DEPARTMENT OF CIVIL ENGINEERING

MANUAL
FOR

CIVIL ENGINEERING LAB-II

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1	DETERMINATION OF SPECIFIC GRAVITY
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16	DETERMINATION OF DISSOLVED OXYGEN IN WATER SAMPLE

1. DETERMINATION OF SPECIFIC GRAVITY

OBJECTIVE

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

THEORY

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

APPARATUS REQUIRED

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

PROCEDURE

1. Clean and dry the density bottle

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

2. Weigh the empty bottle with stopper (W_1)

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

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

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

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

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

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

OBSERVATIONS

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

CALCULATIONS

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

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

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

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

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

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

FIELD DENSITY TEST

2. SAND REPLACEMENT METHOD

OBJECTIVE

To determine the field density or unit weight of soil by Core cutter method.

Field density is used in calculating the stress in the soil due to its overburden pressure. It is needed in estimating the bearing capacity of soil foundation system, settlement of footing, earth pressures behind the retaining walls and embankments. Stability of natural slopes, dams, embankments and cuts is checked with the help of density of soil. It is the density that controls the field compaction of soils. Permeability of soils depends upon its density. Relative density of cohesionless soils is determined by knowing the dry density of soil in natural, loosest and densest states. Void ratio, porosity and degree of saturation need the help of density of soil.

Specifications:

This test is done to determine the in-situ dry density of soil by core cutter method as per IS-2720-Part-29 (1975). Core cutter method in particular, is suitable for soft to medium cohesive soils, in which the cutter can be driven. It is not possible to drive the cutter into hard and boulder soils.

Equipments Required:

1) Cylindrical core cutter, 100mm internal diameter and 130 mm long.
2) Steel dolly, 25mm high and 100mm internal diameter.
3) Steel rammer mass 9kg, overall length with the foot and staff about 900 mm.
4) Balance, with an accuracy of 1g.
5) Palette knife, Straight edge, steel rule etc.
6) Square metal tray – 300mm x 300mm x40mm.
7) Trowel.

Theory:

Field density is defined as weight per unit volume of soil mass in the field at in-situ conditions. In the spot adjacent to that where the field density by sand replacement method has been determined or planned, drive the core cutter using the dolly over the core cutter. Stop ramming when the dolly is just proud of the surface. Dig out the cutter containing the soil out of the ground and trim off any solid extruding from its ends, so that the cutter contains a volume of soil equal to its internal volume which is determined from the dimensions of the cutter. The weight of the contained soil is found and its moisture content determined.

Equations are;

$$\rho_d = \rho_t/(1+w)\ gm/cm^3$$

Where, ρ_d = dry density in g/cm^3,

ρ_t = field moist density in g/cm3,

w =water content %/100,

Υ_w = density of water = 1000

Procedure:

a) Measure the height and internal diameter of the core cutter to the nearest 0.25 mm.

b) Calculate the internal volume of the core-cutter Vc in cm^3.

c) Determine the weight of the clean cutter accurate to 1 g (W1 in g).

d) Select the area in the field where the density is required to be found out. Clean and level the ground where the density is to be determined.

e) Place the dolley over the top of the core cutter and press the core cutter into the soil mass using the rammer. Stop the pressing when about 15mm of the dolley protrudes above the soil surface.

f) Remove the soil surrounding the core cutter by digging using spade, up to the bottom level of the cutter. Lift up the cutter and remove the dolley and trim both sides of the cutter with knife and straight edge.

g) Clean the outside surface of the cutter and determine mass of the cutter with the soil (W2 in g).

h) Remove the soil core from the cutter and take the representative sample in the water content containers to determine the moisture content.

i) The field test may be repeated at other places if required.

j) The water content of sample collected is determined in the laboratory as per Experiment no 1 (Determination of water content of soil solids by Oven Drying Method).

k) Use the above equation, given the theory section, for determining density of soil (ρd).

Observations:

Length of core cutter l =---------- cm

Diameter of core cutter d=---------- cm

Volume of core cutter=Vc= ----------cm

Table::

S.No.	Particulars	Test nos.		
		1 (ρ_{d1})	2 (ρ_{d2})	3 (ρ_{d3})
1.	Weight of empty cutter (W1), g			
2.	Weight of cutter + wet soil (W2), g			
3.	Volume of core cutter (V_c) cm^3			
4.	Weight ass of empty container (W3), g			
5.	Weight of container + wet soil (W4), g			
6.	Weight of container + dry soil (W5), g			
7.	Water content (w)=(W4-W5)/(W5-W3)			
8.	Field moist density ρ_t (kN/m^3) = (W2-W1)/Vc			
9.	Dry density ρ_d (kN/m^3) = ρ_t /(1+w)			
10.	Average density, Avg ρ_d			

Specimen calculations:

Avg $\rho_d = (\rho_{d1} + \rho_{d2} + \rho_{d3})/3$

Result:

Average in-situ field dry density: =----------

Conclusion:

The value of dry density of the soil is _. The type of soil is.

OBJECTIVE

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

APPARATUS REQUIRED

1. Sand pouring cylinder of 3 litre/16.5 litre capacity, mounted above a pouring come and separated by a shutter cover plate.

2. Tools for excavating holes; suitable tools such as scraper tool to make a level surface.

3. Cylindrical calibrating container with an internal diameter of 100 mm/200 mm and an internal depth of 150 mm/250 mm fitted with a flange 50 mm/75 mm wide and about 5 mm surrounding the open end.

4. Balance to weigh unto an accuracy of 1g.

5. Metal containers to collect excavated soil.

6. Metal tray with 300 mm/450 mm square and 40 mm/50 mm deep with a 100 mm/200 mm diameter hole in the centre.

7. Glass plate about 450 mm/600 mm square and 10mm thick.

8. Clean, uniformly graded natural sand passing through 1.00 mm I.S.sieve and retained on the 600micron I.S.sieve. It shall be free from organic matter and shall have been oven dried and exposed to atmospheric humidity.

9. Suitable non-corrodible airtight containers.

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

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

THEORY

By conducting this test it is possible to determine the field density of the soil. The moisture content is likely to vary from time and hence the field density also. So it is required to report the test result in terms of dry density. The in situ density of natural soil is needed for the determination of bearing capacity of soils, for the purpose of stability analysis of slopes, for the determination of pressures on underlying strata for the calculation of settlement and the design of underground structur The relationship that can be established between the dry density with known moisture content is as follows:

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

$\gamma_d = Dry\ density$

$\gamma_b = Bulk\ density$

$w = water\ content$

PROCEDURE

Calibration of the Cylinder

1. Fill the sand pouring cylinder with clean sand so that the level of the sand in the cylinder is within about 10 mm from the top. Find out the initial weight of the cylinder plus sand (W_1) and this weight should be maintained constant throughout the test for which the calibration is used.

2. Allow the sand of volume equal to that of the calibrating container to run out of the cylinder by opening the shutter, close the shutter and place the cylinder on the glass

sand takes place in the cylinder close the shutter and remove the cylinder carefully. Weigh the sand collected on the glass plate. Its weight(W_2) gives the weight of sand filling the cone portion of the sand pouring cylinder.
Repeat this step at least three times and take the mean weight (W_2) Put the sand back into the sand pouring cylinder to have the same initial constant weight (W_1)

Determination of Bulk Density of Soil

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

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

Determination of Dry Density of Soil In Place

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

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

OBSERVATIONS AND CALCULATIONS

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

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

REMARKS

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

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

3. GRAIN SIZE DISTRIBUTION

I. SIEVE ANALYSIS

OBJECTIVE

(a). Select sieves as per *I.S* specifications and perform sieving.
(b). Obtain percentage of soil retained on each sieve.
(c). Draw graph between log grain size of soil and % finer.

