6. Read the point of maximum density from compaction curve.
7. Calculate the degree of saturation at optimum moisture content using above equation

Soil Sample No

Soil retained on 20mm sieve (%) =
Soil retained on 4.75mm sieve (%) =
Soil passing from 4.75mm sieve (%) =

Specific Gravity of soil =
Diameter of mould, d (cm) =
Height of mould, h (cm) =
Volume of mould, V (cm3) =
Mass of mould, W (gm)

Type of test =
Wt.of rammer =
No. of layers =
No. of blows/layer =

Dry Density at 100% Saturation (gm/cc)

RESULT:

1. Optimum Moisture Content =----------- %
2. Maximum Dry Density = ------------- gm/cc
3. Degree of Saturation at OMC=-------- %

TABLE -1

Sr. No.	Determination No.	1	2	3	4	5
1	Mass of mould + compacted soil (gm)					
2	Mass of compacted soil Wt (gm)					
3	Wet Density, gt = Wt /V (gm/cc)					
4	Crucible No.					
5	Mass of Crusible + Wet soil (gm)					
6	Mass of Crucible + dry soil (gm)					
7	Mass of water (5-6)					
8	Mass of Crucible (gm)					
9	Mass of dry soil (gm) (6-8)					
10	Water Content, w = [7/9] x 100 (%)					
11	Dry Density, gd = gt / (1+w) (gm/cc)					

EXPERIMENT NO-7

Aim: To determine the relative density of cohesion less soil.

Theory: Relative density and percent compaction are commonly used for evaluating the state of compactness of a given soil mass. The engineering properties,such as shear strength, compressibility, and permeability, of a givensoil depends on the level of compaction.

Test Procedure:

(1) Fill the mold with the soil (approximately 0.5 inch to 1 inch above the top of the mold) as loosely as possible by pouring the soil using a scoop or pouring device (funnel). Spiraling motion should be just sufficient to minimize particle segregation.

(2) Trim off the excess soil level with the top by carefully trimming the soil surface with a straightedge.

(3) Determine and record the mass of the mold and soil. Then empty the mold (M1). See Photograph on Page 35.

(4) Again fill the mold with soil (do not use the same soil used in step 1) and level the surface of the soil by using a scoop or pouring device (funnel) in order to minimize the soil segregation. The sides of the mold may be struck a few times using a metal bar or rubber hammer to settle the soil so that the surcharge base-plate can be easily placed into position and there is no surge of air from the mold when vibration is initiated.

(5) Place the surcharge base plate on the surface of the soil and twist it slightly several times so that it is placed firmly and uniformly in contact with the surface of the soil. Remove the surcharge base-plate handle.

(6) Attach the mold to the vibrating table.

(7) Determine the initial dial reading by inserting the dial indicator gauge holder in each of the guide brackets with the dial gage stem in contact with the rim of the mold (at its center) on the both sides of the guide brackets. Obtain six sets of dial indicator readings, three on each side of each guide bracket. The average of these twelve readings is the initial dial gage reading, Ri. Record Ri to the nearest 0.001 in. (0.025 mm). See Photograph on Page 35.

(8) Firmly attach the guide sleeve to the mold and lower the appropriate surcharge weight onto the surcharge base plate.

(9) Vibrate the mold assembly and soil specimen for 8 min.

(10) Determine and record the dial indicator gage readings as in step (7). The average of these readings is the final dial gage reading.

(11) Remove the surcharge base-plate from the mold and detach the mold from the vibrating table.

(12) Determine and record the mass of the mold and soil (M2)

(13) Empty the mold and determine the weight of the mold.

