PNS SCHOOL OF ENGINEERING & TECHNOLOGY

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CIVIL ENGINEERING LAB-II

(5th Semester)

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DEPARTMENT OF CIVIL ENGINEERING

EXPERIMENT -1

NAME OF EXPERIMENT:-

To determine the specific gravity of soil by Pycnometer / Density bottle
NEED AND SCOPE : -

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

DEFINITION : - Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water atthat temperature both weights taken in air.

APPARATUS REQUIRED : -

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

PROCEDURE : -

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

2. Weigh the empty bottle with stopper (W_1)

3. Take about 10 to 20 gm of oven soil sample which is cooled in a desiccator. Transfer it to thebottle. 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 about2 hours.

5. Again fill the bottle completely with distilled water put the stopper and keep the bottleunder 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 bottleand the contents (W$_3$).

7. Now empty the bottle and thoroughly clean it. Fill the bottle with only disttiled water andweigh 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$_2$g)			
3	Weight of bottle + dry soil + water (W$_3$ g)			
4	Weight of bottle + water (W$_4$ g)			

CALCULATIONS

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

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

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

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. Soilscontaining organic matter and porous particles may have specific gravity values below
2 0. Soils having heavy substances may have values above 3.0.

EXPERIMENT -2

NAME OF THE EXPERIMENT :-

To determine the field densityof soil by CORE CUTTER METHOD

OBJECTIVE : -

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

NEED AND SCOPE : -

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

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

APPARATUS REQUIRED : -

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

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

3. Cylindrical calibrating container with an internal diameter of 100 mm/200 mm andan 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 100mm/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 shallhave been oven dried and exposed to atmospheric humidity.

9. Suitable non-corrodible airtight containers.
10. Thermostatically controlled oven with interior on non-corroding material tomaintain the temperature between 105^{0}C to 110^{0}C.

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 isrequired to report the test result in terms of dry density. The relationship that can beestablished between the dry density with known moisture content is as follows:

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

$\gamma_d = Dry\ density$

$\gamma_b - Bulk\ density$

$w = water\ content$

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 thetest for which the calibration is used.

2. Allow the sand of volume equal to that of the calibrating container to run out of thecylinder 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 sandfilling 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 backinto 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 makingsure that constant weight (W_1) is maintained. Open the shutter and permit the sand torun 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 furthermovement 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 contentdetermination.

7. OBSERVATIONS AND CALCULATIONS

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

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

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1. 2. 3. 4. 5. 6. 7. 8. 9. 10.	Weight of wet soil from hole W_w gm Weight of sand + cylinder before pouring W_1 gm Weight of sand + cylinder afterpouring W_4 gm Weight of sand in hole $W_b = (W_1 - W_2 - W_4)$ gm Bulk density $g_b = (W_w / W_b)\, g_s$ gm/cc Water content determination Container number Weight of wet soil Weight of dry soil 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.

EXPERIMENT NO.-3

NAME OF THE EXPERIMENT :

To determine the particle size gradation of sand /gravel by sieve analysis.

OBJECTIVE :

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

NEED AND SCOPE OF EXPERIMEN

The grain size analysis is widely used in classification of soils. The data obtained from grain sizedistribution 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 usedto predict soil water movement although permeability tests are more generally used.

Apparatus required : -

1. Balance

2.I.S sieves
3.Rubber pestle and mortar
4.mechanical Sieve Shaker

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

KNOWLEDGE OF EQUIPMENT

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

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

PROCEDURE

1. For soil samples of soil retained on 75 micron I.S sieve
   (a) The proportion of soil sample retained on 75 micron I.S sieve is weighed and recorded weight ofsoil 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 theabove 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 oneach sieve	Cumulative %age retainedon 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 to10%, 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 ofsoil sample taken.
2. Cumulative percentage of soil retained on successive sieve is found.

EXPERIMENT NO- 4

NAME OF THE EXPERIMENT :-

To determine the liquid limit of soil by CASAGRANDE ‘S APPARATUS .

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 fewstrokes of spatula.

PROCEDURE

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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 fewstrokes 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 throughthe 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 halvesof 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 + wetsoil				
Weight of container + drysoil				
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 = ---------------------------

EXPERIMENT NO-5

NAME OF THE EXPERIMENT :-

TO DETERMINE THE PLASTIC LIMIT OF SOIL

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 maintainthe 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 thenearest whole number.

OBSERVATION AND REPORTING

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

Container No.		
Wt. of container + lid, W_1		
Wt. of container + lid + wetsample, W_2		
Wt. of container + lid + drysample, 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

EXPERIMENT NO- 6

NAME OF THE EXPERIMENT :-

TO DETERMINE THE SHRINKAGE LIMIT OF SOIL

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 occurbefore 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 whengoing 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 aflat 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 onemark 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 thesoil 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 obtainthe 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 measuringjar and find the volume of the shrinkage dish directly. Record this volume as the volume of the wet soil pat.

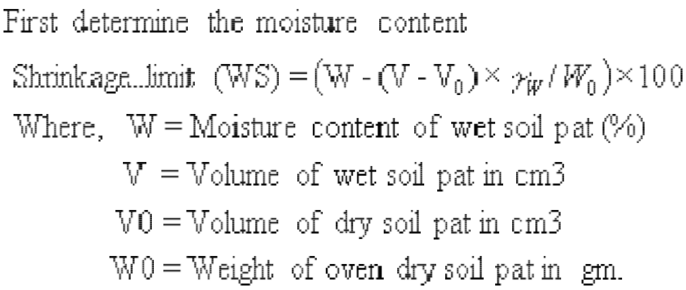
Volume of the Dry Soil Pat

10. Determine the volume of dry soil pat by removing the pat from the shrinkage dishand 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

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 4 5 9 10	Wt. of container in gm,W_1 Wt. of container + wet soil pat in gm,W_2 Wt. of container + dry soil pat in gm,W_3 Wt. of oven dry soil pat, W_0 in gm Wt. of water in gm Moisture content (%), W Volume of wet soil pat (V), in cm Volume of dry soil pat (V_0) in cm^3 Shrinkage limit (W_S) Shrinkage ratio (R)			

EXPERIMENT NO- 7

NAME OF THE EXPERIMENT :-

To determine MDD & OMC of soil by using modified 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 dropto 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 ⍰$_{wet}$ ingrams per cubic centimeter of the compacted soil.