APPARATUS

a. Balance

b. I.S sieves

c. Rubber pestle

and mortar

d. Mechanical

Shaker

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

KNOWLEDGE OF EQUIPMENT

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

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

THEORY

The grain size analysis is widely used in classification of soils. The data obtained from grain size distribution curves is used in the design of filters for earth dams and to determine suitability of soil for road construction, air field etc. Information obtained from grain size analysis can be used to predict soil water movement although permeability tests are more generally used.

PROCEDURE

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

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

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

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

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

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

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

OBSERVATIONS AND RECORDING

Weight of soil sample:

Moisture content:

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

0.30					
0.15					
0.075					

GRAPH

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

CALCULATION

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

4. DETERMINATION OF LIQUID LIMIT

OBJECTIVE

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

NEED AND SCOPE

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

THEORY

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

APPARATUS REQUIRED

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

5. Spatula 6. Electrical Oven

PROCEDURE

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

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

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

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

OBSERVATIONS

Details of the sample:.....

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

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

CALCULATION

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

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

5. PLASTIC LIMIT TEST

NEED AND SCOPE

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

APPARATUS REQUIRED

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

PROCEDURE

1. Take about 20gm of thoroughly mixed portion of the material passing through 425 micron I.S. sieve obtained in accordance with I.S. 2720 (part 1).

2. Mix it thoroughly with distilled water in the evaporating dish till the soil mass becomes plastic enough to be easily molded with fingers.

3. Allow it to season for sufficient time (for 24 hrs) to allow water to permeate throughout the soil mass

4. Take about 10gms of this plastic soil mass and roll it between fingers and glass plate with just sufficient pressure to roll the mass into a threaded of uniform diameter throughout its length. The rate of rolling shall be between 60 and 90 strokes per minute.

5. Continue rolling till you get a threaded of 3 mm diameter.

6. Kneed the soil together to a uniform mass and re-roll.

7. Continue the process until the thread crumbles when the diameter is 3 mm.

8. Collect the pieces of the crumbled thread in air tight container for moisture content determination.

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

OBSERVATION AND REPORTING

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

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

Average Plastic Limit=.....

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

6. SHRINKAGE LIMIT TEST

OBJECTIVE

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

THEORY

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

NEED AND SCOPE

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

A shrinkage limit test should be performed on a soil.

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

2. To obtain an indication of change in volume.

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

APPARATUS

1. Evaporating Dish. Porcelain, about 12cm diameter with flat bottom.

2. Spatula

3. Shrinkage Dish. Circular, porcelain or non-corroding metal dish (3 nos) having a flat bottom and 45 mm in diameter and 15 mm in height internally.

4. Straight Edge. Steel, 15 cmm in length.

5. Glass cup. 50 to 55 mm in diameter and 25 mm in height , the top rim of which is ground smooth and level.

6. Glass plates. Two, each 75 ⨯ 75 mm one plate shall be of plain glass and the other shall have prongs.

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

8. Oven-thermostatically controlled.

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

10. Balance-Sensitive to 0.01 g minimum.

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

12. Wash bottle containing distilled water.

PROCEDURE

Preparation of soil paste

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

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

Use water content some where around the liquid limit.

Filling the shrinkage dish

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

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

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

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

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

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

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

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

Volume of the Dry Soil Pat

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

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

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

CALCULATION

First determine the moisture content

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

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

V = Volume of wet soil pat in cm3

$V0$ = Volume of dry soil pat in cm3

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

Do not touch the mercury with gold rings.

TABULATION AND RESULTS

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

7. PROCTOR TEST

SCOPE

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

APPARATUS

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

PROCEDURE

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

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

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

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

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

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

CALCULATION

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

Dry density = wet density/(1+w)

Where w is the moisture content of the soil.

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

OBSERVATIONS

Cylinder diameter cm.

height cm.

volume cc

weight of cylinder gm

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

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

RESULT

1. Maximum dry density=_____
2. Optimum moisture content =_____

CALIFORNIA BEARING RATIO TEST

1. Objective

CBR is the ratio expressed in percentage of force per unit area required to penetrate asoil mass with a standard circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. The ratio is usually determined for penetration of 2.5 and 5 mm. When the ratio at 5 mm is consistently higher than that at 2.5 mm, the ratio at 5 mm is used.

The following table gives the standard loads adopted for different penetrations for the standard material with a C.B.R. value of 100%.

Penetration of Plunger (mm)	Standard Load (kg)
2.5	1370
5.0	2055

Table 1 : Standard Load Values at Penetration

For Railway Formation purpose, the test is performed on remoulded specimens whichare compacted dynamically.
The methodology covers the laboratory method for the determination of C.B.R. of remoulded /compacted soil specimens in soaked state.

2. Apparatus Required

Fig. 1: CBR Test Apparatus

Consisting of Loading machine with capacity ofatleast 5000 kg and equipped with a movable head or base which enables Plunger of 50 mm dia. to penetrate into the specimen at a rate of

1.25 mm/ minute.

<table>
<tr>
<td>  </td>
<td>Fig. 2: CBR Mould with Base Plate, Stay Rod and Wing Nut

Cylindrical mould:

Inside dia. 150mm and height 175mm with a detachable perforated base plate of 235mm dia. and 10mm thickness. Net capacity - 2250 ml; conforming to IS-9669:1980 (Reaffirmed-2016).

Collar

A detachable extension collar of 60 mm height.

Spacer Disc

148 mm in diameter and 47.7 mm in height along with handle.

Weights

One annular metal weight and several slotted weights weighing 2.5 kg each, 147 mm in diameter, with a central hole 53 mm in diameter.</td>
</tr>
<tr>
<td>  </td>
<td>Weights

Fig. 3: Compaction Rammer

Weight - 4.89 kg with a drop 450 mm.</td>
</tr>
</table>

3. Reference

IS 2720(Part 16):1987 Methods of test for soils: Laboratory determination of CBR

(second revision). Reaffirmed- Dec 2021.

RDSO Specification No. RDSO/2020/GE: IRS-0004 - September 2020 - Comprehensive Guidelines and Specification for Railway Formation

4. Procedure

Preparation of Test Specimen:

1. Remoulded specimens are prepared in the laboratory by compaction. The materialused in the remoulded specimen shall pass 19 mm I.S. sieve. Allowance for largematerial shall be made by replacing it by an equal amount of material which passes a19mm I.S. Sieve but is retained on 4.75 mm sieve.

2. The dry density for a remoulding shall be either the field density or the value of the maximum dry density estimated by the compaction test (Heavy Compaction Test as per IS 2720 (Part-8) - 1983, for Railway Formation). The water content used for compaction shall be the optimum water content or the field moisture as the case may be.

3. Dynamic Compaction: A representative sample of the soil weighing approximately 4.5 kg or more for fine grained soil and 5.5 kg or more for granular soil shall be takenand mixed thoroughly with water. If the soil is to be compacted to the maximum dry density at the optimum moisture content, the exact mass of the soil required shall be taken and the necessary quantity of water added so that the water content of the soil sample is equal to the determined optimum moisture content.

4. Fix the extension collar and the base plate to the mould. Insert the spacer disc overthe base. Place the filter paper on the top of the spacer disc.

5. Apply Lubricating Oil to the inner side of the mould. Compact the mix soil in the mould using heavy compaction. i.e. compact the soil in 5 layers with 55 blows to eachlayer by the 4.89 kg rammer.