(14) Determine and record the dimensions of the mold (i.e., diameter and height) in order to calculate the calibrated volume of the mold, Vc. Also, determine the thickness of the surcharge base-plate, Tp

Analysis:

(1) Calculate the minimum index density (ρ_d min) as follows: $\frac{Ms_1}{V_C}$

Where, Ms1= mass of tested-dry soil = Mass of mold with soil placed loose – mass of mold

Vc= Calibrated volume of the mold

(2) Calculate the maximum index density (ρ_d max) as follows: $= \frac{Ms_2}{V_C}$

Ms2 = mass of tested-dry soil = Mass of mold with soil after vibration – Mass of mold

V = Volume of tested-dry soil = Vc – (Ac*H)
Where, Ac = the calibrated cross sectional area of the mold
$H = [R_f - Ri] + Tp$

Observation and Calculation
Sample Description:

Mass of empty mold: ___ ________________
Diameter of empty mold: ___ ________________
Height of empty mold: ___ ________________
Mass of mold and soil (M1): ___ ________________
Average initial dial gauge reading (Ri): ___ ________________
Average final dial gauge reading (Rf): ___ ________________
Thickness of surcharge base plate (TP): ___ ________________
Mass of mold and soil (M2): ___ ________________

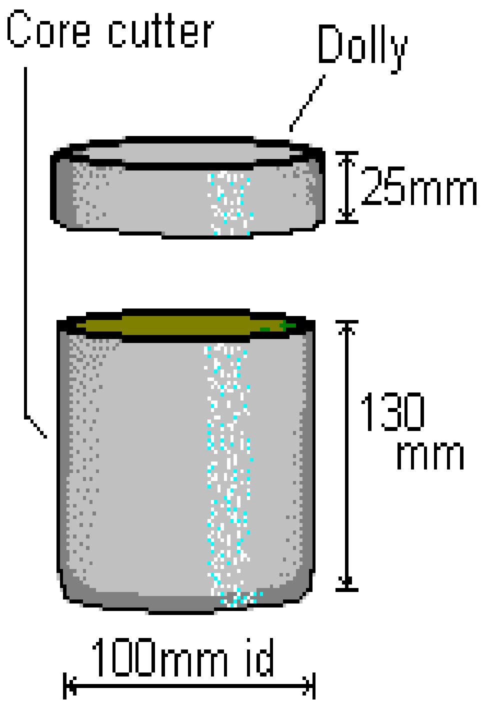
Result:

EXPERIMENT NO-8

Aim: To determine the mass density of soils by
(a) Core cutter method
(b) Sand replacement method

Theory
Density is defined as the mass per unit volume of soil γ= W/V

Where γ= mass density of soil
w = total mass of soil
v = total volume of soil
Here mass and volume of soil comprise the whole soil mass. In the above figure, voids may be filled with both water and air or only air or only water, consequently the soil may be wet or dry or saturated. In soil the mass of air is consider negligible and therefore the saturated density is maximum , dry density is minimum and wet density is in between the two if soils are found below water table submerged density is also estimated. The density can be expressed in g/cm3, or t/m3 or kg/m3 or 1b/t3. For calculating the submerged density the density of water is taken as 1 g/c3 = 1 t/m3 Dry density of the soil is calculated by using some equation.



(A) Core cutter method :-
Apparatus
Special
1. Cylindrical core cutter (height = 12.74 cm, dia 10 cm)
2. Steel rammer
3. Steel dolly (2.5 cm high and 10 cm internal diameter)
General
1. Balance (accuracy 1gm2. Balance (accuracy 0.01g m)
3. Steel rule
4. Spade of pickaxe
5. Straight edge
6. Knife
7. Water content crucibles
8. Desiccator
9. Oven
10. Tongs

Precautions
1. Steel dolly should be placed on the top of the cutter before ramming it down.
2. Core cutter should not be used in gravels and boulders.
3. Before lifting the cutter, soil should be removed round the cutter, to minimize the disturbances.
4. While lifting the cutter, no soil should drop down,

5. During pressing and lifting the cutter care should be taken that some soil is projected at both the ends of the cutter.
6. Values should be reported to second place of decimal

Observations and calculation

1. Ether all observation in table 1.
2. Calculate wet density of soil γ_t

Internal Diameter of Cutter (cm) =
Height of Cutter (cm) =
Cross-sectional Area of cutter (cm2) =
Volume of Cutter (cm3) =
Specific Gravity of soil =