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

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 optimummoisture for the soil.

OBSERVATIONS

Cylinder diameter	cm.
height	cm.
volume	cc
weight of cylinder	gm

Density					
Determination No.					
Water to be added (percent)					
Weightof water to beadded (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 soilgms.					
Wt. Of container + dry soilgms					
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 =_______________

EXPERIMENT -8

DETERMINATION OF CBR VALUE USING CBR TESTING DEVICE.

INTRODUCTION

California bearing ratio is the percentage of stress a soil specimen can resist for a certain amount of penetration relative to the value of stress of which a standard soil could resist. Basically, the value is an indicator of the strength of the soil.

CBR=PsPstd.×100%CBR=PsPstd.×100%

Ps=Stress carried by site soil·
Pstd.=Stress carried by standard soil·

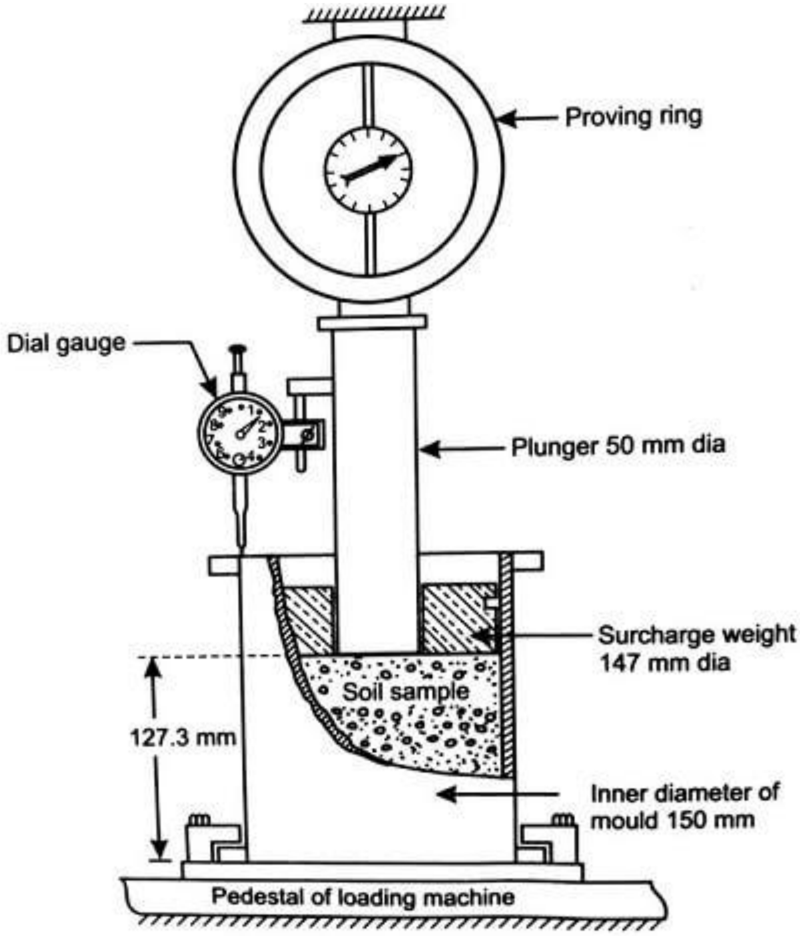
Apparatus required

The followings are the apparatus required to perform the CBR test of soil.

- Loading Machine
- Penetration Piston
- Sieves
- Mold
- Spacer Disk
- Mixing Tools

Loading Machine

with a capability of moving rate 0.05 in. (1.27 mm)/min to apply compressive force in the piston. A penetration measuring device (dial indicator) has to be attached to the machine to provide accurate penetration measurements.



Penetration Piston

A metal piston with 1.954 ± 0.005 in. (49.63 ± 0.13 mm) in diameter and not less than 4 in. (101.6 mm) long.

Sieves

Two sieves are required. ¾ in. (19 mm) & #4 (4.75 mm).

Mold

a rigid metal cylinder with an inside diameter of 6 ± 0.026 inch (152.4 ± 0.66 mm) and a height of 7 ± 0.018 inches (177.8 ± 0.46 mm). It shall be provided with a metal extension collar at least 2.0 inches (50.8 mm) in height.

Spacer Disk

A circular metal spacer disc (see Figure 16.1) having a minimum outside diameter of 5 15/16 inches (150.8 mm). The spacer disc shall be 2.416 ± 0.005 inches (61.37 ± 0.127 mm) in height.

Misc. Mixing Tools

mixing pan, spoon, trowel, spatual, etc.

Rammer for compaction, Balance, Filter Paper, Drying oven, Soaking Tank.

CBR Test Procedure

Detail CBR test procedure is described below.

Specimen Preparation

1. A ¾ in (19 mm) sieve is used to sieve the soil specimen. If all material passes through the sieve, we can use all of it for the test. But some of the material might be retained in the sieve. In that situation have to replace the retained amount with an equal amount of the materials which pass ¾ in the sieve and retained on the #4 sieve.
2. After sieving, make 3 sample specimens each containing 6.8 kg (15 lb).
3. Specimen 1,2,3 will be compacted with about 10, 30 & 56 blows respectively. This will provide variations in the percentage of maximum dry density.
4. Sufficient amounts of water shall be mixed with specimens to maintain optimum water content.
5. The mold shall be attached to the base plate with the extension collar. Then the weight shall be measured. Then a spacer disk shall be placed into the mold with a filter paper on top of the spacer disk.
6. The mold shall be filled with soil in 3 layers. For example: for specimen 1, we have to provide 10 blows per layer with the rammer for the compaction.

The water content of the material shall be determined before and after the compaction procedure.