6. Remove the extension collar and trim the compacted soil carefully at the level of topof mould, by means of a straight edge. Any holes developed on the surface of the compacted soil by removal of the coarse material, shall be patched with the smaller size material. Remove the perforated base plate, Spacer disc and filter paper and recordthe mass of the mould and compacted soil specimen. Place a disc of coarse filter paperon the perforated base plate, invert the mould and compacted soil and clamp the perforated base plate to the mould with the compacted soil in contact with the filter paper.

7. Place a filter paper over the specimen and place perforated plate on the compactedsoil specimen in the mould. Put annular weights to produce a surcharge equal to weightof base material and pavement, to the nearest 2.5 kg.

8. Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Mount the tripod for expansion measuring device on the edge of the mould andrecord initial dial gauge reading. Note down the readings every day against time of reading. A constant water level shall be maintained in the tank throughout the period.

9. At the end of soaking period, note down the final reading of the dial gauge and takethe mould out of water tank.

10. Remove the perforated plate and the top filter paper. Weigh the soaked soil sampleand

record the weight.

Procedure for Penetration Test

1. Place the mould assembly with test specimen on the lower plate of penetration testing machine. To prevent upheaval of soil into the hole of the surcharge weights, 2.5 kg annular weight shall be placed on the soil surface prior to seatingthe penetration plunger after which the remainder of the surcharge weights shallbe placed.
2. Seat the penetration piston at the center of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the pistonon the sample is established.
3. Set the load and deformation gauges to read zero. Apply the load on the pistonso that the penetration rate is about 1.25 mm/min.
4. Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0,7.5, 10 and 12.5 mm.
5. Raise the plunger and detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 30 mm layer and determine the moisturecontent.

5. Observation and Recording

Penetration(mm)	**Applied Load (kg)**
0.50	
1.00	
1.50	
2.00	
2.50	
4.00	
5.00	
7.50	

10.00	
12.50	

Table 2 : Recordings during CBR Test

6. Calculation

1. If the initial portion of the curve is concave upwards, apply correction by drawinga tangent to the curve at the point of greatest slope and shift the origin. Find andrecord the correct load reading corresponding to each penetration.

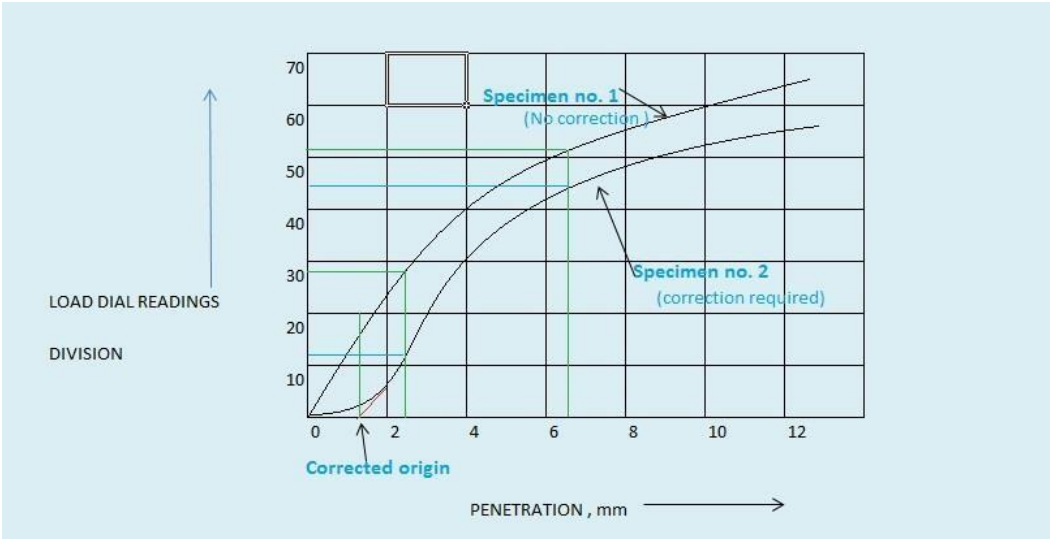
$$\textbf{C.B.R.} = (P_T/P_S) \times 100$$

Where P_T = Corrected test load corresponding to the chosen penetration fromthe load penetration curve.
P_S = Standard load for the same penetration taken from the table above.

2. C.B.R. of specimen at 2.5 mm penetration =
3. C.B.R. of specimen at 5.0 mm penetration =
4. The C.B.R. values are usually calculated for penetration of 2.5 mm and 5 mm. Generally the C.B.R. value at 2.5 mm will be greater than at 5 mm and in such a case/the former shall be taken as C.B.R. for design purpose. If C.B.R. for 5 mm exceeds that for 2.5 mm, the test should be repeated. If identical results follow,the C.B.R. corresponding to 5 mm penetration should be taken for design.

7. Graph

Draw graph between Load versus Penetration.



BERNOULLIS THEOREM

OBJECTIVE

1. To demonstrate the variation of the pressure along a converging-diverging pipe section.

2. The objective is to validate Bernoulli's assumptions and theorem by experimentally proving that the sum of the terms in the Bernoulli equation along a streamline always remains a constant.

Apparatus Required: Apparatus for the verification of Bernoulli's theorem and measuring tank with stop watch setup for measuring the actual flow rate.

THEORY:

The Bernoulli theorem is an approximate relation between pressure, velocity, and elevation, and is valid in regions of steady, incompressible flow where net frictional forces are negligible. The equation is obtained when the Euler's equation is integrated along the streamline for a constant density (incompressible) fluid. The constant ofintegration (called the Bernoulli's constant) varies from one streamline to another but remains constant along a streamline in steady, frictionless, incompressible flow. Despiteits simplicity, it has been proven to be a very powerful tool for fluid mechanics.

Bernoulli's equation states that the "sum of the kinetic energy (velocity head), thepressure energy (static head) and Potential energy (elevation head) per unit weight of the fluid at any point remains constant" provided the flow is steady, irrotational, and frictionless and the fluid used is incompressible. This is however, on the assumptionthat energy is neither added to nor taken away by some external agency. The key approximation in the derivation of Bernoulli's equation is that viscous effects are negligibly small compared to inertial, gravitational, and pressure effects. We can write the theorem as

Pressure head $(\frac{P}{\rho g})$+ Velocity head $(\frac{V^2}{2g})$+ Elevation (Z) = a constant

Where, P = the pressure.(N/m^2)

r = density of the fluid, kg/m^3

V = velocity of flow, (m/s)

g = acceleration due to gravity, m/s^2

Z = elevation from datum line, (m)

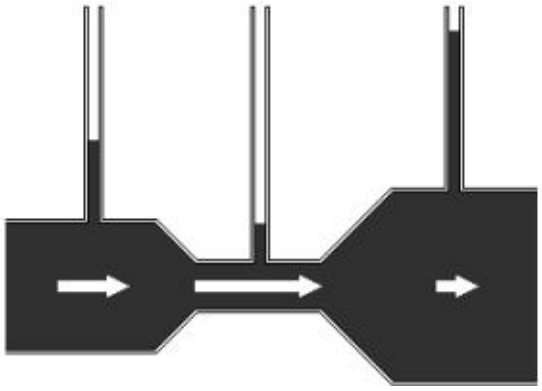


Figure 1.1: Pressure head increases with decrease in velocity head.

$$\mathbf{P_1/w+V_1^2/2g+Z_1= P_2/w+V_2^2/2g+Z_2= constant}$$

Where **P/w** is the pressure head

V/2g is the velocity head

Z is the potential head.

The Bernoulli's equation forms the basis for solving a wide variety of fluid flow problems such as jets issuing from an orifice, jet trajectory, flow under a gate and over a weir, flow metering by obstruction meters, flow around submerged objects, flows associated with pumps and turbines etc.

