Soil Mechanics Laboratory Manual

DEPARTMENT
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Experiment No. 1

Object: To determine the specific gravity of soil by pycnometer.

Apparatus used: A pycnometer (Fitted with a conical brass cap screwed at its top), balance (sensitive to 1 gm), glass rod or some stirrer, oven.

Theoretical background:

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.

$$G = \rho_{s} / \rho_{w}$$

ρ_s = unit wt. of soil solid

ρ_w= unit wt. of water

Where unit weight is defined as weight per unit volume.

The specific gravity is determined by

$$G = (W_1 - W_1) / \left[(W_1 - W_1) - (W_1 - W_1) \right]$$

Procedure :

1. Weight the dry and empty pycnometer, Let this be W_1.
2. Take about 200 gm oven died 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 he 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 :

		1	2	3
1.	Wt. of pycnometer (W_1 gm).			
2.	Wt. of pryc + dry soil (W_2 gm).			
3.	Wt. 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 =

Precaution:

1. Water must be as pure as possible. If available take distilled only, because impurities in water may lead to wrong observation.
2. There should not be any air bobbies in soil (in pycnometer method) and after that up the pycnomter up to the hole of conical cap.

Limitation :

This pycnomter method is used in coarse grain soils only.

Experiment No. 2

Object: To determine the water content of a soil simple by pycnometer

Apparatus Used: A pycnometer (Fitted with a conical brass cap screwed at its top), balance (sensitive to 1 gm), glass rod or some stirrer, oven.

Theoretical background:The water content of any soil sample can be determined by pycnomter of soil , specific gravity (G) is known.

Water content (w) is given by

$$w = \left(\left(\frac{W2 - W1}{W3 - W4} \right) \left(\frac{G - 1}{G} \right) - 1 \right) X100$$

W_1.= wt. of empty pycnometer
W_2= wt. of pyc. +wet soil
W_3= wt. of pyc. + soil+Full of water
W_4 = wt. of pyc. +Full of water

Procedure:

1. Weight the dry and empty pycnometer, Let this be W_1.
2. Take about 200 gm wet soil and put it in pycnometer. The weight of pycnometer and soil is say 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).

Observations: For water content

	Sample no.	1	2	3
1.	Wt. 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)			

The specific gravity of soil(G) =

Result: Water content (w)is given by

$$w = \left(\left(\frac{W2 - W1}{W3 - W4} \right) \left(\frac{G - 1}{G} \right) - 1 \right) X100$$

Precaution:

1.Water must be as pure as possible. If available take distilled only, because impurities in water may lead to wrong observation.

2.There should not be any air bobbles in soil (in pycnometer method) and after that up the pycnomter upto the hole of conical cap.

Limitation :

This pycnomter method is used in coarse grain soils only

Experiment No.3

Object : To determine the Liquid limit by Casagrande's apparatus.

Apparatus used: Cassangrande apparatus consisting of a brass cup and carriage mounted on base Micarta Number 221A; grooving tool 'a' (Cassangrande or B.S tool) and grooving tool 'b' (ASTM tool); porcelain evaporating dish, about 12 cm in diameter; flexible spatula, with blade about 8 cm long and 2 cm wide; balance; air tight containers to determine water content ; thermostatically controlled oven to maintain temperature between 105^0 to 110^0C ; wash bottle containing distilled water; 425 micron sieve desicator.

Theoretical background:

Liquid limit is the minimum water content at which the soil is still in liquid state but has a small shearing strength against flowing. In other words it is the water content at which soil suspension gains an infinitesimal strength from zero strength. In the standard liquid limit apparatus from practical purposes, it is the minimum water content at which part of soil cut by groove of standard dimensions, will flow together for as a distance of 12 mm (1/2 inch) under an impact of 12 blows.

Procedure

1. By means of the gauge on he handle of the grooving tool and the adjustment plate, adjust the height through which the cup is lifted and dropped so that point on the cup which comes in contact with the base falls through exactly 1 cm when the handle is rotated by one revolution. When the adjustment is complete, secure the adjustment plate by tightening its screws.
2. Take about 120 g of the specimen passing through the 425 micron sieve, and mix it thoroughly with distilled water in the evaporating dish or on the marble plate so that uniform paste is formed; leave the soil for sufficient time so that water may permeate throughout the soil mass. In the case of fat clays, this measuring time may be upto 24 hours. For an average soil, thorough mixing for 15 to 30 minutes is sufficient. The amount of water depth of the soil being 1 cm .
3. Take a portion pf the paste with spatula and place it in the center of the cup so that it is almost half filled. Level lat the top of the wet soil symmetrically with the spatula, so that it is parallel to the rubber base with a maximum depth of the soil being 1 cm .
4. With he help of grooving tool 'a' the paste in he cup is divided along the cup diameter (through) the center line of the can follower), by holding the tool normal to the surface of the cup and drawing it firmly across. Thus a V shaped groove 2mm vide at the bottom and 11mm at the top and 8 mm deep will be formed. However, in the case of sandy soil tool 'a'; does not form a neat groove and hence tool 'b' is used.
5. Turn the handle of the apparatus at the rate of 2 revolution per second, unit the two parts of the soil come in contact with the bottom of he groove along a distance of 10 mm. Record the no. of blow required to cause the groove close for approximate length of 10 mm.
6. Collect a representative slice of soil by moving the spatula widthwise from one edge to the other edge of the soil cake at right angles to he groove, including the portion of the groove in which the soil flowed together, and put it in an air tight container. Its water content is then determined.

7. Remove the remaining soil from the cup and mix it with the soil left earlier on the marble plate (or evaporating dish). Change the consistency of the mix by either adding more water or leaving the soil paste to dry as the case may be and repeat steps 3, 4, and 5 and 6. note the number of revolutions to close the groove and keep the soil for water content determination. These operations are repeated for 3 or 4 more additional trials. The soil paste in these operations should be of such consistency that the number of revaluations or drops to close the groove is 25±10.

Observations:

	Determination No.	1	2	3	4
1.	Container No.				
2.	Wt. of container (g)				
3.	No. of blows				
4.	Wt. of container + wet soil (g)				
5.	Wt. of container + dry soil (g)				
6.	Wt. of water (g)				
7.	Wt. of oven dry soil (g)				
	Water content $= \frac{(6)}{(7)}$ (%)				

Calculations:

Plot he flow curve on a semi log graph water content as the ordinate and no. of blows as abscissa. The water content corresponding to 25 blows is taken as the liquid limit of the soil.

Results :

Liquid Limit ^{W}L (from graph) =

Flow index or slope of the curve, I_f (from graph) $= \dfrac{W1 - W2}{\log10 \frac{n1}{n2}}$

W_1 = water content corresponding to blow n1

W_2 = water content corresponding to blows n_2

Precautions :

The test should always proceed from drier to the water condition of the soil.

Experiment No. 4

Object: Determination of Plastic limit

Apparatus/Equipment

All items of part A Except first two items and rod of 3 mm diameter.

Theoretical background :

Plastic limit is the minimum water content at which a soil just deigns to crumble when rolled into a thread of 3 mm in diameter. This water content in is between the plastic and semi-soil states of soil.

Procedure:

1. Take about 29g of air dried soil from a thoroughly mixed portion of the soil passing 425 micron IS sieve. Mix it on he marble plate with sufficient distilled water to make it plastic enough to be shaped into a ball. Leave the plastic soil mass for some time to mature. For some fat clays, the plastic soil mass may be left for 24 hours to allow water to permeate throughout the soil mass.
2. Take about 8 g of plastic soil, make a ball of it and roll it on the marble (or glass) plate with just sufficient pressure to roll the mass into the thread of uniform diameter throughout its length. When he diameter or thread has decreased to mm the specimen is kneaded together and rolled out again. Continue this process untill the thread just crumble at 3mm diameter.
3. Collect the crumbled soil thread in he airtight container and keep it for the water content determination. Thus, there readings are obtained for the determination.
4. Also, determine the natural water content of the soil sample obtained from the field.