7. Then the extension collar shall be removed and the top of the mold shall be trimmed with a straightedge to smoothen the surface.
8. The other two specimens shall be compacted following the same procedures mentioned above.
9. Remove spacer disk, base plate. then the weight of Mold plus compacted soil shall be measured.
10. Then invert the mold and soil and attach the base plate to the mold with a coarse filter paper.

Soaking

1. Place a specified amount of surcharge weight (typically 4.54 kg) on top of the base plate.
2. Use a water tank to soak the specimen for around 4 days (96 hrs.)
3. Measure the height of the specimen before and after soaking to determine the swell percentage of the initial height. An expansion measurement equipment can be used for this purpose.
4. After 4 days of soaking, the mold shall be from water. The base plate, filter paper, and surcharge weights shall also be removed. mass of the mold plus soil shall be measured.

Load Test

1. Place the mold under the penetration piston of the compressing machine. The same amount of surcharge weight (4.54 kg) shall be placed on top of the mold.
2. Then the compressing machine shall be started to apply load with a constant penetration rate of 0.05 in. (1.27 mm)/min. The piston will start to penetrate through the soil for the loading.
3. The machine has two indicators. One is a proving ring and another is dial gauge. The dial gauge indicates the penetration and the proving ring will indicate the amount of load is applied to gain that penetration.
4. See the table below, column 2 shall be filled in with corresponding proving ring readings for the penetrations specified in column 1.
5. Proving readings shall be multiplied with machine constant to find the piston load (col. 3)
6. Then penetration stress shall be determined from piston load (col. 4)

California Bearing Ratio Calculation from the Test Values

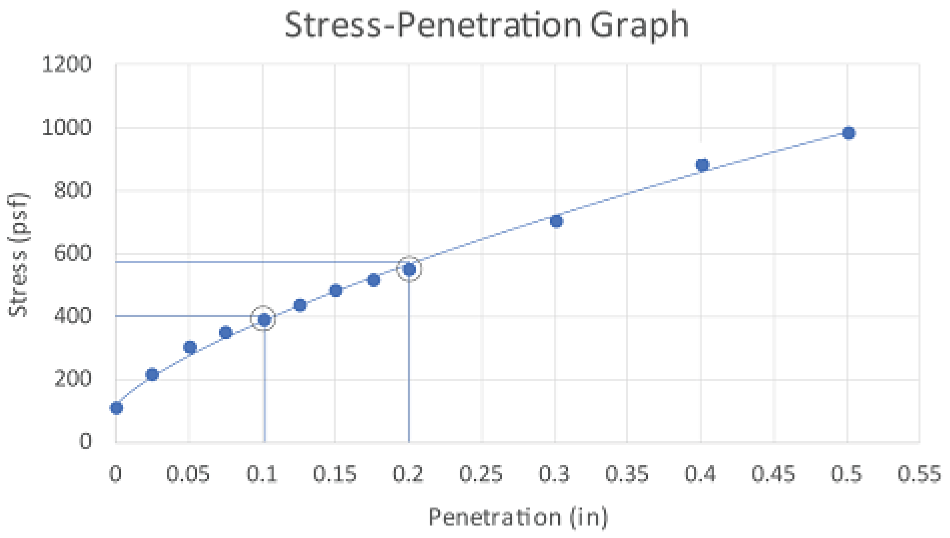
Stress-Strain Curve

Then Stress vs. Penetration (strain) curve shall be drawn. If the curve is concave upward in the near of the origin, the values have to be adjusted according to the guidelines.

CBR Calculation

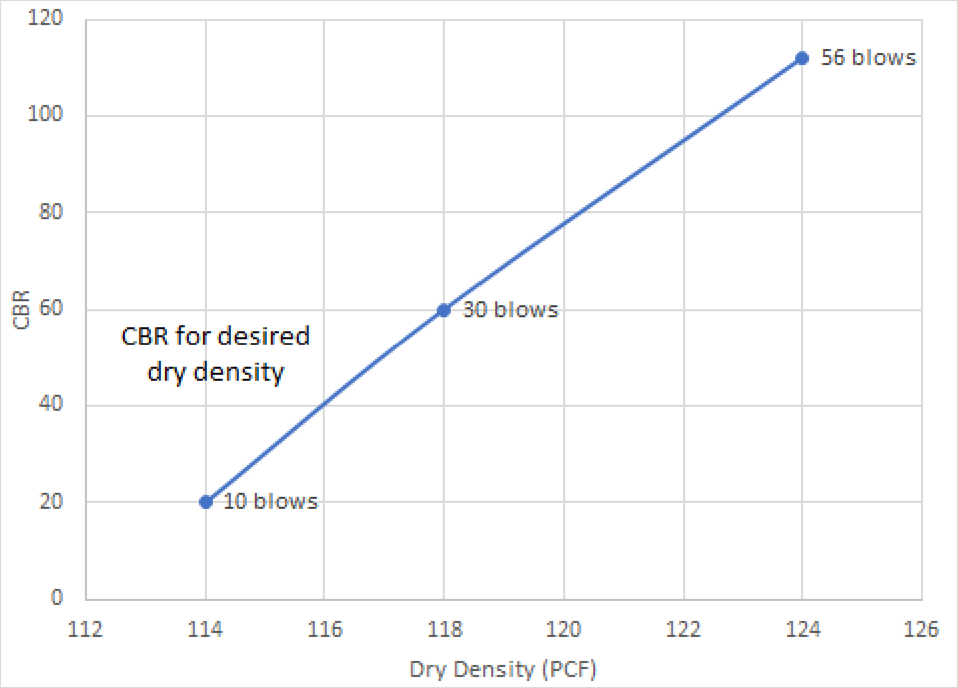
1. From the curve, corresponding stress shall be determined for 0.1 in. (2.55 mm) & 0.2 in (5.08 mm) penetration. See the figure.
2. Use the equation to determine the CBR value
   CBR0.1in=Stressofsoilspecimenfor0.1inpenetration1000psi×100

2. Generally, $CBR_{0.1}$ is taken as a CBR value. But for the condition where, $CBR_{0.1\ in} < CBR_{0.2\ in}$ significantly, the test shall be done again from the beginning.
3. CBR of each specimen shall be determined in this process.