The equipment is designed as a self-sufficient unit it has a sump tank, measuring tank and a pump for water circulation as shown in figure1. The apparatus consists of a supply tank, which is connected to flow channel. The channel gradually contracts for a length and then gradually enlarges for the remaining length.

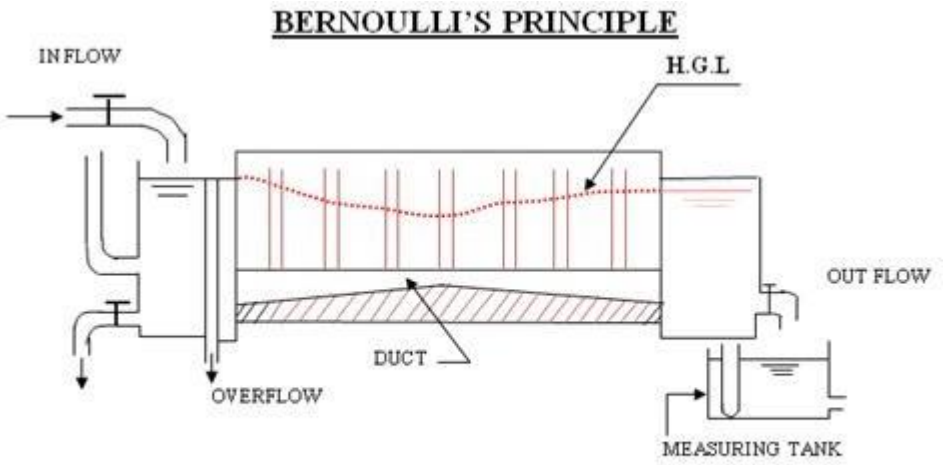


FIG.NO. 1 BERNOULLI'S APPARATUS

In this equipment the **Z** is constant and is not taken for calculation.

Procedure:

1. Keep the bypass valve open and start the pump and slowly start closing valve.
2. The water shall start flowing through the flow channel. The level in the Piezometer tubes shall start rising.
3. Open the valve on the delivery tank side and adjust the head in the Piezometer tubes to steady position.
4. Measure the heads at all the points and also discharge with help of diversion pan in the measuring tank.
5. Varying the discharge and repeat the procedure.

Observations:

Distance between each piezometer = 7.5 cm

Density of water = 0.001 kg/cm^3

1) Note down the Sl. No's of Pitot tubes and their cross sectional areas.
2) Volume of water collected q =..... cm^3
3) Time taken for collection of water t = ...sec

OBSERVATION & RESULT TABLE:

Tube No	**Area of the flow 'A' in (cm^2)**	**Discharge 'Q' in (cm^3/sec)**	**Velocity 'V' in (cm/sec)**	**Velocity head in (cm)**	**Pressure head in (cm)**	Total head **'H' (cm)**
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						

Sample Calculations:

1. Discharge Q = q / t = ... cm^3/sec

2. Velocity V= Q/ A= ..... = ...cm/sec

Where A is the cross sectional area of the fluid flow

3. Velocity head **$V^2/2g$ = ...cm**

4. Pressure head (actual measurement or piezometer tube reading)

P/w=.....cm

5. Total Head

H = Pressure head + Velocity Head =..... **cm**

Result & Discussion:

- Plot the graph between P/w and x.
- Plot the graph between $V^2/2g$ and x.

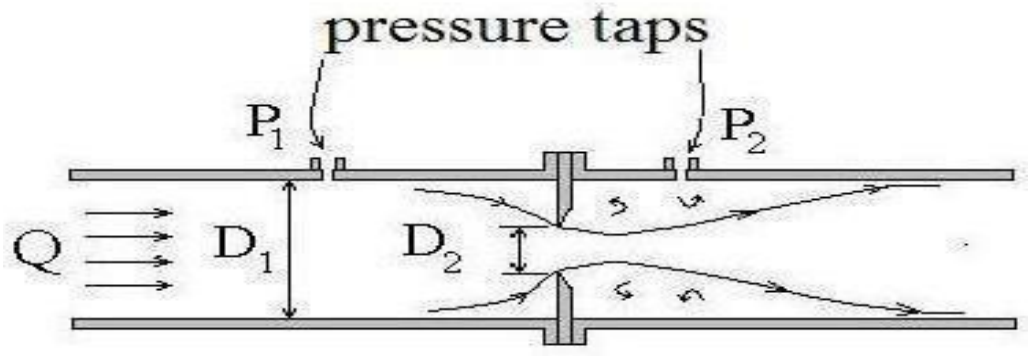
COEFFICIENT OF DISCHARGE BY ORIFIC MATER &VENTURI METER

Aim: - To calibrate a given Orifice meter and to study the variation of coefficient of discharge.

Apparatus:-

The apparatus consists of (1) Orifice meter (2) Piping system (3) supply pump set (4) Measuring tank (5.) Differential manometer (6) Sump

Theory: An orifice meter is a simple device used for measuring the discharge through pipes. The basic principle on which an Orifice meter works is that by reducing the cross – sectional area of the flow passage, a pressure difference between the two sections before and after Orifice is developed and the measure of the pressure difference enables the determination of the discharge through the pipe. However an Orifice meter is a cheaper arrangement for discharge measurement through pipes and its installation requires a smaller length as compared with venturimeter. As such where the space is limited, the Orifice meter may be used for the measurement of discharge through pipes.



Specification:-

1. **Flow Meters:** Consists of Orifice meter of size 25 mm provided for experiments. The meter has the adequate cocks also with them.
2. **Piping System:** Consists of a set of G.I. piping of size 25 mm with sufficient upstream and downstream lengths provided with separate control valves and mounted on a suitable stand. Separate upstream and downstream pressure feed pipes are provided for the measurement of pressure heads with control valves situated on a common plate for easy operation.

3. **Supply Pump Set:** Is rigidly fixed on sump. The mono block pump with motor. Operating on single phase 220/240 volts 50 Hz AC supply.
4. **Measuring Tank:** Measuring tank with gauge glass and scale arrangement for quick and easy measurement.
5. **Differential Manometer:** Differential manometer with 1 mm scale graduations to measure the differential head produced by the flow meter.
6. **Sump:** Sump to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

Procedure:-

1. First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.
2. Check whether all the joints are leak proof and water tight. Fill the manometer to about half the height with mercury.
3. While taking readings, close all the cocks in the pressure feed pipes except the two (Down stream and upstream) cocks which directly connect the manometer to the required flow meter, for which the differential head is to be measured. (Make sure while taking reading that the manometer is properly primed. Priming is the operation of filling the manometer upper part and the connecting pipes with water and venting the air from the pipes).

Close all the cocks, pressure feed pipes and manometer to prevent damage and over loading of the manometer.

4. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertically.
5. Check proper electrical connections to the switch, which is internally connected to the motor.
6. Start the motor keeping the delivery valve close. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.
7. By regulating the valve control the flow rate and select the corresponding pressure tapings (i.e. of orifice meter).
8. Make sure while taking readings, that the manometer is properly primed. Priming is the operation of filling the manometer s upper part and the connecting pipes with water by venting the air from the pipes. Note down the difference of head "h" from the manometer scale.
9. Note down the time required for the rise of 10cm (i.e. 0.01m) water in the collecting tank by using stop watch.

Sample calculations:-

1. Calculate actual discharge using the formula

   Discharge: - The time taken (t) to collect some R cm of water in the collecting tank

   $$Q_{act} = A \times R/t$$

   Where:

   A = Area of the collecting tank in m² (0.3m X 0.3m)

   R = Rise of water level taken in meters (say 0.1m or 10cm)

   t = Time taken for rise of water level to rise "R" cm in t seconds.