Core Cutter Method

Sr.No.	Determination No.	1	2	3
1	Mass of Core Cutter W1(gm)			
2	Mass of Core + Soil, W2(gm)			
3	Mass of wet soil (W2-W1)			
4	Mass of Crucible(gm)			
5	Mass of Crucible + wet soil (gm)			
6	Mass of Crucible + dry soil (gm)			
7	Mass of Water = (6-7)			
8	Mass of Dry soil = (7-5)			
9	Moisture Content, W= (8/9) x 100			
10	Wet Density (ρ_b) = (W2-W1) / V (gm/cc)			
11	Dry Density (ρ_d)= ρ_b/ (1+w) (gm/cc)			
12	Void Ratio, e = (Gs ρ_w)/ ρ_b			
13	Degree of Saturation , S = (w.Gs /e) *100(%)			

Observations and Calculation

1. Enter all the readings in table 2, 3 and 4
2. Bulk density of sand is calculated as shown in table (2.) This density is used in determining the volume of the hole made in the soil.
3. Table 4 show the calculations of wet density, dry density, void ratio and degree of saturation of the soil.
4. Above Equations are used to calculate the dry density, void and degree of saturation

Determination:

01. Container No.
02. Mass of container with lid. W1 (gm)
03. Mass of container with lid + wet soil, W2 (gm)
04. Mass of container with lid + dry soil, W2 (gm)
05. Mass of water, Ww = W2 - W3 (gm)
06. Mass of dry soil, Ws = W3 - W1 (gm)

07. Moisture content, W = [W2 - W3 / W3-W1] x 100, (%)

Calibration of Apparatus Date

1. Volume of Calibrating Container, V (gm)
2 .Mass of Pouring Cylinder+ Sand, W'1(gm) (Before Pouring in the Calibration Cylinder)
3 Mass of Pouring Cylinder +Sand W'2 (gm) (After Pouring In the Calibration Cylinder)
4 Mass of Pouring Cylinder +Sand W'3 (gm) (After Making the sand cone on flat surface)
5 Mass of sand for filling the calibrating cylinder and cone (gm) W'4 = (W'1-W'2)
6 Mass of sand for making the cone only (gm) W'5 = (W'2-W'3)
7 Mass of sand in the calibrating cylinder only (gm) W'6 = (W'4-W'5)
8 Bulk Density of Sand, g_d = W'6 /V (gm/cc)

Sand Replacement Method

1. Mass of Pouring Cylinder+ Sand, W'1(gm) (Before Pouring In the Calibration Cylinder)
2 Mass of Pouring Cylinder +Sand W'2 (gm) (After Pouring In the Calibration Cylinder)
3 Mass of Pouring Cylinder +Sand W'3 (gm) (After Making the sand cone on flat surface)
4 Mass of sand used in the hole and cone (gm) W4 = (W1-W2)
5 Mass of sand in the Cone only (gm) W5 = (W2-W3)
6 Mass of sand in the hole only (gm) W6 = (W4-W5)
7 Volume of Sand, V= W6/ ρ_d
8 Mass of Tray + Excavated Soil, W7 (gm)
9 Mass of Tray Only, W8 (gm)
10 Mass of Excavated Soil, (W= W7-W8) (gm)

Result
1 Wet Density (ρ_b) = (10/7) (gm/cc)
2 Dry Density (ρ_d) = ρ_b / (1+w) (gm/cc)
3 Void Ratio, e = [(Gs ρ_w)/ρ_d]-1
4 Degree of Saturation, S = (w.Gs/e) x 100 (%)

Result:
In-situ density of soil by
1. Core cutter = ------------ gm/cc

EXPERIMENT NO-9

Aim: To determine coefficient of permeability of given soil sample at desired density by a suitable method.

Theory

The property of the soils which permits water (fluids) to percolate through its continuously connected voids is called its permeability. Depending upon the value of Reynolds number the flow of water through soils may be 'laminar' or 'turbulent'. In laminar flow, a particle of water starting from a given position follows a definite path without crisscrossing the path of other particles. In turbulent flow the particles do not follow any definite path but have random, twisting and crisscrossing path. For laminar and steady flow, according to Darcy's law the rate of flow of water is proportional to the hydraulic gradient in uniform and homogeneous soils.