Design Bearing Ratio for Specified Dry Density

The dry density of each specimen (10, 30 & 56 blows) shall be calculated. Then a graph shall be drawn with dry density vs. corresponding CBR values of each specimen. (see the figure). The curve shall be used to determine the CBR value for specified dry density.



Penetration (in)	**Proving Ring (Dial Reading)**	**Piston Load (lb)**	**Penetration Str (psi)**
0			
0.025			
0.05			
0.075			
0.1			
0.125			
0.150			

Penetration (in)	**Proving Ring (Dial Reading)**	**Piston Load (lb)**	**Penetration Str (psi)**
0.175			
0.2			
0.3			
0.4			
0.5			

RESULT…….

CONCLUSION…..

DETERMINATION OF COEFFICIENT 0F PERMEABILITY OF SOIL BY CONSTANT HEAD METHOD(EX-10)

Constant Head Permeability Test :-

The constant head permeability test is a laboratory experiment conducted to determine the permeability of soil. The soils that are suitable for this tests are sand and gravels. Soils with silt content cannot be tested with this method.The test can be employed to test granular soils either reconstituted or disturbed.

Objective and Scope :-

The objective of constant head permeability test is to determine the coefficient of permeability **of a soil. Coefficient of permeability helps in solving issues related to:**

1. **Yield of water bearing strata**
2. **Stability of earthen dams**
3. **Embankments of canal bank**
4. **Seepage in earthen dams**

5. **Settlement Issues**

Apparatus for Constant Head Permeability Test

1. Permeameter mould, internal diameter = 100mm, effective height =127.3 mm, capacity = 1000ml.
2. Detachable collar, 100mm diameter, 60mm height
3. Dummy plate, 108 mm diameter, 12mm thick,
4. Drainage base, having porous disc
5. Drainage cap having porous disc with a spring attached to the top.
6. Compaction equipment such as Proctor's rammer or a static compaction equipment, as specified in IS:2720 (Part VII)-1965.
7. Constant head water supply reservoir
8. Vacuum pump
9. Constant head collecting chamber
10. Stop watch
11. Large funne

11. Thermometer
12. Weighing balance accuracy 0.1g
13. Filter paper.

PROCEDURE

Specimen Preparation

1. Remove the collar of the mould. Measure the internal dimensions of the mould. Weigh the mould with dummy plate to the nearest gram.
2. Apply a little grease on the inside to the mould. Clamp the mould between the base plate and the extension collar and place the assembly on a solid base.
3. Take about 2.5kg of the soil sample, from a thoroughly mixed wet soil, in the mould. Compact the soil at the required dry density using a suitable compacting device.
4. Take a small specimen of the soil in a container for the water content determination.
5. Remove the collar and base plate. Trim the excess soil level with the top of the mould.
6. Clean the outside of the mould and the dummy plate. Find the mass of the soil in the mould.
7. The mould with the sample is now placed over the permeameter. This will have drainage and cap discs properly saturated.

Observation and Calculations

Initially, the flow is very slow. It later increases and will become constant. The constant head permeability test is best for cohesionless soils. Observations and Computation in Constant Head Pemeameter The data that is obtained directly from the tests are:

1. **Length (L) in cm**
2. **Area (A) in cm²**
3. **Constant Head (H) in cm**
4. **Discharge (q) cm³/sec**

Sl. No.	**Observations**	**Determination No.**		
		1	**2**	**3**
	Observations			
1	Mass of empty mould with base plate			
2	Mass of mould, soil and base plate			
3	Hydraulic head (h)			
4	Time interval (t)			
5	Quantity of flow (Q)			
	(a) First time in period t			
	(b) Second time in period t			
	(c) Third time in period t			
	Average Q			
	Calculations			
6	Mass of soil = (2) – (1)			
7	Bulk Density			
8	Water content w			

9	Dry density			
10	Void ratio			
11	Coefficient of permeability Where q= dischargeQ=total volume of watert=time periodh=head causing flow L= length of specimen A= cross-sectional area.			

The dry density and void ratio have to be reported along with the test results.

Results

The coefficient of permeability of given soil, k = _________ mm/sec

The dry density = The void Ratio =

HYDRAUYLICS LABORATORY

VERIFICATION OF BERNOLLI'S THEOREM (EX-2.1)

INTRODUCTION :-

Bernoulli's theorem states - For a continuous, steady and frictionless flow the total head (which is the sum of pressure head, velocity head and elevation head) at any section remains constant.

Total Head = pressure head + velocity head + elevation head

$H = P/w + V^2 / 2g + Z$

Apparatus required

Apparatus required to conduct Bernoulli's experiment are :

- Supply tank
- Tapered inclined pipe with piezometer tubes at different points
- Measuring tank

- Stop watch
- Scale

Test procedure to verify Bernoulli's experiment is as follows :

- Open the inlet valve and allow the water to flow from the supply tank to the receiving tank through a tapered inclined pipe.
- Adjust the flow using an outlet valve to make the head constant in the supply tank. At the constant head, head causing inflow and outflow are equal.
- After adjusting the flow, Note down the readings of the water level of each piezometer tube which are nothing but pressure heads at different points of tapered tube.
- Compute the area of cross-section of tapered pipe at points where piezometer tubes are located.
- Now, take the stopwatch and measure the height of water collected for a particular time interval.
- Also, note down the measuring tank dimensions.
- Repeat the same procedure for different discharges for at least two more times

Observations

Pressure head or Piezometer readings, P/w =

Area of cross section of tapered pipe under piezometer tubes = A_1, A_2, A_3…….