Observations and Result:

Determination No.	1	2	3	4
Container No.				
Wt. of container (g)				
Wt. of container + wet soil (g)				
Wt. of container +oven dry soil (g)				
Wt. of water (g)				
Wt. of dry soil (g)				
Water content = $\frac{\text{Wt. of water}}{\text{Wt. of dry soil}}$ (%)				

Plastic limit w_p=

Av water content =

Calculation :

1. Plastic limit=
2. Plasticity index I_p w_L-w_p
3. Flow index I_f (from part A of Exp.) =
4. Toughness index I_T $= \frac{Ip}{If} =$

Experiment No. 5

Object: Determination of Shrinkage Limit

Apparatus/Equipment :

Evaporating dish, shrinkage dish, glass plastic, spatula, straight edge, 452 micron IS sieve, balance oven,, mercury, dissector, wash bottle.

Theoretical background :

Shrinkage limit is the water content at which further reduction in it will not lead to decrease in volume of soil mass.

Let, Wt.. of wet soil = W_1 gm

Vol. of wet soil V_1 = Vol. of dish

Wt. of dry soil =W_2

Vol. of dry soil =V_2 gm

Loss of volume =V_1-V_2

Loss of water at shrinkage limit ? …(i)

Loss of wt. of water till the start of shrinkage = ρw ($V_1-V_{2=}$) …(ii)

Total loss of water = W_1-W_2 gm …(iii)

Therefore,

Wt. of water at shrinkage limit = total loss of water –loss of water at the start of shrinkage limit = W_1-W_2- ρr (V_1-V_2) ….(iv)

$$\text{Shrinkage limit = water content at shrinkage } u = 100 \times \frac{W_1 - W_2 \quad - \rho w (V_1 - V_2)}{W_2}$$

$$\text{Shrinkage limit} = \frac{W_1 - W_2}{W_2} - \frac{\rho w (V_1 - V_2)}{W_2} \times 100$$

$$\frac{W_1 - W_2}{W_2} = w = \text{water content}$$

ρw= 1

W_2=Wd

V_1=V

V_2=V_d

$$\text{Shrinkage limit} = w - \frac{V - V_d}{W_d} \times 100$$

Procedure:

1. Preparation of soil paste. Take about 100g of soil sample from a thoroughly mixed portion of the material passing 425 micron IS sieve.

2. Place about 30 g of he above sample to evaporation dish and mix it thoroughly with distilled water. Water added should be sufficient to fill the voids in the soil completely and make the soil wet enough to be reading worked into the shrinkage dish without entrapping air bubbles.

3. Clean the shrinkage dish and determine its weight accurate to 0.1 g. To determine its volume, place the shrinkage dish in the evaporating dish and fill it with mercury. Remove the excess mercury by pressing the glass plate firmly on its top taking care hat no air is entrapped. Wipe off. Carefully, the mercury which is adhering to the outside of the shrinkage dish. Carefully transfer the mercury of the shrinkage dish to the other evaporating dish, and then determine the weight of mercury accurate to 01.g. The weight of mercury divided by its unit weight give the volume of the shrinkage dish which is also the volume of the wet soil.

4. *Filling the shrinkage dish with wet soil.* Cost the inside of the shrinkage dish with a thin layer of silicon grease or Vaseline. Strike off the excess soil paste with a straight edge. Wipe off the soil adhering to the outside dish of he dish.

5. *Determination of wet and dry weight of soil.* Weight immediately the shrinkage dish plus the wet soil, accurate to 0.1g. keep the shrinkage dish open to air until the colour of soil sample turn from dark to light. Keep the shrinkage in the oven and thus dry the soil sample at constant temperature at 105^0C to 110 ^{0}C. Cool the dish in a dedicator and weight immediately.

6. *Determination of volume of dry soil.* To determine the volume of dry soil, keep the glass cup in the evaporating dish. Fill the cup to over flowing with mercury. Remove the excess mercury bty pressing the glass plate with the three prongs firmly over the top to the cup. Transfer the cup carefully to another evaporating dish, carefully wiping off any mercury which may be adhering to the outside of the cup. Place the oven dried soil pat on the surface of mercury in the cup and carefully force the pat into the mercury by pressing it by the same glass plate containing three prongs. Press the plate firmly on the top of the cup. Collect carefully the displaced mercury and weight to an accuracy of 0.01 g. The volume of the dry soil is then determined by dividing this weight by the unit weight of mercury.

Observation:

	No.	1	2	3
(a) Water content of wet soil				
1.	Shrinkage dish No.			
2.	Wt. of shrinkage dish (g)			
3.	Wt. of shrinkage dish + wet soil (g)			
4.	Wt. of shrinkage dish + dry soil (g)			
5.	Wt. of dry soil (W_d) (g)			
6.	Wt. of water (g)			
7.	Water content of soil (w) (ratio) = $\frac{(6)}{(5)}$			
(b) Volume of wet soil				
8.	Evaporating dish No.			
9.	Wt. of mercury filling shrinkage dish + Wt. of evaporating dish (g)			
10.	Wt. of evaporating dish (g)			
11.	Wt. of mercury filling evaporating dish (g)			
12.	Vol. of wet soil V = $\frac{(11)}{13.6}$ (cm^3)			
(c)	Volume of dry soil			
13.	Evaporating dish No.			
14.	Wt. of mercury displaced by dry soil +wt. of evaporating (g)			
15.	Wt. of evaporating dish (g)			
16.	Wt. of mercury displaced by dry soil (g)			
17	Vol. of dry soil V_d = $\frac{(16)}{13.6}$ (cm^3)			

Calculations :

Shrinkage Limit

$$ws = w - \frac{V - Vd}{Wd} \times 100$$

Results:

Questions:

1. Why do you use mercury only to determine the volume of wet and dry soil pat ? Can you use any other compound?
2. Is it possible to get the true value of plastic limit?
3. How the plastic limit is defined to determine it in the laboratory ?
4. What is plastic state? What is the state of soil at plastic limit? Do different spoils at their plastic limits have the same state?

5. What is the consistency of soil at plastic limit ? Do different soils at their plastic limits have different consistencies?
6. Is plastic limit a natural or conventional soil index?
7. What is the degree of saturation at plastic limit?
8. What happens when water content of soil is reduced from liquid to plastic limit ?
9. Do different soils have the same shear strength at their plastic limits ? Justify,
10. What are the practices application of plastics limit, Justify.
11. Why do you use the soil passing from 425 microns sieve to determine the plastic limit while it value is used to classify only the fine grained soils, which is passing from 75 microns sieve?
12. If a thread of 5 mm is made instead of 3 mm then what is the effect on plastic limit ?
13. What is the degree of saturation at shrinkage limit?
14. Does volume increase on addition of water content at shrinkage limit?
15. What are the factors affecting the value of shrinkage limit?
16. If air bubble is left during filling the wet soil in the shrinkage dish, what is its effect n shrinkage limit?

Values (Standard):
Unit weight of mercury = 13.53 g/cc
Unit weight of water= 1.00 g/cc

Experiment No.6

Object: The grain-size analysis of a soil by mechanical method.

Apparatus:

Balances, set of IS sieves, mechanical sieve- shaker

Theoretical background:

The grain size of soil can be determined by the plate aperture size used in the process of sieving. The weight of soil retained in each stack is used to get the percentage finer "by weight" and obtain the grain size distribution and hence the distribution.

Procedure:

For sandy to fine grained soil, the recommended sieve stack (in order from top to bottom) is as follows :

4.75mm
2.00 mm
1.00 mm
600 microns
425 microns
300 microns
212 microns
150 microns
75 microns

Remove the stack of sieve from the shaker and obtain the weight of material retained on each sieve.