2. Using difference in mercury level "h" calculate the theoretical discharge of venturimeter

$$Q_{th} = \frac{a_1 * a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

Where,

a_1= Area of venture at inlet = $(\prod /4)\ d_1^2$ m^2

a_2= Area of venture at throat = $(\prod /4)\ d_2^2$ m^2

h = difference of head in meters = (h_1-h_2) x (= (h_1-h_2) X 12.6 m

g =Acceleration due togravity.

d_1 =Inlet diameter in meters.

d_2 =Throat diameter inmeters.

10.

S. No.	Time for (10 cm) raise of water level in sec.	Actual discharge = Q_{act}	Differential head in mm of mercury			Theoretical discharge = Q_{the}	$C_d = Q_{act}/Q_{the}$
			h_1	h_2	H		
1							
2							
3							
4							
5							
6							
7							

Assume:

S.No.	Orifice inlet diameter d_1	Orifice diameter d_2
1.	25mm	13.0mm

Precautions:-

1. Do not run the pump dry.
2. Clean the tanks regularly, say for every 15days.
3. Do not run the equipment if the voltage is below 180V.
4. Check all the electrical connections before running.
5. Before starting and after finishing the experiment the main
6. Control valve should be in closed position.
7. Do not attempt to alter the equipment as this may cause

Results and Conclusions:-

Graphs: Draw the graphs between Q_{act} Vs Q_{the} Draw the graphs between C**d** Vs Q_{act}

Applications of Orifice meter: It is used as a flow measuring device.

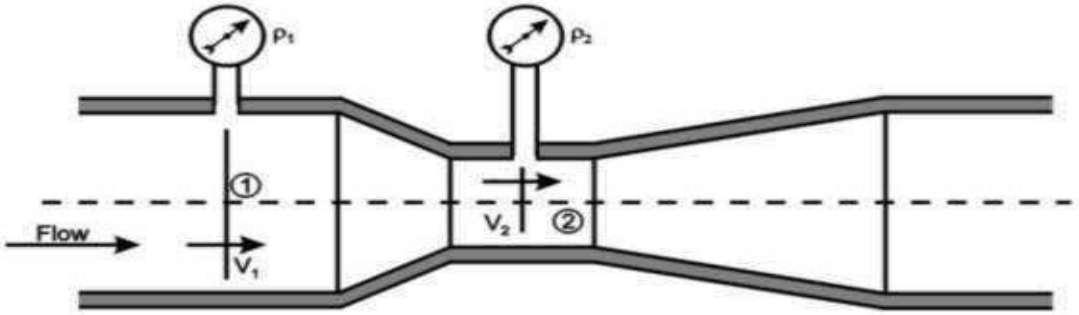
Aim: - To calibrate a given venture meter and to study the variation of coefficient of discharge of it with discharge.

Apparatus: -.

(1) Venturi Meter

(2) Piping System

(3) Supply Pump Set
(4) Measuring Tank
(5) Differential Manometer
(6) Sump
(7) Stop Watch



Theory: - A venture meter is a device that is used for measuring the rate of flow of fluid through a pipeline. The basic principle on which a venture meter works is that by reducing the cross - sectional area of the flow passage, a pressure difference is created between the inlet and throat & the measurement of the pressure difference enables the determination of the discharge through the pipe. A Venturi meter consists of an inlet section followed by a convergent cone, a cylindrical throat, and gradually divergent cone.

The inlet section of the venture meter is of the same diameter as that of the pipe, which is followed by a convergent one. The convergent cone is a short pipe, which tapers from the original size of the pipe to that of the throat of the venturi meter. The throat of the venturi meter is a short parallel side tube having its cross – sectional area smaller than that of the pipe. The divergent cone of the venturi meter is a gradually diverging pipe with its cross – sectional area increasing from that of the throat to the original size of the pipe. At the inlet and the throat, of the venture meter, pressure taps are provided through pressure rings.

Specifications:-

Flow Meters: Consists of venture meter of size 25 mm provided for experiments. The meter has the adequate cocks also with them

Piping System: Consists of a set of G.I. piping of size 25 mm with sufficient upstream and downstream lengths provided with separate control valves and mounted on a suitable stand. Separate upstream and downstream pressure feed pipes are provided for the measurement of pressure heads with control valves situated on a common Pipe for easy operation

Supply Pump Set: Is rigidly fixed on sump. The mono block pump with motor, operating on single phase 220/240 volts 50 Hz AC supply.

Measuring Tank: Measuring tank with gauge glass and scale arrangement for quick and easy measurement.

Differential Manometer: Differential manometer with 1 mm scale graduations to measure the differential head produced by the flow meter.

Sump: Sump to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

Procedure:-

1. Check whether all the joints are leak proof and water tight. Fill the manometer to about half the height with mercury

2. Close all the cocks, pressure feed pipes and manometer to prevent damage and overloading of the manometer. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water height and vertically.

3. Check proper electrical connections to the switch, which is internally connected to the motor. First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.

4. The actual discharge is measured with the help of the measuring tank. The differential head produced by the flow meter can be found from the manometer for any flowrate.

5. Start the motor keeping the delivery valve close. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.

6. By regulating the valve control the flow rate and select the corresponding pressure tapings (i.e. of orifice meter).Make sure while taking readings, that the manometer is properly primed. Priming is the operation of filling the manometers upper part and the connecting pipes with water by venting the air from the pipes.

7. Note down the difference of head "h" from the manometer scale, and time required for the rise of 10cm (i.e. 0.01m) water in the collecting tank by using stop watch.

Sample Calculations:-

1. Calculate actual discharge using below formula.

Discharge: - The time taken to collect some, R cm of water in the collecting tank in m^3/sec.

$$Q_{act} = \frac{A \times R}{t}$$

PENITRATION TEST OF BITUMEN

AIM

To determine consistency of bitumen or the grade of the bitumen by penetration test.

THEORY

Bitumen is the residue or by-product obtained by the refining of crude petroleum. A wide variety of refining techniques like straight distillation technique, solvent extraction technique etc are used to produce bitumen of different consistency and other desirable properties. Depending on the origin and other characteristics of the crude oils and property of bitumen required, more than one processing method may be employed. The type of construction decides the type of bitumen needs to be used. But in general good bitumen should have following properties.

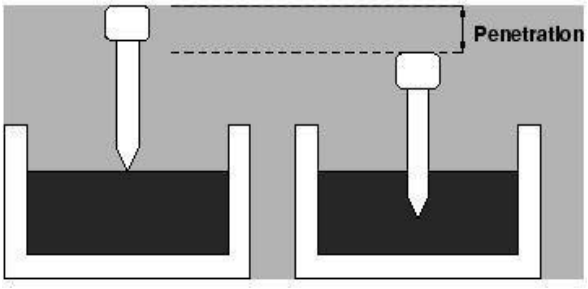
Temperature susceptibility of bitumen: the bitumen mix should not become too soft or unstable during hot weather, and not become too brittle during cold weather.

Viscosity of the bitumen: at the time of mixing and compaction should be adequate. This can be managed by the use of cutbacks or emulsions of suitable grades or heating the bitumen and aggregates prior to mixing.

Affinity and adhesion of bitumen: There should be adequate affinity and adhesion between the bitumen and aggregates used in the mix.