Area of Measuring tank, A =

Height of water collected for "t" interval of time =

Elevation head, Z =

Calculations

Volume of water Collected in measuring tank (V) = Area of measuring tank (A) X height of water collected for "t" interval of time (h)

Discharge Q = volume / time = V/t

Velocity of flow, v = Discharge / Area of cross section of tapered pipe

Velocities under each piezometer tube are $v_1 = Q/A_1$,

$v_2 = Q/A_2$,

$v_3 = Q/A_3$………

Velocity head = $v^2 / 2g$

Total Head = $P/w + V^2 / 2g + Z$

S.no	Discharge, Q (cm^3/sec)	Area of c/s under each piezometer (cm^2)	Velocity of flow under each piezometer (cm/sec)	Pressure Head, P/w (cm)	Velocity Head, v^2 / 2g (cm)	Elevation Head, Z (cm)	Total Head (cm)
1		A_1	v_1				
2		A_2	v_2				
3		A_3	v_3				
4		A_4	v_4				
5		A_5	v_5				

Result

Hence, Bernoulli’s theorem is proved .

DETERMINATION OF COEFFICIENT OF DISCHARGE OF A RECTANGULAR NOTCH FITTED IN OPEN CHANNEL .(EX -2.2)

1. INTRODUCTION

A weir is a barrier across the width of a river or stream that alters the characteristics of the flow and usually results in a change in the height of the water level. Several types of weirs are designed for application in natural channels and laboratory flumes. Weirs can be broad-crested, short-crested, or sharp-crested. Sharp-crested weirs, commonly referred to as *notches*, are manufactured from sharp-edged thin plates. The relationship between the flow rate and water depth above the weir can be derived by applying the Bernoulli’s equation and by making some assumptions with regard to head loss and pressure distribution of the flow passing over the weir. A coefficient of discharge needs to be determined experimentally for each weir to account for errors in estimating the flow rate that is due to these assumptions.

2. PRACTICAL APPLICATION

Weirs are commonly used to measure or regulate flow in rivers, streams, irrigation canals, etc. Installing a weir in an open channel system causes critical depth to form over the weir. Since there is a unique relationship between the critical depth and discharge, a weir can be designed as a flow-measuring device. Weirs are also built to raise the water level in a channel to divert the flow to irrigation systems that are located at higher elevations.

3. OBJECTIVE

The objectives of this experiment are to:

a) determine the characteristics of flow over a rectangular and a triangular weir, and

b) determine the value of the discharge coefficient for both notches.

4. METHOD

The coefficients of discharge are determined by measuring the height of the water surface above the notch base and the corresponding flow rate. The general features of the flow can be determined by direct observation.

5. EQUIPMENT

The following equipment is required to perform the flow over weirs experiment:

- F1-10 hydraulics bench;
- F1-13 rectangular and triangular weirs;
- Vernier height gauge; and
- Stopwatch.

6. EQUIPMENT DESCRIPTION

The flow over the weir apparatus includes the following elements that are used in conjunction with the flow channel in the molded bench top of the hydraulics bench (Figure 9.1).

- A combination of a stilling baffle and the inlet nozzle to promote smooth flow conditions in the channel.
- A vernier hook and point gauge, mounted on an instrument carrier, to allow measurement of the depth of flow above the base of the notch.
- The weir notches that are mounted in a carrier at the outlet end of the flow channel.

THEORY

The depth of water above the base of a weir is related to the flow rate through it; therefore, the weir can be used as a flow measuring device. The relationships of flow over weirs can be obtained by applying the energy equation from a point well upstream of the weir to a point just above the weir crest. This approach requires a number of assumptions, and it yields the following results:

where:

Q : flow rate;

H : height above the weir base;

b : width of rectangular weir (R-notch);

: angle of triangular weir (V-notch);

C_d: discharge coefficient to account for the effects of simplifying assumptions in the theory, which has to be determined by experiment

This experiment will be performed by taking the following steps:

- Ensure that the hydraulics bench is positioned so that its surface is horizontal. This is necessary because the flow over the notch is driven by gravity.
- Mount the rectangular notch plate onto the flow channel, and position the stilling baffle as shown in Figure 9.3.
- Turn on the pump, and slightly adjust the flow control to fill the channel upstream of the weir with water.
- Turn off the pump when the water starts to flow over the weir.
- Wait a few minutes to allow the water to settle.
- Level the point gauge with the water level in the channel. Record the reading as *ho*.

Note: To measure the datum height of the base of the notch (*ho*), position the instrument carrier as shown in Figure 9.3. Then carefully lower the gauge until the point is just above the notch base, and lock the coarse adjustment screw. Then, using the fine adjustment, adjust the gauge until the point just touches the water surface and take a reading, being careful not to damage the notch.

- Adjust the point gauge to read 10 mm greater than the datum.
- Record the reading as *h*.
- Turn on the pump, and slightly adjust the flow until the water level coincides with the point gauge. Check that the level has stabilized before taking readings.
- Measure the flow rate using the volumetric tank.
- Observe the shape of the nappe and take pictures of it.

Note*:* The surface of the water will fall as it approaches the weir. This is particularly noticeable at high flow rates by high heads. To obtain an accurate measurement of the undisturbed water level above the crest of the weir, it is necessary to place the measuring gauge at a distance of at least three times the head above the weir.

- Increase the flow by opening the bench regulating valve to set the heads above the datum level in 10 mm increments until the regulating valve is fully open. Take care not to allow spillage to occur over the plate top that is adjacent to the notch. At each condition, measure the flow rate and observe the shape of the nappe.

  Note: To obtain a sufficiently accurate result, collect around 25 liters of water each time, or collect the water for at least 120 seconds.

- Close the regulating valve, stop the pump, and then replace the weir with the V-notch.
- Repeat the experiment with the V-notch weir plate, but with 5 mm increments in water surface elevation.
- Collect seven head and discharge readings for each weir.

9.1. RESULT

Use the following tables to record your measurements. Record any observations of the shape and the type of nappe, paying particular attention to whether the nappe was clinging or sprung clear, and of the end contraction and general change in shape.