Compute the per cent retained on each sieve by dividing the weight retained on each sieve by original sample weight w_5. Compute the per cent passing (or per cent finer) by starting with 100% and subtracting the per cent retained on each sieve as cumulative procedure. Make a semi logarithmic plot of grain size versus per cent finer.

Observation and Calculation :

Weight of dry soil sample W_s =

S. No.	IS Sieve	Particle size D (mm)	Weight retained (g)	% weight retained	Cumulative % retained	Cumulative % finer

Result :

From the graph get the following

(a) Coefficient of uniformity $C_u = \dfrac{D_{60}}{D_{10}}$

(b) coefficient of concavity curvature Ce=

(c) Classify the soil sample as per MIT and Indian Standard classification .

Note : D refers to the grain size, or apparent diameter, of soil particles and the subscript of (10, 30, 60 denotes the percent that is smaller. For example, if D10 is equal to 0.15 mm, it will mean that 10% of sample grains are smaller than 0.15 mm.

Precautions :

1. Take the dry soil. If it is wet, dry it in oven.
2. The time of shaking obtain the weight of material on each sieve. Sun these weight and detect any loss of soil. If the loss of weight is more than 2% of initial weight than repeat the whole experiment carefully.

Limitation:

1. It is only for coarse grained soil
2. It does not provide information on the shape of the soil grains i.e. whether they are angular or rounded or flaky etc. It only yield information on grains that passes with proper orientation through openings of certain size>

Question :

1. What dose C_u Indicate ?
2. What is the significance of C_c
3. Does MIT classification and IS classification give coherent result?

Experiment No.7

Object: The grain size analysis of a soil by hydrometer.

Apparatus: Hydrometer, thermometer, balance etc.

Thermometer background:

This test is based on stoke's law, According to this terminal velocity is given by

$$v = \frac{ps - pw}{18u} D2$$

ρ_s = Unit wt. of solid particles

ρ_w= unit wt. of water

u= viscosity of water

D= diameter of soil particles

If a particle of diameter D Falls through a distance H n time t

V=h/t

The specific gravity of suspension is determined by hydrometer at a particular depth.

The height h can be written in term of h_1, h_0, V_H, A_j

$$h = h1 + h0 + \frac{VH}{2Aj} - \frac{VH}{Aj}$$

where $\frac{VH}{2Aj}$ = rise in the level of water at the centre of bulb of hydrometer. Since below the centre of bulb of hydrometer the rice in the level is due to half of the volume of hydrometer only.

$\frac{VH}{Aj}$ = total rise or rise in the surface of suspension. Here full volume (interred part only of hydrometer is taken into account. the reading of hydrometer gives the sp. gravity of the suspension

$$= \frac{\text{wt. of water / cc - immersed wt. of solid / cc}}{\text{wt. ofwater / cc}}$$

= 1+ immersed wt. of slid/cc

from the reading of hydrometer the sp. gravity is determined as given below.

Let R is reading (corrected) of hydrometer. Specific gravity = $1 + \frac{R}{100}$

$$\therefore 1 + \frac{R}{100} = +\text{immersedof solid / cc}$$

Immersed wt. of solid/cc = $W_d \frac{G - 1}{G}$

Therefore

$$\frac{R}{100}\left(\frac{G}{G - 1}\right)$$

$W_d =$

G= specific gravity of solid
W_d = wt. of solids/cc at depth h after time t.
Hence percentage of practices smaller them D is equal to

$$\frac{Wd}{\text{wt. of solid / cc in original suspension}} \times 100$$

Procedure :

Calibration of hydrometer

1. Immerse the hydrometer in jar full of water and not down the rise in level of water. Increased volume of water corresponds to temperature of hydrometer.
2. Measure the distance between any tow graduation marks on jar and find the volume included in between these two graduation. Ratio of his volume and height gives the cross sectional area A of jar.
3. Calculate the effective height for each major calibration mark and draw the calibration curve between effective height and hydrometer reading.
4. Weight about 50 gm to 100 gm of soil and pour it in jar filled with water. Them mix some dispersing agent in suspension in jar to assure uniform density of suspension.
5. Place a suitable cover on the top of jar and shake it vigorously end. Stop shaking and allow it to settle. Remove the top cover and start stop watch immediately.
6. Insert the hydrometer and take reading after periods of ½,1,2,4 minutes. Take out hydrometer and rinse it with distilled water.
7. Reinsert the hydrometer and take the reading for , 15, 30 minutes, 1 hr, 2 hr, 4hr. After each reading hydrometer should be rinsed.

Observation

A= G=
V_H= h_0=

Time	Hydrometer Reading	h_1	h

Calculation Table:

Time	*R*	*h*	W_d	*% finer*	*Particle size D*

h_1 should be determined by calibration curve from calculation table. Draw the graph between size and percentage finer.

Determine from graph.

D_{60} =

D_{10} =

and find out uniformity coefficient. $= \frac{D60}{D10} =$

Result:

Uniformity constant

Precautions :

After first four reading hydrometer should be inserted in the suspension only a few second before the reading is to be taken.

Limitation :

Its is fine soil only.

Questions :

1. What does uniformity coefficient indicate ?
2. What type of corrections can be done in hydrometer reading?
3. What is the effect of using erroneous value of G being 2.60 when the correct value is 2.70?
4. What is hydrometer and sedimentation analysis?
5. What is Stock's law and what are its assumptions?
6. How does Stock's law help in hydrometer analysis?
7. What is the effect of he size of the soil particles on their velocities in soil water suspension?
8. State two or more uses of hydrometer lest data.
9. What is the role of dispersing/deflocculating agent in hydrometer analysis ? Name the most common used in hydrometer analysis. How is it solution prepared.

Experiment No. 8

Object: Standard Proctor Test.

Apparatus

Metal rammer, steel straight edge, 20 mm and 4.75 mm Is sieves, balance. Water content containing, mixing equipment, measuring cylinder of glass, Proctor's needle.

Theoretical background:

Compaction is the process in which soil particles are rearranged in a closer state by impact loading and air is expelled from voids. the dry density of soil change s with its water content. Initially density increase with increase in water content since this moisture helps in bringing the soil particles closer. if we for on adding the water then after a certain stage dry density of soil starts decreasing, since the excess of water starts occupying the space that should have been occupied by grain under compaction. thus the water content at which the dry density of soil is maximum is called optimum content.

Procedure:

1. Take a representative sample weight approximately 20 kg. of thoroughly mixed dried soil passing 4.75 mm (or 20mm) IS sieve. Add enough water to bring content upto 7% (sandy soil) or 10% (clayey soils) less than the estimated optimum moisture content.
2. Clean the mould and fix it to the base. Take the empty weight of mould and base nearest to 1g.
3. Attach the collar to the mould. The inside of the mould should be grease.
4. Mix. the matured soil thoroughly. Take out about 2½kh. of the soil and compact it in the mould in three equal layer, each layer being given 25 blows from the rammer weighing 2.6kg. dropping from a height of 310 mm if 1000 ml mould is used. If, however the 2250 ml **,** mould is used about 26 blows soil should be taken, and should be compacted in three equal layers, each layer being given 56 blows from the rammer weighting 2.6 kg dropping from a height of 310mm. the blows should be uniformly districted over the surface of each layer. Each layer of the compacted soil should be scored with a spatula before putting the soil for the succeeding layer. The amount of soil used should be just sufficient to fill the mould leaving about 5 mm to be struck off when the collar is removed. Find the penetration resistance of compacted soil, using the Proctor's needle.
5. Remove the collar and cut the excess soil with the help of straight edge, Clean the mould from outside and weight it to the nearest gram. take out the soil from the mould. Cut it in middle and keep a representative soil specimen for water content determination.
6. Repeat steps 4 and 5 for about five or six time, using a fresh part of the soil specimen and after adding a higher water than the preceding specimen.