Apparatus

Special

1. Parameter mould (internal dia = 100 mm. effective height = 127.3 mm. Capacity 100cc)
2. Accessories of the permeameter (cover, base, detachable collar, porous stones, dummy plate) (common)
3. Round filter paper 100 mm. dia (common)
4. A static or dynamic compaction device (if remolded samples are used)
5. Constant head reservoir (common)
6. Graduated glass stand pipe (internal dia 5to 20 mm, preferably 10mm) (Variable head)
7. Support frame and clamps (variable head)
8. Funnel (variable head)
9. Measuring flask (Constant head)

General (Common to both the methods)

1. Metre Scale
2. Balance
3. Stop watch
4. Thermometer
5. Deaired water
6. Drying oven
7. IS: Sieve 4.75 mm (if remolded samples are used) Geotechnical Engineering- I
8. Grease
9. Straight edge
10. Drying crucibles
11. Dedicator

Procedure

A. Variable Head Method

1. Remove the cover of the mould and apply a little grease on the sides of the mould.
2. Weigh the mould with dummy plate.
3. Measure the internal diameter and effective height of the mould, then attach the collar and the base plate.

4. (i) Compact the soil at given dry density and moisture content by a suitable static or dynamic device for remolded samples.
(ii) For undisturbed samples, trim off the undisturbed specimen in the form of a cylinder about 85 mm in diameter and height equal to that of mould. Place the specimen centrally over the bottom porous dise & filter paper. Fill the annular space between the mould and the specimen with an impervious material such as cement slurry or bentonite slurry to provide sealing against leakage from the sides.
5. Remove the collar & base plate, trim off the excess soil and level with the top of the mould.
6. Clean the outside of the mould and dummy plate.
7. Weigh the mould with soil and dummy plate. Difference of this mass and the mass taken in step 2 will give the mass of soil used.
8. Apply grease around the porous stone and base plate, put the porous stone inside the base plate and filter paper on porous stone.
9. Remove the dummy plate and place the mould with washer on the base plate.
10. Put the small quantity of the soil sample in drying oven to determine the moisture content.
11. Clean the edges of the mould and the collar and apply grease in the grooves around them.
12. Place a filter paper, porous stone and washer on the top of the soil sample and fix up the collar again.
13.Connect the reservoir with water to the outlet at the bottom of the mould and allow the water to flow in. wait till the water has been able to travel up and saturate the sample .Allow about one cm depth of free water to collect on the top of the sample.
14. Fill the remaining portion of the cylinder with deaired water without disturbing the surface of the soil.
15. Fix the cover plate over the collar and tighten the nuts in the rods.
16. Disconnect the reservoir from the outlet at the bottom and connect the stand pipe to the inlet at the top plate. Fill the stand pipe with water.
17. Open the stop cock at the top and allow water to flow out so that all the air in the cylinder is removed.
18. Fix the height h1 and h2 won the pipe from the centre of the outlet such that (h1-h2) is about 30 to 40 cm. Mark the level of $\sqrt{}$ h1 h2 from the centre of the outlet.
19. When all the air has escaped, close the stop cock and allow the water from the pipe to flow through the soil and establish a speedy flow.
20. Record the time intervals for the head to fall from $\sqrt{}$ h1 h2$\sqrt{}$ h1 h2 to h2. The time intervals should be same, otherwise steady flow in established.
21. Change the height h1 and h2 and record the time intervals.
22. Stop the flow of water, disconnect all parts.
23. Take a small quantity of the soil sample from the mould in the drying crucible and put inside the drying oven for moisture content determination.
24. Measure the temperature of the water.

B. Constant Head method

1. Take steps 1 to 16.
2. Disconnect the reservoirs from the outlet as the bottom and connect to the inlet at the top plate.
3. Open stop cock at the cover and allow water to flow out so that all the air in the cylinder is removed.
4. When all the air has escaped close the stop cock and open the outlet. Allow the water to flow through the soil and established a steady flow.
5. When steady flow is reached collect the water in a measuring flask for a convenient time interval. Repeat this thrice quantity of water collected must be same, otherwise observations are repeated.