DETERMINATION OF COEFFICIENT OF DISCHARGE OF A VENTURIMETER ,ORIFICEMETER FITTED IN A PIPE .(EX-2.3)

INTRODUCTION :-

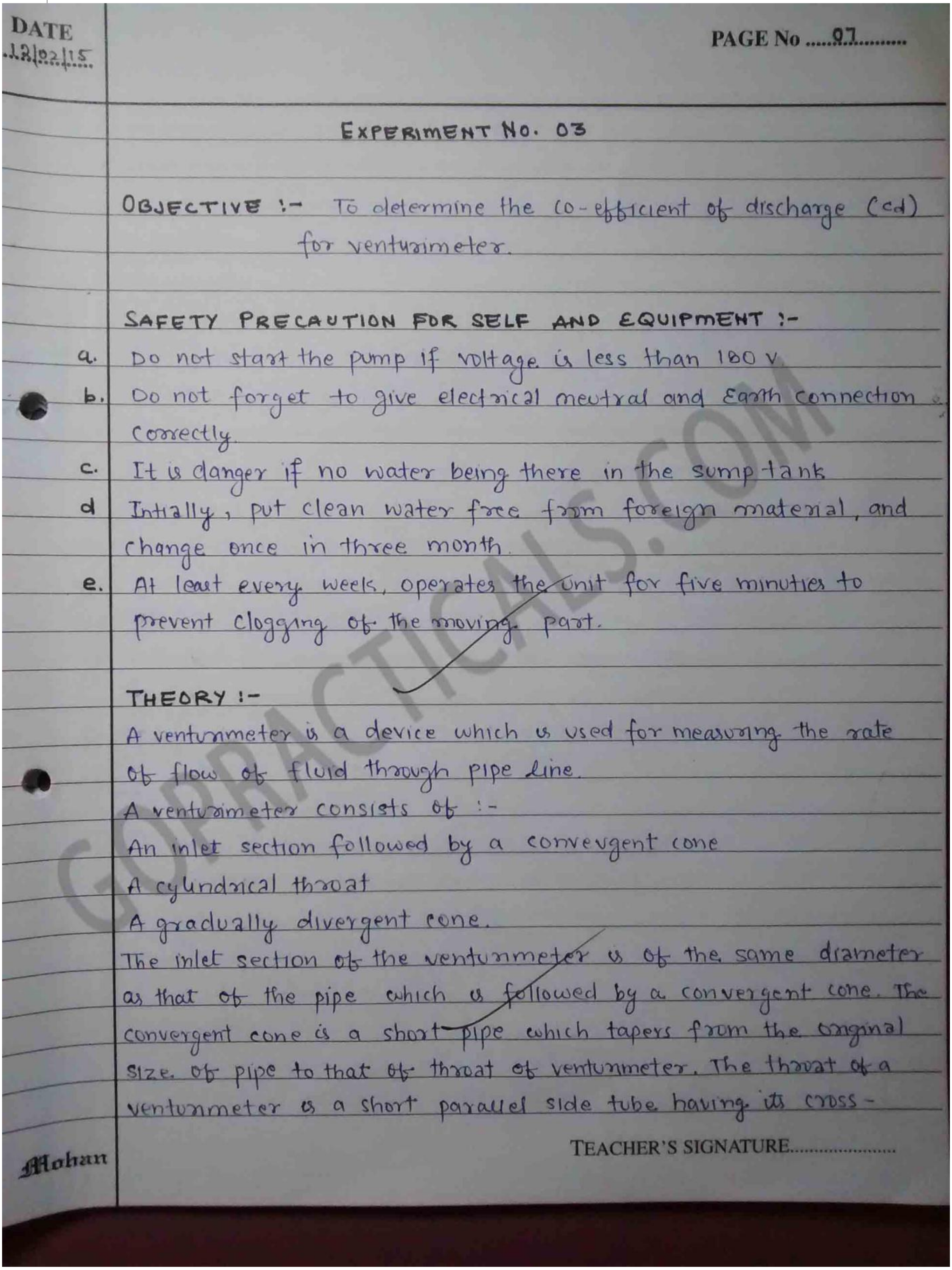
A venturimeter is a device used for measuring the rate of a flow of a fluid flowing through a pipe. It consists of three parts.

1. A short converging part: It is that portion of the venturi where the fluid gets converges.

2. Throat: It is the portion that lies in between the converging and diverging part of the venturi. The cross section of the throat is much less than the cross section of the converging and diverging parts. As the fluid enters in the throat, its velocity increases and pressure decreases.
3. Diverging part: It is the portion of the venturimeter (venturi) where the fluid gets diverges

The working of venturimeter is based on the principle of Bernoulli's equation.

Bernoulli's Statement: it states that in a steady, ideal flow of an incompressible fluid, the total energy at any point of the fluid is constant. The total energy consists of pressure energy, kenetic energy and potential energy or datum energy.



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EXPERIMENT NO. 03

OBJECTIVE :- To determine the co-efficient of discharge (cd) for venturimeter.

SAFETY PRECAUTION FOR SELF AND EQUIPMENT :-

a. Do not start the pump if voltage is less than 180 V.

b. Do not forget to give electrical neutral and Earth connection correctly.

c. It is danger if no water being there in the sump tank

d Intially, put clean water free from foreign material, and change once in three month.

e. At least every weeks, operates the unit for five minuties to prevent clogging of the moving part.

THEORY :-

A venturimeter is a device which is used for measuring the rate of flow of fluid through pipe line.

A venturimeter consists of :-

An inlet section followed by a convergent cone

A cylindrical throat

A gradually divergent cone.