Observations:

Test No.	1	2	3	4	5	6	7
(a) Density							
wt. of mould + compacted soil							
wt. of mould							
wt. of compacted soil							
Bulk density							
(b) Water content							
Wt. of container + wet soil							
Wt. of container +dry soil							
Wt. of water							
Wt. of container							
Wt. of dry soil							
Water content (%)							
Dry Density =							

Calculations :

1. The dry density of the compacted soil is calculated as :

   A curve showing the relationship between dry density and water content is to be plotted. the water content corresponding to maximum dry density is to be found from the curve.
2. The void ratio is found from the relation

$$e = \frac{G}{pd} - 1$$

   Where G= specific gravity and ρ_d = dry density soil
3. On the same plot, a curve is drawn between penetration resistance and water content.

Result :

The optimum water content is ____________________

Max. dry density_____________________________

Questions :

1. On what factors does optimum moisture content depend for a given soil? Explain.
2. Prove that ratio of compactive energy imparted in modified test to that of standard test is 4.55 :1 when both the test have same mould.

Experiment No.9

Object: Direct Shear Test

Apparatus:

1. Shear box equipment consisting of (a) shear box 69 mm2 and 50 mm deep divided into two parts horizontally with suitable spacing screws (b) container for shear box (c) grid plates, one plane and other perforated.
2. Loading frame.
3. Providing ring with dial gauge to measure shear force.
4. Dial gauge to measure horizontal displacement.

Theory:

Shear strength of soil is the ability to sliding along internal surfaces within a mass. The direct shear test is conducted on a soil in the idealized condition i.e. the failure plane is forced to occur at a predetermined location.

τ=c σ_n tan ϕ (c is for cohesion less soils

Procedure:

1. Carefully assemble the shear box, keeping the grid plate at the bottom. The serrations of the grid plate should be placed a right to the direction of shear.
2. Place the soil sample in the shear box to about 5mm from the top and place the grid plate and loading block on top of the soil.
3. Mount the shear box assembly on the load frame. Set the lower part of the shear box to bear against the load jack and upper part of the box to bear against providing ring. Set the dial of proving ring to zero. Attach the dial gauge to measure the shear displacement.
4. Put the loading yoke on top of loading block. Put Normal weight on the hanger of loading yoke. Remove the shear box pins.
5. Starts the horizontal (shear) loading and take the reading of load dial(of proving ring) and shear displacement dial. The rate of strain may vary from 1 to25 mm per minute. Conduct the test till failure of sample.
6. Repeat the test for vertical load of 5 kg, 7.5kg, 15 kg, 30 kg, an d 40 kg.

Observations:

Area of soil specimen = (6 x 6) cm^2

Proving ring constant : 1 Div. =

Displacement dial reading	Proving ring reading				
	5kg	7.5kg	15kg	30kg	40kg

Test No.	Normal stress (kg/cm^2)	Shear stress at failure = at failure (kg/cm^2)	Shear displacement at failure
1.			
2.			
3.			
4.			

1. Plot the values of shear stress εversus normal stress σ_n for the test. Construct a best straight line through the plotted. Be sure to use same scale for both the ordinate (ε) and the abscissa (σ_n) obtain the cohesion (if only) as the intercept with the ordinate axis and measure the slope of the line to obtain ϕ.
2. Plot ϕ versus shear displacement and find out the peal strength

Result:
Cohesion 'e' =
Angle of internal friction 'ϕ'=
Precaution:
Rate of application of shear force must be constant in whole experiment.
Limitation:
The plane of failure is predetermined which may not be he weakest point.
Questions:
1. What are the factors which govern the angle of internal friction ?
2. What is he critical void ratio?

Experiment No.10

Object: To determine the permeability of a soil.

Apparatus:

Permeameter, mixing pan, balance, stop which container for water determination.

Theoretical Background:

The property of material, which permits fluids to percolate through its voids, is called permeability. According to Darcy's law in the laminar range the velocity of percolation is proportional to the hydraulic gradient.

$V \propto i$

V= Ki

AV =Kai

AV= flow rate = Q= Kai

$$K = \frac{QL}{hA}$$

I = hydraulic gradient $\frac{h}{L}$

A= cross-sectional area of soil mass perpendicular to the direction of flow

V= velocity of flow

h= head loss in distance L along the flow path

If the head is not constant and the rate of fall is $\frac{dh}{dt}$ then

flow rate
$$Q = -a \frac{dh}{dt}$$

$$-d \frac{dh}{dt} = k \frac{h}{L} a$$

a = cross sectional area of stand pipe

t = time of flow

h_1 = initial head

h_2 = final head

Procedure :

A. Constant Head Method

(a) Preparation of specimen :

1. Take about 800 to 1000 gm of soil and mix water its water content rises to optimum water content.
2. Grease the mould. Assemble the dynamic permeameter. Place the mould upside down on the dynamic compaction base and weight the assembly. Put 3 cm collar to the other end.
3. Compact the wet soil in two layers by addling 15 blows to each layer with 2.5 kg. ramming rod. Remove the collar and trim off the excess soil and weigh assembly filled with soil and determine the weigh of the soil.
4. Place the filter paper or fine wire mesh on the top of specimen and fix the perforated plated on it.
5. Turn the specimen upside down. Remove the compaction plate and place the perforated plated on the top of the specimen and fix up the sealing and top cap.

(b) Saturation of compacted specimen

Place the permeameter mould in the vacuum dedicator and open air release valve. Fill the desicator with desired water such that it reaches well above the top cap. Apply the vacuum the increase it gradually to abut 70 cm of mercury.

Testing :

1. Place the mould in bottom tank and fill it with water upto its outlet.
2. Connect the outlet of constant head tank to the inlet of permeameter. Adjust the head by either adjusting the relative height of mould and constant head tank or by raising or lowering the air in-take tube with in the head tank.
3. Run the test for some convenient time interval.
   Note the duration of test by stop watch. Collect the water (Vcc) in a beaker flowing from outlet of bottom tank and measure it.

Observation

h=
L=
A=
t=
v I test =
II test = V_{av}=
III test =
K=
Test temperature =
Permeability at 27 ^{0}C =

Calculations :

$$Q = \frac{V}{t}$$

$$k = \frac{V}{t} x \frac{1}{h} x \frac{1}{A}$$

Result :

K =

B. Falling Head Method

Preparation and saturation of specimen are same as that of constant method.

Testing :

1. Keep the permeameter mould assemble in the bottom tank and fit it upto it outlet.
2. Connect inlet of mould to the stand pipe filled with water. Permit water to flow for some time unit steady state of flow is reached.
3. Note the time required for water level in the stand pipe to fall from some initial value to some final value.
4. Repeat the step 3 for two or three times for same initial and final head value.

Determination of a : Collect water contained in between two graduation (of the stand pipe) of known distance apart. weigh it and determine the inside area of stand pipe.

Observations :

a = area of stand pipe =
A= area of soil specimen =
h_1= initial head in stand pipe =
h_2 = final head in stand pipe
t_1 =

t_2 =
t_3 =
Average t =

Calculations :

$$K = \frac{al}{At} \text{in} \frac{h1}{h2}$$

Result :

K =

Precautions : *Increase the cacousion slowly and in every increment sufficient time should be given to escape the air bubbles off the specimen without the specimen.*

Limitations : *Generally this apparatus is used for fine grained (pervious) soil only.*

Questions :

1. How does the pore affect the permeability?
2. Does cohesion of soil play any role in the determination of permeability ?
3. Compare the values of permeability K obtained from both methods and state the probable cause for any difference in the two values.
4. Does temperature play any significant role in computing the permeability ?

Experiment No. 11

Object: Determination of consolidation properties of soil.