6. Repeat step (5) for at least two more different time intervals.
7. Repeat steps (22), (23) and (24)

Precautions

1. All the possibilities of leakage at the joints must be eliminated .All the joints and washer must be thoroughly cleaned so that there are no soil particles between them.
2. Apply the grease liberally between mould, base plate and collar.
3. Rubber washer must be moisture with water before placing.
4. Porous stones must be sutured just before placing
5. Desired and distilled water must be used to avoid the chocking of flow water.
6. Soil samples must be fully saturated before taking the observations.
7. In order to ensure laminar flow condition, cohesion less soil must be tested under low hydraulic gradient.
8. Steady floe must be established before taking the observations.
9. In constant head method, quantity of water collected must be sufficient and measured very accurately to eliminate large errors.

Observations and Calculations

(a)Enter all observations of variable head method in table 2 and of constant head method in table 3.
(b)Calculate the coefficient of permeability of the soil using the following equations. kT = 2.303 [aL/At] log10 (h1/h2)

For **Variable Head Method**

Where, KT = Coefficient of Permeability at Test temperature T0C (cm/sec)
a= Cross-Sectional area of stand pipe (cm2)
L= Effective length of sample (cm)
A= Cross-Sectional area of Sample (cm2)
t= Time Interval to fall the head from h1 to h2 (sec)
h1= Initial height of water in the pipe above the outlet (cm)
h2= Final height of water in the pipe above the outlet (cm)

For **Constant Head Method**

KT = Q.L/At. h
Where, KT = Coefficient of Permeability at Test temperature T0C (cm/sec)
Q = Quantity of Water collected in time t (ml)
L = length of soil sample (cm)
A= Cross-Sectional area of Soil Sample (cm2)
h = Constant hydraulic head (cm)

Soil Sample No

1. Length of sample, L (cm) =
2. Diameter of sample, d (cm) =
3. Area of sample, A (cm2) =
4. Mass of Mould + dummy plate, W1 (gm) =
5. Mass of Mould + soil + dummy plate, W2 (gm) =
6. Mass of soil, W= (W1-W2) (gm) =
7. Volume of Soil sample (cm3) =
8. Density of soil sample [ρ_b= W/V] (gm/cc) =

9. Moisture Content at the start, w1 =
10. Dry Density of soil sample [$\rho_d = (\rho_b/1+w1)$] (gm/cc) =
11. Void ratio, e= [Gs/ρ_d]-1=

TABLE 1

Sr. NO	Determination No.	At the Start (before saturation)			At the end (after saturation)		
1	Container No.						
2	Mass of Container + Wet soil (gm)						
3	Mass of Container + dry soil (gm)						
4	Mass of Container (gm)						
5	Mass of soil (3-4) (gm)						
6	Mass of water (2-3) (gm)						
7	Water Content, w = [6/5]x 100						
8	Degree of Saturation = (w x Gs) / e						

Soil Sample No

Variable Head Method Date
1. Diameter of stand pipe (cm) =
2. Cross sectional area of pipe (cm2) =
3. Temperature of water, T0 c =
4. Correction factor due to temperature, Ct = □T/□27 =
5. Constant Factor = 2.303 [aL/A] =

TABLE 2

Sr. No.	Determination No.	1	2	3
1	Initial Head, h1 (cm)			
2	Final Head, h2 (cm) 3 Head Ö (h1-h2) (cm) 4 Time Interval (sec) A From h1 to Ö (h1-h2) B From Ö (h1-h2) to h2 C From h1 to h2, t = A+B 5 Log10 h1/h2 6 Coefficient of permeability k (cm/sec) K at test temperature T0c = (2.303 [aL/A] x 5) / 4C			
3	Head sq. root of (h1-h2) (cm)			
4	Time Interval (sec)			
5	From h1 to sq. root of (h1-h2)			

6	From sq. root (h1-h2) to h2			
7	From h1 to h2, t = A+B			
8	Coefficient of permeability k (cm/sec) ,K at test temperature T0c = (2.303 [aL/A] x 5) / 4C			
9	Coefficient of permeability k (cm/sec) K at test temperature 270c = 6 x hT/h27			

Result

1. Average value of coefficient of permeability at test temperature, KT =
2. Average value of coefficient of permeability at standard temperature 270 c , K27 =
3. Void ratio of soil sample, e =
4. Type of soil =