The inlet section of the venturimeter is of the same diameter as that of the pipe which is followed by a convergent cone. The convergent cone is a short pipe which tapers from the original size of pipe to that of throat of venturimeter. The throat of a venturimeter is a short parallel side tube having its cross -

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Mohan

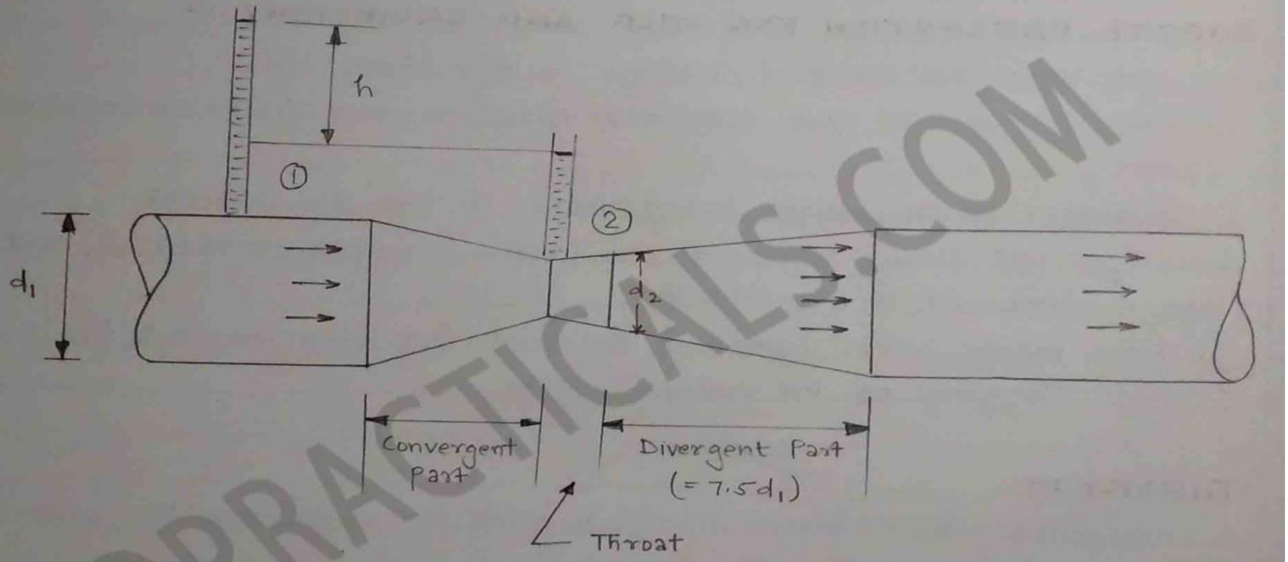

FIG 1.1 VENTURIMETER

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sectional area smaller than that of the pipe. The divergent cone of the venturimeter is gradually diverging pipe with its cross-sectional area increasing from that of the throat to the original size of the pipe.

PROCEDURE :-

a- Fill in the sump tank with clean water
b- Keep the delivery valve closed
c- Connect the power cable to 1Ph, 220V, 10 amp with earthing.
d- Switch-on the pump and open the delivery valve
e- Open the corresponding ball valve of the venturimeter pipe line.
f- Adjust the flow through the control valve of the pump.
g- Open the corresponding ball valves fitted to venturimeter tapping.
h- Note down the differential head reading in the manometer
i- Operate the butterfly valve to note down the collecting tank reading against the known time.
j- Change the flow rate and repeat the experiment.

CALCULATION :-

Area of measuring tank = $0.12 m^2$.
Diameter of venturimeter d = 12.5 mm
Diameter of inlet pipe of venturimeter D = 25 mm

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

$$Q_{Th} = \frac{A_1 A_2 \sqrt{2gH}}{\sqrt{A_1^2 - A_2^2}}$$

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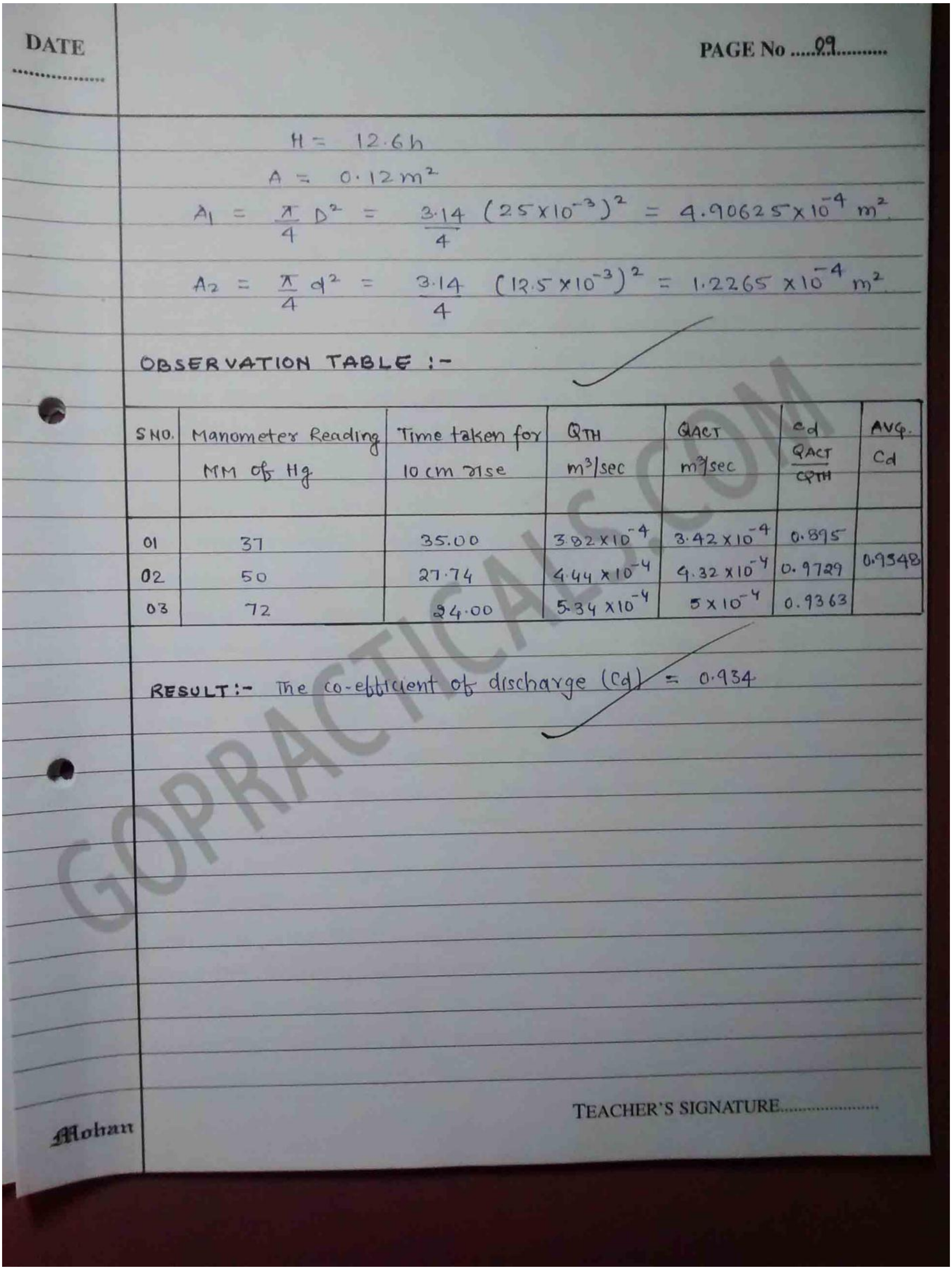