Apparatus :

Fixed ring type consolidometer, suitable loading device fro applying vertical loading dial gauge, balanced, thermostatically controlled oven, containers, mixing basin, glass plate, filter paper, stop watch.

Theoretical background :

The process of compression resulting from long term steady load and gradual reduction of pore space by escaping of pore water is termed as consolidation. The permeability of an undisturbed sample of clay is determined directly at several different void ratios while running a consolidation test.

Procedure :

(a) Preparation of soil specimen :

1. *Preparation of specimen from undisturbed soil sample.* The undisturbed sample from the filed may be circular (at least 1 cm in diameter) or a block sample. Clean the specimen ring and weigh it empty. Cut off about 3 to 5 cm of soil specimen from one end of the sample by pressing with hands and carefully removing the martial around the ring. The soil specimen so obtained should project about 1 cm form either side of the ring. Trim the sample smooth and flush at the top and bottom of the ring by using glss plates. Clean the ring from outside and weigh. Keep three specimens from the soil trimmings fro water content determination.
2. *Preparation of specimen from representative soil samples.* If the consolidation properties are to be determined from a disturbed soil sample, soil is compacted at the desired water content and density, in a separate large mould, and then the specimen is cut as explained in step (1) above).

(b) ***Preparation of mould assembly and sample:***

1. Saturate the poruse stones either by boiling in distilled water for about 15 minutes or by keeping them submerged in distilled water for 4 to 8 hours. Wipe away excess water. Moisture all surfaces of the consolidometer which are to be enclosed.
2. Assemble the consolidometer with the soil specimen (in the ring) and porous stones at top and bottom if the specimen providing a filter paper between soil specimen and porous stone. Position the pressure pad centrally on he top porous stone.
3. Mount the mould assembly on he loading frame and centre it such that the applied load is axial.
4. Position the dial gauge to measure vertical compression of the specimen. The dial gauge holder should be so set that the dial is near the beginning of its release run. Allowing sufficient margin for the swelling of the soil, if any.
5. Connect the mould assembly of the water reservoir and allow the sample to be saturated. The level if water in the reservoir is at about the same level as the specimen.
6. Apply an initial setting load to the assembly. The magnitude of this load should be chosen by trial such that there is no swelling. It should not be less than 50gm/cm^2 for ordinary soil (or 25g/cm^2 for very soft soils). The load should be

allowed to stand until there is no change in dial gauge reading for two consecutive hours or for a maximum of 24 hours.

(c) Consolidation test.

1. Note the fine dial reading under the initial setting load. Apply first load of intensity of 5.1 kg/cm^2 and start the stop watch simultaneously with loading. Record the dial gauge readings at various time intervals indicated in the observation table. The dial gauge readings are taken until 90% consolidation in reached. Primary consolidation is generally reached within 24 hours.
2. At the end of the period, specified above, take the dial reading and time reading. Double the intensity and take dial reading at various time intervals. Repeat this procedure for successive load increments. The usual load intensities are follows : 0.1, 0.2, 0.5, 1, 2, 4, and 8 kg/cm^2.
3. After the last5 loading is completed, reduce the load ¼of he value of the last and allow it or stand for 24 hours. Reduce the load further in steps of ¼th of the pervious intensity till an intensity of 0.1kg/cm^2 is reached. Taken the final reading of the dial gauge.
4. Reduce the load to the initial setting load, keep it for 24hours and note the final readings.
5. Quickly dismantle the specimen assembly and remove the excess surface water on the soil specimen by blotting and weigh the ring with consolidation specimen. Dry the soil specimen in oven and determine its dry weight.

Observations and Result:

(a) For Pressure, Compression and Time

Empty weight of ring :
Dia. Of ring :
Ht. of ring.
Area of O ring :
Volume of ring :
Sp. gravity of soil sample G:

Pressure Intensity (kg/cm^2)		0.1	0.2	0.5	1	2	4
Elapsed Time (min.)	$\sqrt{t}$	Dial Gauge Readings					
0	0						
0.25	0.5						
1	1						
2.25	1.5						
4	2						
6.25	2.25						
9	3						

Pressure Intensity (kg/cm^2)		0.1	0.2	0.5	1	2	4
Elapsed Time (min.)	$\sqrt{t}$	Dial Gauge Readings					
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						
169	13						
196	14						
225	15						
256	16						
289	17						
324	18						
361	19						
430	20						
500	22.4						
600	24.5						
1440	38						

(B) For Pressure Void Ratio

Applied pressure (kg/cm^2)	Final dial reading	Dial change H	Specimen height H_1=H	Drainage path d= ¼ (H_1+H)	Ht. of voilds H-Hs	Voilds ratio	Fitting time		Cv (cm^2/min.)		Av. C_e	Remarks
						$e = \frac{H-Hs}{Hs}$	t_{50}	t_{90}	$\frac{01.97\ d^2}{t_{50}}$	$\frac{0.848\ d^2}{t_{90}}$		
0.1												
0.2												
0.5												
1.0												
2.0												
8.0												
0												

(C) For water content

		Before	After
1.	Wt. of ring + wet soil (g)		
2.	Wt. ring + dry soil (g)		
3.	Wt. of ring (g)		
4.	Wt. dry soil (W_d) (g)		
5.	Wt. of water (g)		
6.	Water content 'w'		
7.	Degree of saturation $\frac{wG}{e}$		
8.	Ht. solids $H_s = \frac{Wd}{GA}$		

Calculations :

1. Height of solids (H_s) can be calculation as $H_s = \frac{Wd}{GA}$
2. Voids ration e= $\frac{H - H_s}{H_s}$
3. Coefficient of consolidation

$$Cv = \frac{0.197\,d^2}{t_{50}} \quad \text{(log fitting methdo)}$$

$$Cv = \frac{0.848d^2}{t_{90}} \quad \text{(spuare root fitting method)}$$

In the log fitting method. A plot is made between dial reading and logarithm of time and the time corresponding is determined. In the square root fitting method , plot is made between dial reading and the squire root of time and the time corresponding to 90% consolidation is determined.

4. Compression index. A plot of void ratio e versus log I is made. the initial compression curve would be found to be straight line and the slope of this line would give you the compression index G.
5. Coefficient of compressibility (av) = $\frac{0.435C_c}{\sigma_1}$

   where σ_1 = average pressure for the increment
6. Coefficient of permeability (k)

$$k= \frac{C_v(av)y_w}{1+e}$$

Result:

Coefficient of consolidation

C_v (log fitting method) =
C_v (square root fitting method) =
Coefficient of compressibility a =
Coefficient of permeability k =
height of voids = H- H_s

Questions :

1. What do you understand by coefficient of consolidation ?
2. What do you mean by corrected zero point and its significance?
3. Why the consolidation test is required?

Experiment No.12

Object: California Bearing Ratio (CRB)

Apparatus:

Mould, spacer disc, collar, rammer, compacting weight, annual slotted weigh and other miscellaneous apparatus.

Theory :

CBR is the ratio of test load to the standard load expressed as percentage for a given penetration of the plunger.

$$CBR = \frac{\text{test load}}{\text{standard}} \times 100$$

Test load is the penetration resistance at a particular penetration and standard load is the penetration resistance of the plunger into the standard sample (crushed stones) for that particular penetration.

Procedure :

Take about 4.5 to 5.5 kg. Soil mix it with water to attain optimum moisture content. Fix the base plate to bottom of the mould and extension collar to its top. Insert the spacer disc over the base. Put the filter paper on he top of he displacer disc. Now compact the mixed soil in he mould either by light comp[action or heavy compaction as explained in compaction test. Remove the collar and trim off the excess soil. Turn the mould upside down and remove base plate and displacer dice. Weight the mould with compacted soil and find out he weight of soil and dry density of soil. Put the filter paper on the op of the compacted soil clamp the perforated base plate on it.