Penetration is a measure of consistency. It quantifies the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds under specified temperature, load and duration of loading. BIS had

standardized the equipment and test procedure. The penetrometer consists of a needle assembly with weight of 100g and a device for releasing and locking in any position. The bitumen is softened to a pouring consistency, stirred thoroughly and poured into containers at a depth at least 15 mm in excess of the expected penetration. The test should be conducted at a specified temperature of 25°C. It may be noted that penetration value is largely influenced by any inaccuracy with regards to pouring temperature, size of the needle, weight placed on the needle and the test temperature. A grade of 40/50 bitumen represents the penetration value is in the range 40 to 50 at standard test conditions. Higher is the penetration of bitumen softer is the consistency. This is one of the most widely used test for classifying bituminous materials into different grades.



Penetration Test on Bitumen

The use of different grade of bitumen depends on climatic conditions and type of construction. Commonly used grades are 30/40, 60/70 and 80/100. For bituminous macadam and penetration macadam, IRC suggests bitumen grades 30/40, 60/70, 80/100. Generally, in warmer regions, lower penetration grades are preferred to avoid softening and in colder regions bitumen with higher penetration grades like 180/200 are used to prevent the occurrence of excessive brittleness. The test is not intended to estimate consistency of softer materials like cut back which are usually graded by viscosity test. High penetration grade is used in spray application works.

The penetration value of bitumen is measured by distance in tenths of mm that a standard needle would penetrate vertically into bitumen sample under standard conditions of test. By this test we can determine the hardness or softness value of bitumen.

In this test, firstly heat the bitumen above its softening point and pour it into a container of depth attest 15mm. bitumen should be stirred wisely to remove air bubbles. Then cool it to room temperature for 90 minutes and then placed it in water bath for 90 minutes.

Then place the container in penetration machine adjust the needle to make contact with surface of sample. Make dial reading zero and release the needle for exactly 5 seconds and note down the penetration value of needle for that 5 seconds. Just repeat the procedure thrice and note down the average value.

Relevant Indian Standard for Penetration Test on Bitumen:

IS 1203-1978 Edition 2.2 (1989-03): Methods for Testing Tar and Bituminous Materials : Determination of Penetration

PROCEDURE

1. The bitumen is softened to a pouring consistency, stirred well and poured into the test containers. The depth of bitumen in container is kept **at least 15mm** more than the expected penetration. (I.S. 1203-1978).

2. Now the sample containers are placed in a temperature controlled water bath at a temperature of 25 c for one hour.
3. Then at the end of one hour, the sample is taken out of water bath and the needle is brought in contact with the surface of bitumen sample at that time reading of dial is set at zero or the reading of dial noted, when the needle is in contact with the surface of the sample.
4. After that the needle is released and the needle is allowed to penetrate for ***5 seconds*** and the final reading is recorded. On that sample at least three penetration observations should be taken at distances at least **10 mm** apart. After each test, the needle should be disengaged, wiped with benzene and dried. The amount of penetration is recorded.
5. The main value of three measurements is reported is the penetration test.
6. The accuracy of the test depends upon pouring temperature, size of needle, weight placed on the needle, and test temperature.
7. Te **grade of bitumen** is specified in terms of penetration value. For example, 30/40 grade bitumen indicates the penetration value of the bitumen in the range of 30 to 40 at standard test conditions.
8. Readings are taken as units of penetration

Where, **1 unit = (1/10) mm**

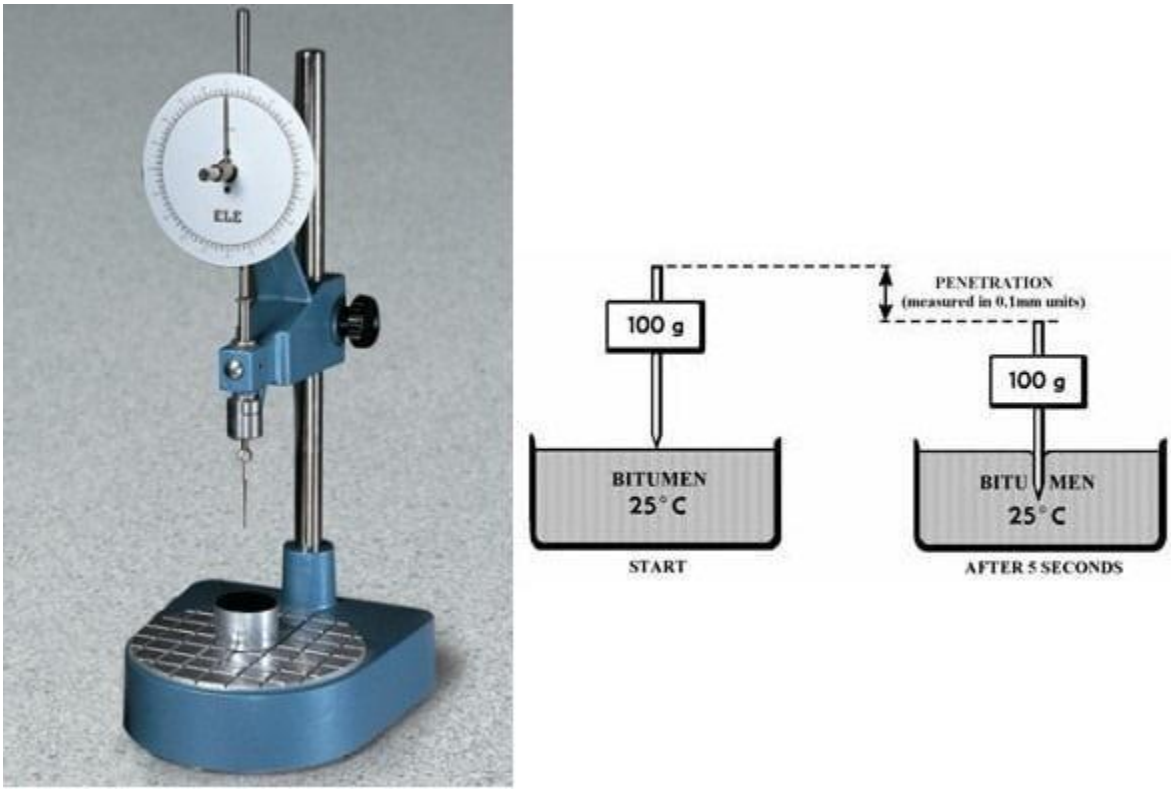


Fig:- Penetration apparatus and concept of penetration test.

Precautions during Penetration Test

- The container should not be moved while needle penetrates into sample.
- The sample should be free from any external materials.
- Benzene is used to clean up the needle and dried before penetration.
- Penetration test of bitumen is applied exclusively to bitumen. Tars being soft, penetration test on these materials cannot be carried out.

Penetration value of different types of bitumen used in road construction range between 20 to 225 . However 30/40 and 80/100 grade bitumen are more common for road construction depending upon the type of construction and climate conditions. In hot 30/40 bitumen is preferred.

The value of temperature effects the use of the bitumen. Lower penetration grade is used

in warm climate condition to avoid softening and high penetration grade range of 180/210 areused in cold climate condition to prevent it from excessive brittleness.

In the last word, the Penetration test of Bitumen is used for the Garde of bitumen material in terms of its hardness. A 70/100 grade bitumen shows that its penetration value lies between 70 & 100.

DUCTILITY TEST OF BITUMEN

AIM:

1. To measure the ductility of a given sample of bitumen

2. To determine the suitability of bitumen for its use in road construction

THEORY:-

The property of bitumen which allows it to undergo deformation or elongation is called ductility of bitumen. The ductility of bitumen is measured by the distance in Cm (centimeter), to which the bitumen sample will elongate before breaking when it is pulled by standard specimen at specified speed and temperature.

APPARATUS :

Briquette mould, (length – 75mm, distance between clips – 30mm, width at mouth of clips – 20mm, cross section at minimum width – 10mm x 10mm), Ductility machine with water bath a pulling device at a precaliberated rate, a putty knife, thermometer.