TABLE 3

Soil Sample No Constant Head Method Date

Sr. NO	Determination No.	1	2	3
1	Hydraulic Head, h (cm)			
2	Time Interval (sec)			
3	Quantity of flow, Q (ml)			
a	I test for time , t (ml)			
b	B II test for same time , t (ml)			
c	C III test for same time , t (ml)			
4	5 Average Quantity of Flow(A+B+C)/3 (ml)			
5	6 Coefficient of permeability at test temperature kT (cm/sec)			
6	7 Coefficient of permeability k27 at 270c temperature (cm/sec)			

Result

1. Average value of coefficient of permeability at test temperature, KT =
2. Average value of coefficient of permeability at standard temperature 27^{o} C, K27 =
3. Void ratio of soil sample, e =
4. Type of soil =

EXPERIMENT NO-10

DIRECT SHEAR TEST

Aim: To determine shear strength parameters of the given soil sample at known density and moisture content by direct shear test.

Theory

Shear strength of a soil has its maximum resistance to shearing stress at failure on the failure plane. Shear strength is composed of

(i) Internal friction which is the resistance due to friction between individual particles at their contact points and interlocking of particles.

(ii) Cohesion which is resistance due to inter particles forces which tend to hold the particles together in a soil mass. Coulomb has represented the shear strength of soil by the equation:

$\boldsymbol{\tau = c + \sigma \tan\varphi}$

Where t = shear strength of soil = shear stress at failure

C = Cohesion

sn = Total normal stress on the failure plane

f = Angle of internal (shearing) friction

The parameters c and f are not constant for type of soil but depend on it degree of saturation and the condition of laboratory testing. There are three types of laboratory test.

(a) Undrained Test –water is not allowed to drain out during the entire test, hence there is nodissipation of pressure.

(b) Consolidate under the initially applied normal stress only, hence drainage is permitted. But no drainage is allowed during shear.

(c) Drained Test— Drainage is slowed throughout the test during the application of normal and shear stresses, No pore pressure is set-up at any stage of the test. Coulomb’s shear strength equation has been modified on the concept of pore pressure development. Modified equation is

$\boldsymbol{\tau' = c' + \sigma \tan\varphi}$

Where c’ = effective cohesion

s’ = effective normal stress

u = pore pressure

s = total normal stress

f = effective angle of shearing resistance

Apparatus

Special

1. Shear box (Non- corrosive meal, size 60 mm X 60mm X 50mm)
2. Container for shear box.
3. Grid plates (two plain and two perforated, depth of serrations 1.5mm)
4. Base plate (non-corrosive metal with cross-grooves on its top face)
5. Porous stone (two, 6 mm thick).
6. Loading pad.
7. Loading frame.
8. Loading yoke.

9. Proving ring with dial gauge (capacity 1.5-2.0M accuracy of dial gauge 0.002mm).
10. Other accessories (two fixing screws, two spacing screws)
11. Static/ dynamic compaction device (for remolded samples)

General:
1. Sample trimmer
2. Stop clock
3. Balance (capacity 1kg sensitivity 0.1 gm capacity 160 gm sensitivity 0.01)
4. Spatula and straight edge.
5. Drying crucibles.
6. Drying oven
7. Scale.
8. Desired water (for saturated samples).
9. Dial gauges (two, sensitivity 0.01 mm)
10. Weights
11. Oven

Procedure
1. Prepare a soil specimen of size 6 cm X 6cm X 2 cm either from undisturbed soil sample or from compacted and remoulded sample
2. Fix the upper part of the box to the lower part by the fixing screws. Attach the base plate to the lower part.
3. Place a porous stone in the box.
4. For undrained test, place the grid on the stone, keeping the serrations of the grid at right angle to the direction of shear. For consolidated undrained and drained tests use the perforated grid in place of plain grid.
6. Weigh the box with base plate, porous stone and grid
7. Transfer the soil specimen prepared in step in the box.
8. Weigh the box with soil specimen
9. Place the upper grid, porous stone and loading pad in the order on soil specimen.
10. Place the box inside the container and mount it on loading frame.
11. Bring the upper half of the box in contact with proving ring assembly. Contact is observed with proving ring assembly. Contact is observed by a slight movement of proving ring dial gauge.
12. Fill the container with if soil is to be saturated.
13. Mount the loading yoke on the ball placed on the loading pad.
14. Mount one dial gauge on the yoke to record the vertical movement and other dial gauge on the container to record the shear movement.
15. Put the weights on the loading yoke to apply the normal stress of intensity 2.5N/cm2 .Add the weight of yoke also in estimating the normal stress intensity.
16. For consolidated undrained fully under this normal load. This step is avoided for undrained test.
17. Remove the fixing screws from the box and raise slightly the upper half box with the help of spacing screws. Remove the spacing screws also.
18. Adjust all the three dial gauges to read zero.
19. Shear load is applied at a constant rate of strain
20. Record readings of proving ring dial gauge and vertical and shear movement dial gauges at every half minute.
21. Continue the test until the specimen fails
22. Repeat the test on identical specimen under increasing normal stress 0.5,1,2 and 4 kg/cm2