Testing :

1. Place the surcharge weight on top of the soil specimen and place the mould assemble on the loading machine or compaction machine.
2. Put the penetration piston at he centre of the specimen with smallest possible load but in no case excess of 4 kg.
3. Set the stress and strain dial gauge to zero. Apply the load so that penetration ratio is approximately 1 to 5 mm/mm. Note the load readings at various penetration, e.e, 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.o, 5.0, 7.5, 10, 12.5 mm. Record maximum load and penetration before 12.5 mm penetration.
4. Take some soil from specimen for water content determination at the end of loading. This soil must be taken from the top 3 cm layer of the specimen.

Observation:

Surcharge wt. used =

Water content after penetration test =

Penetration Dial Reading (Penetration) (mm)	Load Dial Reading (load (kg)	Correct Load
0		
0.5		
1.0		
1.5		
2.0		
2.5		
3.0		
4.0		

Calculations :

Plot the graph for load versus penetration. If the curve is concave upward in starting draw a tangent at the highest point and wherever it touches abscissa that will be corrected zero. With respect to this zero, mark the penetration value and find the correec5t load corresponding to them. Now. The CBR-

$$\text{CBR} = \frac{\text{correct test load}}{\text{standard load}} \text{ x } 100$$

Standard Load:

Penetration	Load (b)
0.1	3000
0.2	4500
0.3	5700
0.4	6900
0.5	7800

The CBR values are usually calculation for penetration of 2.5 mm and 5mm. If CBR fro 5 mm exceeds that for 2.5 mm, repeat the test. If identical results follow. CBR corresponding to 5mm penetration should be taken for design.

If CBR value for 2.5 mm penetration is greater than that of 5 mm, 2.5 mm penetration CBR values is taken for design.

Result :

CBR value = at a penetration of ---

Limitation:

This method is applicable to flexible pavements only.

Questions:

1. What is the function of surcharge load ?
2. What do you mean by a flexible pavement?
3. What is the use of CBR value in design of pavement ?
4. While in designing the pavement. If you come across the situation where water table is just below the subsoil and the subsoil is always saturated and submerged in water then what measure will you take in design to get the value of CRB.

Experiment No.13

Object: To determine unconfined compressive strength of a soil specimen.
Apparatus: Compression device, sample ejector, dial gauge, stopwatch oven, balance, etc.
Theoretical background:
The test is performed on cylindrical sample. Sample is subjected to direct compression until it fails.

Let the initial length $= L_0$
Change in length $= \Delta L$

$$\therefore \text{axial strain} = \frac{\Delta L}{L_0}$$

Initial area $= A_0$

Assuming volume of sample is constant throughout the test and area at failure is A_1
$\therefore A_0 L_0 = A_1 L_1$
where $L_1 = L_0 - \Delta L$
Since compressive force is applied
$A_0 L_0 = A_1 (L_0 - \Delta L)$

$$A_1 = \frac{A_0 L_0}{L_0 - \Delta L} = \frac{A_0}{1 - \frac{\Delta L}{L_0}}$$

$$\frac{\Delta L}{L_0} = \text{Strain}$$

Procedure :

1. Soil witch is to be tested is mixed with water. This sample is than filled in the mould which is oiled in advance. The mould is having the same internal diameter as that of specimen which is to be tested. The mould is opened carefully and sample is taken out Prepare two or three such samples for testing.
2. Measure the initial length and diameter of the specimen.
3. Put the specimen on bottom of the loading device. Adjust upper plate to make contact with the specimen. Set the dial gauge (compression)at zero.
4. Compress the specimen until crakes are developed or the strain curve is well past its peak or until a vertical deformation of 20% is reached. Take the dial reading approximately at every 1mm deformation of the specimen.
5. Repeat of he specimen.
6. Determine water content of each sample.

Observations:

1. Internal diameter of specimen (D_0) =
2. Initial length (L_0) =
3. Initial area (A_0)=
4. Initial density =
5. Initial water content =
6. Spring constant =

S. No.	Sample No.	Load in Kg	Deformation in mm	Strain E%	Area A cm^2	Stress kg/cm^2

Calculation:

A plot is made between stress and strain for each soil sample. The maximum from curve gives the value of the unconfined compressive strength witch is taken is taken as the stress ate 20% axial strain. Try to find the effect of water content on the compressive strength.

Result :

The unconfined compressive strength =

Limitation :

It is possible for cohesive soil only.

Questions :

1. Why is his test possible for cohesive soil only?
2. Why is it called quick test.

Experiment No. 14

Object: To determine the shear parameters of a soil by triaxial test (unconsolidated undrained).

Apparatus:

Triaxial cell, apparatus for applying and maintaining the desire fluid pressure in he cell, compression machine for application of deviator stress, dial gauge, split mould, rubber membrane stretcher, balance, stop watch, trimmer, etc.

Theoretical background :

A cylindrical soil specimen is subjected to direct stresses action in three mutually perpendicular directions. Major principal stress acts in vertical direction and other two principal stresses namely intermediate and minor, act in horizontal directions. Minor principal stress is constant throughout the test and major principal circle is drawn for the stresses at failure. By Mohr circle shear strength of soil is determined.

Procedure:

Sample Preparation:

1. Mix the soil with water at desired water (optimum) content. Compact the soil properly in the split mould, which should be oiled properly. Trim the excess soil and take out the specimen from mound carefully.
2. Determine the water content of this soil.
3. then place the specimen on one of the end caps and put the other end cap on the top of the specimen.
4. Place the rubber membrane all round the specimen with the help membrane stretcher.
5. Seal the rubber membrane with caps by means of rubber reigns.

Compression Test :

1. Place the specimen on the pedestal in the triaxial cell.
2. Assemble the cell with the loading r.
3. Admit the operation fluid in the cell and raise its pressure to he desired value. Adjust the loading machine to bring the loading ram a short distance away from the seat on the cap of the specimen. Read the initial reading of load measuring dial gauge. Bring the loading ram just in contact with the seat on the top of specimen. Read the initial reading of dial gauge measuring axial compression.
4. Repeat the test on three of four specimen of same water content and same soil under different cell pressure.

Specimen measurements:

Initial weight =	Final weight =
Initial water content =	Final water content =
Diameter=	Area =
Volume =	
Cell pressure =	

Specimen	Comp. Dial reading	Load gauge reading	Comp. Of sample	Strain	Connected area	Load	Deviator Stress (σ_1-σ_3)	Vertical stress	Stress ratio
1.									
2.									
3.									

Sample	σ_3	σ_1-σ_3	σ_1	σ_1/σ_3
1.				
2.				
3.				

σ_3 = cell pressure at failure
σ_1 = vertical stress at failure
σ_1-σ_3 = deviator stress at failure

Calculations :

1. Plot (σ_1-σ_3) versus strain (g) for each specimen.
2. obtain the shear strength from circle Mohr circle and find out coefficient of cohesion also.

Result :

(i) Shear strength =
(ii) Cohesion =

Question :

1. What is meant by “ area correction” of specimen? Apply this correction in your experiment.
2. What changes in the experiment are to be incorporated if pore pressure is also taken into consideration .

APPENDIX-I DENSITY (UNIT WEIGHT) DETERMINATION

Purpose:

This lab is performed to determine the in-place density of undisturbed soil obtained by pushing or drilling a thin-walled cylinder. The bulk density is the ratio of mass of moist soil to the volume of the soil sample, and the dry density is the ratio of the mass of the dry soil to the volume the soil sample.