PROCEDURE

1. Melt the bituminous test material completely at a temperature of 75^{o}C to 100^{o}C above the approximate softening point until it becomes thoroughly fluid

2. Strain the fluid through IS sieve 30.

3. After stirring the fluid, pour it in the mould assembly and place it on a brass plate

4. In order to prevent the material under test from sticking, coat the surface of the plate and interior surface of the sides of the mould with mercury or by a mixture of equal parts of glycerin and dextrin

5. After about 30 – 40 minutes, keep the plate assembly along with the sample in a water bath. Maintain the temperature of the water bath at $27^{o}C$ for half an hour.

6. Remove the sample and mould assembly from the water bath and trim the specimen by leveling the surface using a hot knife.

7. Replace the mould assembly in water bath maintained at $27^{o}C$ for 80 to 90 minutes

8. Remove the sides of the moulds

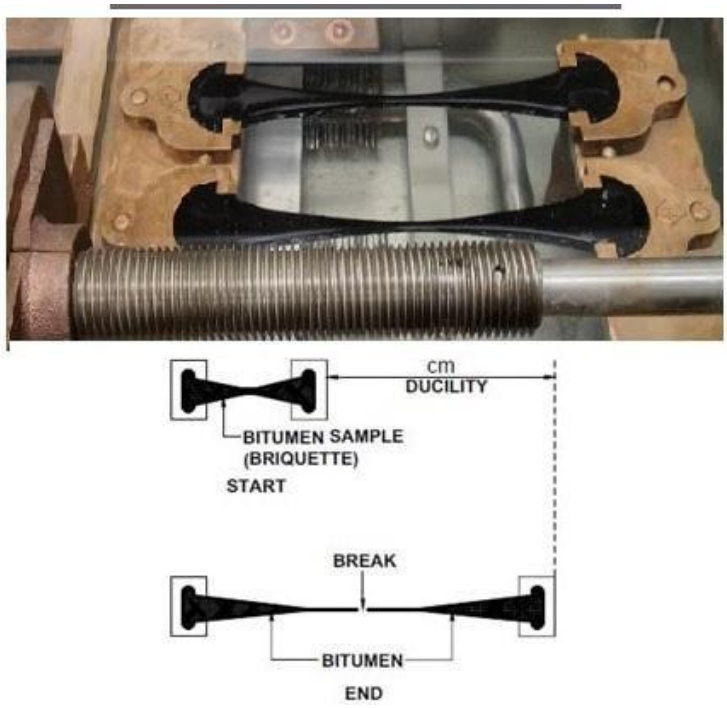
9. Hook the clips carefully on the machine without causing any initial strain

10. Adjust the pointer to read zero

11. Start the machine and pull two clips horizontally at a speed of 50mm per minute

12. Note the distance at which the bitumen thread of specimen breaks.

13. Record the observations in the proforma and compute the ductility value report the mean of two observations, rounded to nearest whole number as the “Ductility Value”



RECORD AND OBSERVATIONS:

I. Bitumen grade = _

II. Pouring temperature oC =

III. Test temperature oC =

IV. Periods of cooling, minutes =

a) In air =

b) In water bath before trimming =

c) In water bath after trimming =

RESULT:

The Ductility value of given bitumen is _____

TURBIDITY BY NEPHELOMETER

Aim
To find out the turbidity of the given sample.

Principle:
When light in passed through a sample having Suspended particles, some of the light in Scattered by the particles. The scattering to the light is generally proportional to the turbidity. The turbidity of sample is thus measured from the amount of light scattered by the sample, taking a reference with standard turbidity suspension.

Apparatus Required:
Nephelometers turbidimeter, Sample tubes**.**

Reagents Preparation
1. Dissolve 1.0gm Hydrazine sulphate and dilute to 100ml
2. Dissolve 10gm Hexa methylene Tetra min& and dilute in l00ml
3. 5ml of each of the above solution (1 and 2) in a l00ml volumetric flask and allow to stand for 24 hrs at 25±3°C and dilute to l000ml. This solution has a turbidity of 40NTU.

Procedure:
1. The Nephelometer turbidimeter in switched on and waited for few minutes till it warms up.
2. The instrument is set up with a 4ONTU standard suspension
3. The sample is thoroughly shaked and kept it for sometimes so the air bubbles are eliminated
4. The sample is taken in Nephelometer sample tube and the sample is put in Sample chamber and the reading is noted directly.
5. The sample is diluted with turbidity free water and again the turbidity is read.

Environmental Significance
Turbidity is objectionable because of

a. Aesthetic considerations and
b. Engineering considerations

When turbid water in a small, transport container. such as drinking glass is help up to the light, an aesthetically displeasing opaqueness or ȝmilky coloration is apparent

The colloidal material which exerts turbidity provides adsorption sites for chemicals that may be harmful or cause undesirable tastes and odours & for biological organism that may be harmful. Disinfections of turbid water is difficult because of the adsorptive characteristics of some colloids and because the solids may partially shield organisms from disinfectant.

In natural water bodies, turbidity may impart a brown or other colour to water and may interfere with light penetration and photosynthetic reaction in streams and lakes.
Turbidity increases the load on slow sand filters. The filter may go out of operation, if excess turbidity exists.

Application of Turbidity Data in Environmental Engineering Practice:
Turbidity measurements of particular importance in the field of water supply. They have limited use in the field of domestic and Industrial waste treatment.
1. Knowledge of the turbidity variation in raw water supplies along with other information is useful to determine whether a supply repairs Special treatment by chemical coagulation and filtration before it may be used for a public water supply.
2. Turbidity measurements are used to determine the effectivness of the treatment produced with different chemicals and the dosages needed.
3. Turbidity measurements help to gauge the amount of chemicals needed from day-today in the operation of water treatment works.
4. Measurement of turbidity is settled water prior to filtration is useful in controlling chemical dosages so as to parent excessive loading or rapid sand filters.
5. Turbidity measurements of the filtered water are needed to check o faculty filter operation.
6. Turbidity measurements are useful to determine the optimum dosage of coagulants to treat the domestic and Industrial wastes.
7. Turbidity determination is used to evaluate the performance of waste treatment plants.

OBSERVATION :
Source of sample :
Date of collection :
Time :
Temperature :

Tabulation

S.No.	Burette Reading (ml)		Vol $Na_2S_2O_3$ consumed X (ml)	% of chlorine in powder sample = $\frac{X*0.71}{M}$
	Initial	Final		

Calculation:

Chlorine in mg/L in chlorine solution = ml of $Na_2S_2O_3$ consumed i.e X*35.5*1000*.0.025

Ml of chlorine solution

% age chlorine in sample = mg/1 of chlorine X 100

Mg/1 of powder

= X 35.5×100

5000 M

= X*0.71 %

Result:

The turbidity of Tap water =
Synthetic sample =

pH BY pH METER

Aim:

To determine the pH value of the given sample by electrometric method.

Apparatus Required

pH meter with combined electrode, beakers

Chemicals Required

Buffer tablet of pH values 4 and 9.2

Reagents preparation

Buffer solution of pH value 4

Buffer tablet of pH value 4 is dissolved in 100 ml of distilled water. This solution should preferably be stored in a plastic bottle in cool place.

Buffer solution of pH value 9.2

Buffer tablet of pH value 9.2 is dissolved in 100 ml of distilled water. This solution should preferably be stored in a plastic bottle in cool place.