23. Determine the moisture contents of the specimen before and after the test.

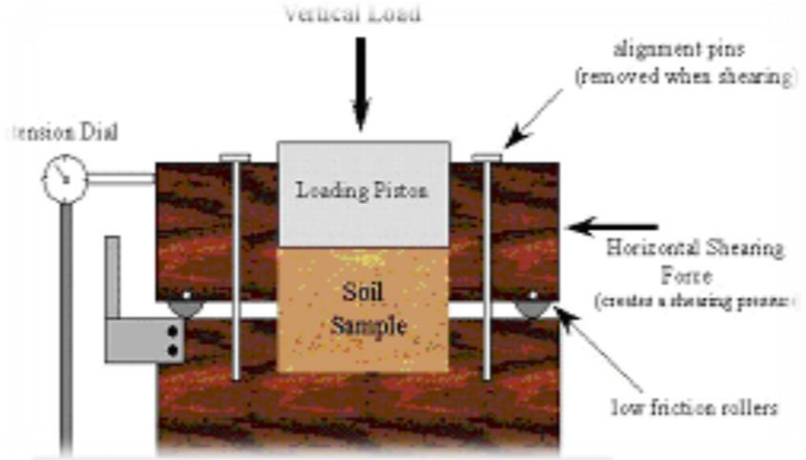


Fig. Shear Box Test

Precautions

1 Before starting the test upper half of the box should be brought in contact of the proving ring assembly

2. Before subjecting the specimen to shear, the fixing screws should be taken out.

3. Spacing screws should also be removed before shearing the specimen.

4. The vertical stress on the sample should remain uniform, vertical and constant during the test.

5. The rate of strain should be constant throughout the test.

6. The shearing strain and stress should be applied in the same plane as the dividing plans of the two part of the box.

7. No vibrations should be transmitted to the specimen during the test.

8. For drained test, the porous stones should be deaired and saturated boiling.

9. Do not forget to add the self weight of the loading yoke in the vertical loads

10. Do not mix with each other the least counts and readings of the three dial gauges.

Observation and Calculation

1. Calculate the normal stress by dividing the total normal load with the area of the shear box. Normal stress,

2. Calculate the normal displacement by multiplying the normal dia gauge divisions with the least count of that dial gauge.

3. Calculate the shear displacements by multiplying shear dial gauge division with the least count of the dial gauge

4. Calculate the shear strains by dividing the shear displacement with the length of the specimen.

5. Calculate the shear force by multiplying the proving ring dial gauge division with the proving ring constant.

6. Calculate the shear stress by dividing the shear force with the shear area (equal to area of shear box.)

7. Use sheet 3 [graph paper] to draw the shear stress-strain curves, taken shear strain on X-axis, corresponding to each normal stress.

8. Read the maximum value of shear stress if failure has occurred, otherwise read the shear stress at 20% strain which is defined as failure shear stress.

9. Use sheet 4 [graph paper] to plot the normal stress on X-axis and corresponding shear stress at failure on Y-axis. Join the points by smooth curve. This is defined as the shear strength envelope.
10. Read the slope of the line, which is defined as the angle of shearing resistance and the intercept of the line with Y axis the cohesion of the soil.

Soil Sample No
(i) Size of box,(cm)=
(ii) Thickness of sample, cm =
(iii)Area of box, (cm) =
(iv)Volume of the sample (cm^3) =