Standard Reference:

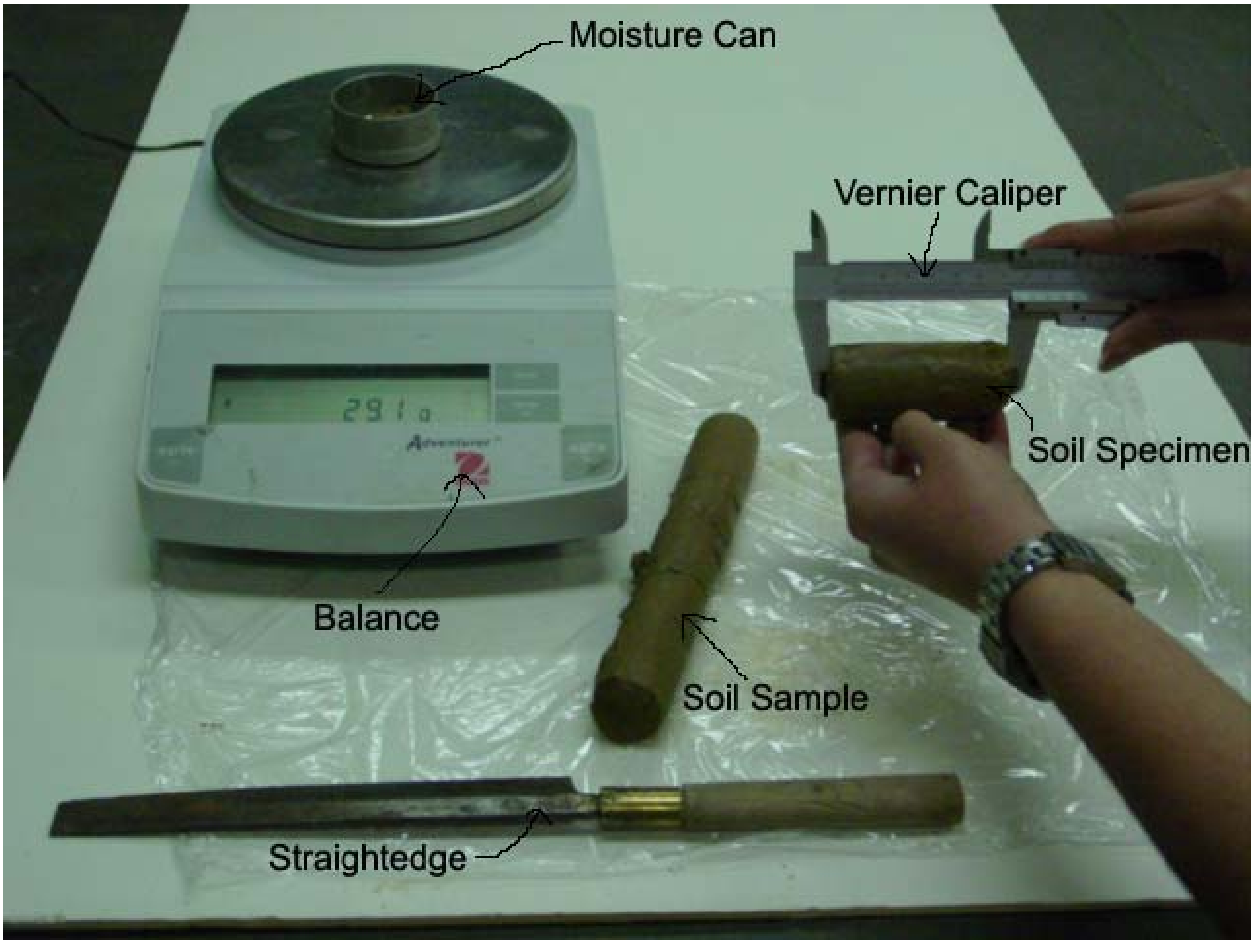
IS 2720 Part 29 - 1975 (1995) and ASTM D 2937-00

Significance:

This test is used to determine the in-place density of soils. This test can also be used to determine density of compacted soils used in the construction of structural fills, highway embankments, or earth dams. This method is not recommended for organic or friable soils.

Equipment:

Straightedge, Balance, Moisture can, Drying oven, Vernier caliper



Test Procedure:

(1) Extrude the soil sample from the cylinder using the extruder.

(2) Cut a representative soil specimen from the extruded sample.

(3) Determine and record the length (L), diameter (D) and mass (M_t) of the soil specimen.

(4) Determine and record the moisture content of the soil (w). (See Experiment 1)

(Note: If the soil is sandy or loose, weigh the cylinder and soil sample together. Measure dimensions of the soil sample within the cylinder. Extrude and weigh the soil sample and determine moisture content)

Data Analysis:

(1) Determine the moisture content as in Experiment 1

(2) Determine the volume of the soil sample

$$V = \frac{\pi D^2 L}{4} \quad cm^3$$

(3) Calculate bulk density (ρ_t) of soil

$$\rho_t = \frac{M_t}{V} \quad \frac{g}{cm^3}$$

or unit weight $\gamma_t = \rho_t g$

(4) Calculate dry density (ρ_d) of soil

$$\rho_d = \frac{\rho_t}{1+w} \quad \frac{g}{cm^3}$$

or dry unit weight $\gamma_d = \rho_d g$

DENSITY (UNIT WEIGHT) DETERMINATION
DATA SHEET

Sample number: Date Tested:
Soil description:

Mass of the soil sample (M_t):
Length of the soil sample (L):
Diameter of the soil sample (D):

Moisture content determination:

Specimen number	1
Moisture can and lid number	
M_C = Mass of empty, clean can + lid (grams)	
M_{CMS} = Mass of can, lid, and moist soil (grams)	
M_{CDS} = Mass of can, lid, and dry soil (grams)	
M_S = Mass of soil solids (grams)	
M_W = Mass of pore water (grams)	
w = Water content, w%	

Calculations:

APPENDIX-II VISUAL CLASSIFICATION OF SOILS

Purpose:

Visually classify the soils.

Standard Reference:

IS: 1498-1970 and ASTM D 2488

Significance:

The first step in any geotechnical engineering project is to identify and describe the subsoil condition. For example, as soon as a ground is identified as gravel, engineer can immediately form some ideas on the nature of problems that might be encountered in a tunneling project. In contrast, a soft clay ground is expected to lead to other types of design and construction considerations. Therefore, it is useful to have a systematic procedure for identification of soils even in the planning stages of a project.

Soils can be classified into two general categories: (1) coarse grained soils and (2) fine grained soils. Examples of coarse-grained soils are gravels and sands. Examples of fine-grained soils are silts and clays. Procedures for visually identifying these two general types of soils are described in the following sections.

Equipment:

Magnifying glass (optional)

Identification Procedure:

a. Identify the color (e.g. brown, gray, brownish gray), odor (if any) and texture (coarse or fine-grained) of soil.

b. Identify the major soil constituent (>50% by weight) using Table 1 as coarse gravel, fine gravel, coarse sand, medium sand, fine sand, or fines.

c. Estimate percentages of all other soil constituents using Table 1 and the following terms:

Trace - 0 to 10% by weight
Little - 10 to 20%
Some - 20 to 30%
And - 30 to 50%

(Examples: trace fine gravel, little silt, some clay)

d. If the major soil constituent is sand or gravel:

Identify particle distribution. Describe as **well graded** or **poorly graded**. Well-graded soil consists of particle sizes over a wide range. Poorly graded soil consists of particles which are all about the same size.

Identify particle shape (angular, subangular, rounded, subrounded) using Figure 1 and Table 2.

e. If the major soil constituents are fines, perform the following tests:

<u>Dry strength test:</u> Mold a sample into 1/8" size ball and let it dry. Test the strength of the dry sample by crushing it between the fingers. Describe the strength as none, low, medium, high or very high depending on the results of the test as shown in Table 3(a).

<u>Dilatancy Test</u>: Make a sample of soft putty consistency in your palm. Then observe the reaction during shaking, squeezing (by closing hand) and vigorous tapping. The reaction is rapid, slow or none according to the test results given in Table 3(b).