Procedure:

Electrometric method:

1. Wash the combined electrode of pH meter with distilled water and clean the same with distilled water.
2. Dip the combined electrode in the buffer solution of pH value 4.
3. Adjust the temperature by the adjustment knob to an ambient (room) temperature.
4. If the instrument shows the reading as 4 then it is in order if not, adjust the reading to 4.0 by calibration adjustment knob.
5. Wash the electrode of pH meter with distilled water and clean the same with distilled water and dip it to the buffer solution of pH value 9.2.
6. Note the reading if the instrument shows the reading as 9.2 then it is in order otherwise use the calibration adjustment knob and bring the reading to 9.2.
7. Repeat the above procedure until the meter shows reading as 4 when electrode is dip in buffer solution of pH 4 and shows reading as 9.2 when electrode is dip in buffer solution of pH value 9.2.
8. Now the instrument is calibrated.

9. After cleaning the electrode dip in the sample for which p1! value is to be found out.
10. Directly record the reading from the meter without doing any adjustments.

Environmental significance

pH (6.5 to 8.5) has no direct effect on health however a lower value below 4 will produce sour taste and higher value above 8.5 a bitter taste. Higher values of p1-I have scale formation in water heating operators and also reduce the germicidal potential of chlorine. High pH induces the formation of trihalomethanes which are causing cancer in human beings.

pH below 6.5 starts corrosion in pipes, thereby releasing toxic metals such as zinc, lead, cadmium & copper etc., According to BIS water for domestic consumption should have pH between 6.5 to 8.5

Application of pH data in environmental engineering practice

1. Determination of pH is one of the important objective in biological treatment, if the pH goes below 5 due to excess accumulation of acids, the process is severely affected. Shifting of pH beyond 5 to 10 upsets the aerobic treatment of the waste waters. In these circumstances, the pH can be adjusted by addition of suitable acid or alkali to optimize the treatment of waste water.

2. Its range is of immense value for any chemical reaction. A chemical value shall be highly effective at particular pH. Chemical coagulation; disinfection, water softening and corrosion control are governed by pH adjustment.

3. Dewatering of sludges, oxidation of cyanides and reduction of hexa covalent chromium in to trivalent chromium also need a favorable range 4. It is used in the calculation of carbonate, bicarbonate, C02 calculation, stability index and acid- base equilibrium.

OBSERVATION :
Source of sample :
Date of collection :
Time :
Temperature :

Jar No	**Amount of coagulant added (g)**	**Floc formation (ml)**

Result:

The pH value of the given sample by electrometric method is _____

CHLORIDE CONTENT

Aim
To determine the amount of chloride present in the given sample

Apparatus required
Burette with stand, pipette, conical flask measuring jar etc.,

Chemicals Required
Sodium Chloride, Silver nitrate, Potassium Chromate

Reagents preparation

Silver Nitrate Solution
Dissolve 1 .2g of silver nitrate in distilled water and make up to 250 ml.
Sodium chloride Solution (O.028N)
Dissolve 0.1 648g of sodium chloride in distilled water and make up to 100ml.
Potassium Chromate Solution (K2CrO4)
Dissolve 1 gm of potassium chromate in 20m1 of distilled water.

Procedure
Standardization of Silver Nitrate Solution

1. Pipette 20 ml of sodium chloride solution in to the conical flask.
2. Add one or two drops of potassium chromate solution.
3. Titrate against Silver Nitrate solution until the appearance of reddish brown colour
4. Re peat the titration for concordant values.

Silver Nitrate Vs Sample -
1. Pipette 20 ml of sample in the conical flask.
2. Add one or two drops of potassium chromate solution
3. Titrate against silver Nitrate solution until the appearance of reddish brown colour.
4. Repeat the titration for concordant values.

Environmental Significance of Chlorides
Chloride associated with sodium exerts salty taste, when its concentration is more than 250 mg/1 .There is no known evidence that chloride- constitute any human health hazard. For this reason, chlorides a re generally limited to 250 mg/L in supplies intended for public use. In many areas of world where water supplies are scarce, sources containing as much as 2000mg/L are used for domestic purposes without the development of adverse effect once the human system becomes adapted to the water.

It can also corrode concrete by extracting calcium in the form of calcide. Magnesium chloride in water generates hydrochloric acid after heating which is also highly corrosive and create problems in boilers.

Application of chlorides data in environmental engineering practice

1. Chlorides determination in natural waters is useful in the selection of water supplies for human use.
2. Chlorides determination is used to determine the type of desalting operators to be used.
3. The chloride determination is used to control pumping of ground water from locations where intrusion of sea water is a problem.
4. Chlorides interfere in the determination of COD a correction must be made on the basis of the amount of chloride present. -

OBSERVATION :
Source of sample :
Date of collection :
Time :
Temperature :

Tabulation

S.No.	Sample details	Turbidity (NTU)

NTU =*A *(B+C)/C*

Where

A= NTU of diluted sample
B=Volume of dilution water
C=Sample volume taken for dilution, ml.

Result:

Amount of chloride present in the given sample= _____ mg/L

DISSOLVED OXYGEN

Aim:
To determine the amount of Dissolved Oxygen present in the given sample.

Apparatus Required:
Burette with stand ,pipette,conical flask,measuring jar

Chemicals Required:
Sodium Hydroxide, Manganous Sulphate, Potassium iodide, Sodium Thiosuiphate, Conc.H2SO4, Starch

Reagent Preparation:
1. Manganous Sulphate:
12 gms of Manganous Sulphate is dissolved in 25m1 of distilled water.
2. Alkaline —Iodide Solution
9 gms of Sodium Hydroxide and 2.5gms of Potassium iodide are dissolved in 25m1 of distilled water.
3. Sodium thiosulphate Solution (O.O1N)
2.48gms of Sodium thiosulphate is dissolved in 1 litre of water.
4. Starch Solution
Take 1 gm of starch. Prepare paste with distilled water. Make 100 ml with water and boil by stirring and cool it.
5. Pipette Solution:
2m1 of Manganous Sulphate solution and 2ml of alkaline Iodide Solution is added to 250m1 of the sample taken in a reagent bottle. The bottle is stoppered and shaken thoroughly when the precipitate formed is settled, 2ml of Cone. HCL or Conc. H2S04 is added and shaken thoroughly until the precipitate gets dissolved completely.

Procedure:
1. Take 50ml of clear pipette solution in a conical flask
2. Add to it one or two drops of starch indicator until the colour becomes blue.
3. Titrate against Standard Sodium Thiosulphate solution until the disappearance of colour.
4. Repeat the titration for concordant values.

Sanitary Significance:
In liquid wastes Dissolved Oxygen is the most important factor in determining whether aerobic or anaerobic organisms carryout biological changes. If sufficient D.O is available aerobic organisms oxidize the wastes to stable products. If D.O is deficient anaerobic bacteria take part in the conversion and reduce the waste often to obnoxious and nuisance conditions are usually resulted.

Application in Environmental Data:
1. It is one of the most important tests often used in most instances involving stream pollution control.
2. For the survival of aquatic life maintenance of D.O level is a must.
3. Determination of D.O serve as the basis of B.O.D test and thus they are the

foundation of the most important determination used to evaluate pollution strength of sewage and industrial waste.

OBSERVATION :
Source of sample :
Date of collection :
Time :
Temperature :

Tabulation

S.No.	Weight of empty crucible(g) A	Weight of crucible after heated in oven(g) B

Calculation:

Volume of sample taken = 50ml Weight of empty silica crucible = Ag Weight of crucible+precipitate=Bg 233g of $BaSO_4$ contains 96g of SO_4

(B-A) g of $BaSO_4$ will contain = $\frac{96\times(B-A)}{233}$

In 10_6 ml = $\frac{96\times (B-A) \times 10^6}{233\times 50}$ ppm

In terms of me/litre = ppm/48.

Result:

Amount of Dissolved Oxygen present in a given sample is_____