During dilatancy test, vibration densifies the silt and water appears on the surface. Now on squeezing, shear stresses are applied on the densified silt. The dense silt has a tendency for volume increase or dilatancy due to shear stresses. So the water disappears from the surface. Moreover, silty soil has a high permeability, so the water moves quickly. In clay, we see no change, no shiny surface, in other words, no reaction.

<u>Plasticity (or Toughness) Test</u>: Roll the samples into a thread about 1/8" in diameter. Fold the thread and reroll it repeatedly until the thread crumbles at a diameter of 1/8". Note (a) the pressure required to roll the thread when it is near crumbling, (b) whether it can support its own weight, (c) whether it can be molded back into a coherent mass, and (d) whether it is tough

during kneading. Describe the plasticity and toughness according to the criteria in Tables 3(c) and 3(d). A low to medium toughness and non-plastic to low plasticity is the indication that the soil is silty; otherwise the soil is clayey.

Based on dry strength, dilatancy and toughness, determine soil symbol based on Table 4.

f. Identify moisture condition (dry, moist, wet or saturated) using Table 5.

g. Record visual classification of the soil in the following order: color, major constituent, minor constituents, particle distribution and particle shape (if major constituent is coarse-grained), plasticity (if major constituent is fine-grained), moisture content, soil symbol (if major constituent is fine-grained).

Examples of coarse-grained soils:

Soil 1: Brown fine gravel, some coarse to fine sand, trace silt, trace clay, well graded, angular, dry.

Soil 2: Gray coarse sand, trace medium to fine sand, some silt, trace clay, poorly graded, rounded, saturated.

Examples of fine-grained soils:

Soil A: Brown lean clay, trace coarse to fine sand, medium plasticity, moist, CL.

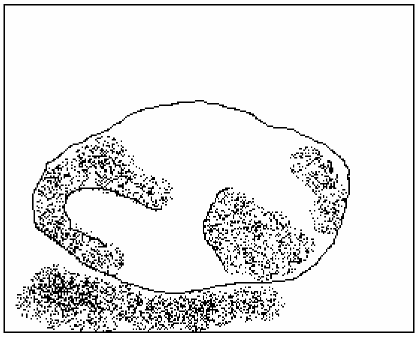
Soil B: Gray clayey silt, trace fine sand, non-plastic, saturated, ML.

Table 1. Grain Size Distribution

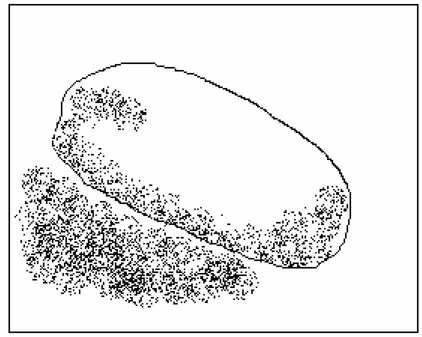
Soil Constituent	Size Limits	Familiar Example
Boulder	12 in. (305 mm) or more	Larger than basketball
Cobbles	3 in (76 mm) -12 in (305 mm)	Grapefruit
Coarse Gravel	¾ in. (19 mm) – 3 in. (76 mm)	Orange or Lemon
Fine Gravel	4.75 mm (No.4 Sieve) – ¾ in. (19 mm)	Grape or Pea
Coarse Sand	2 mm (No.10 Sieve) – 4.75 mm (No. 4 Sieve)	Rocksalt
Medium Sand	0.42 mm (No. 40 Sieve) – 2 mm (No. 10 Sieve)	Sugar, table salt
Fine Sand*	0.075 mm (No. 200 Sieve) – 0.42 mm (No. 40 Sieve)	Powdered Sugar
Fines	Less than 0.0075 mm (No. 200 Sieve)	-

*Particles finer than fine sand cannot be discerned with the naked eye at a distance of 8 in (20 cm).

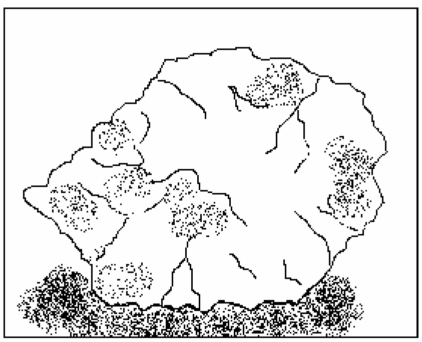
Figure 1. Shape of Coarse-Grained Soil Particles



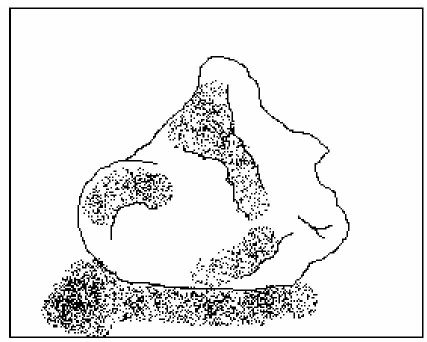
Rounded



Subrounded



Angular



Subangular

Table 2. Criteria for Describing Shape of Coarse-Grained Soil Particles

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description, but have rounded edges.
Subrounded	Particles have nearly plane sides, but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Table (3a). Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen ball crumbles into powder with the slightest handling pressure.
Low	The dry specimen crumbles into powder with some pressure form fingers.
Medium	The dry specimen breaks into pieces or crumbles with moderate finger pressure.
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

Table (3b). Criteria for Describing Dilatancy of a Soil Sample

Description	Criteria
None	There is no visible change in the soil samples.
Slow	Water slowly appears and remains on the surface during shaking or water slowly disappears upon squeezing.
Rapid	Water quickly appears on the surface during shaking and quickly disappears upon squeezing.

Table (3c). Criteria for Describing Soil Plasticity

Description	Criteria
Non-plastic	A 1/8” (3-mm) thread cannot be rolled at any water content.
Low	The thread is difficult to roll and a cohesive mass cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and little time is needed to reach the plastic limit. The thread cannot be re-rolled after the plastic limit is reached. The mass crumbles when it is drier than the plastic limit.
High	Considerable time is needed, rolling and kneading the sample, to reach the plastic limit. The thread can be rerolled and reworked several times before reaching the plastic limit. A mass can be formed when the sample is drier than the plastic limit

Note: The plastic limit is the water content at which the soil begins to break apart and crumbles when rolled into threads 1/8” in diameter.

Table (3d). Criteria for Describing Soil Toughness

Description	Criteria
Low	Only slight pressure is needed to roll the thread to the plastic limit. The thread and mass are weak and soft.
Medium	Moderate pressure is needed to roll the thread to near the plastic limit. The thread and mass have moderate stiffness.
High	Substantial pressure is needed to roll the thread to near the plastic limit. The thread and mass are very stiff.

VISUAL SOIL CLASSIFICATION
DATA SHEET

Soil Number: ________________
Classified by: _________________
Date: _________________

1. Color __________________
2. Odor __________________
3. Texture ___________________
4. Major soil constituent: ____________
5. Minor soil constituents: ___________

Type	Approx. % by weight
__________	________
__________	________
_________	_________

6. For coarse-grained soils:

   Gradation: ____________
   Particle Shape: ____________

7. For fine-grained soils:
   - Dry Strength ___________
   - Dilatancy ___________
   - Plasticity ___________
   - Toughness ___________
   - Soil Symbol ___________

8. Moisture Condition: _____________

Classification:

Disclaimer

This laboratory manual has been prepared under the guidance of Prof. A.Trivedi by the active contribution of the faculty members of the Department of Civil Engineering namely Sh. A.K.Sahu, Dr A.K.Gupta, Sh. Naresh Kumar, Sh. K. Aryan, and Sh. Amit Shrivastava.

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The content of this manual is from various resources readily available. Therefore any claim on the originality of the content is strongly desisted.

This manual is strictly for the use of the students for learning soil mechanics practices within the domain of laboratory work and has no commercial scope.