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$H = 12.6h$

$A = 0.12 m^2$

$A_1 = \frac{\pi}{4} D^2 = \frac{3.14}{4} (25 \times 10^{-3})^2 = 4.90625 \times 10^{-4} m^2$

$A_2 = \frac{\pi}{4} d^2 = \frac{3.14}{4} (12.5 \times 10^{-3})^2 = 1.2265 \times 10^{-4} m^2$

OBSERVATION TABLE :-

S NO.	Manometer Reading MM of Hg	Time taken for 10 cm rise	Q_{TH} m^3/sec	Q_{ACT} m^3/sec	Cd $\frac{Q_{ACT}}{Q_{TH}}$	AVG. Cd
01	37	35.00	3.82×10^{-4}	3.42×10^{-4}	0.895	0.9548
02	50	27.74	4.44×10^{-4}	4.32×10^{-4}	0.9729	
03	72	24.00	5.34×10^{-4}	5×10^{-4}	0.9363	

RESULT :- The co-efficient of discharge (Cd) = 0.934

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DETERMINATION OF HEAD LOSS DUE TO FRICTION AND COEFFICIENT OF FRICTION FOR FLOW THROUGH PIPE .(EX-2.4)

INTRODUCTION -

Losses in Pipes

This page provides a quick review of piping losses, starting with Bernoulli's Equation The basic approach to all piping systems is to write the Bernoulli equation between two points, connected by a streamline, where the conditions are known. For example, between the surface of a reservoir and a pipe outlet.

The total head at point 0 must match with the total head at point 1, adjusted for any increase in head due to pumps, losses due to pipe friction and so-called "minor losses" due to entries, exits, fittings, etc. Pump head developed is generally a function of the flow through the system, with head rise decreasing with increasing flow through the pump.

Friction Losses in Pipes

Friction losses are a complex function of the system geometry, the fluid properties and the flow rate in the system. By observation, the head loss is roughly proportional to the square of the flow rate in most engineering flows (fully developed, turbulent pipe flow). This observation leads to the Darcy-Weisbach equation for head loss due to friction:

which defines the friction factor, f. f is insensitive to moderate changes in the flow and is constant for fully turbulent flow. Thus, it is often useful to estimate the relationship as the head being directly proportional to the square of the flow rate to simplify calculations.

Reynolds Number is the fundamental dimensionless group in viscous flow. Velocity times Length Scale divided by Kinematic Viscosity.

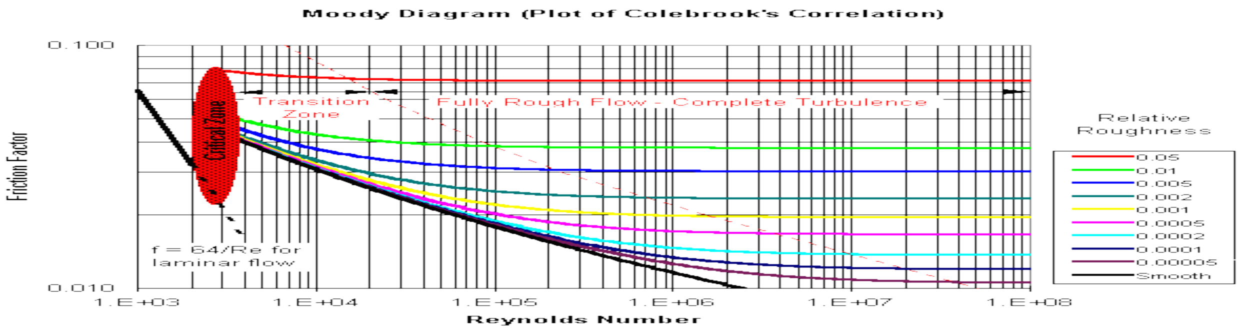
Relative Roughness relates the height of a typical roughness element to the scale of the flow, represented by the pipe diameter, D.

Pipe Cross-section is important, as deviations from circular cross-section will cause secondary flows that increase the pressure drop. Non-circular pipes and ducts are generally treated by using the hydraulic diameter, in place of the diameter and treating the pipe as if it were round.

For laminar flow, the head loss is proportional to velocity rather than velocity squared, thus the friction factor is inversely proportional to velocity.

Geometry Factor k	
Square	56.91
2:1 Rectangle	62.19
5:1 Rectangle	76.28
Parallel Plates	96.00

The Reynolds number must be based on the hydraulic diameter. Blevins (Applied Fluid Dynamics Handbook, table 6-2, pp. 43-48) gives values of k for various shapes. For turbulent flow, Colebrook (1939) found an implicit correlation for the friction factor in round pipes. This correlation converges well in few iterations. Convergence can be optimized by slight under-relaxation.



RESULT –

The familiar Moody Diagram is a log-log plot of the Colebrook correlation on axes of friction factor and Reynolds number, combined with the f=64/Re result from laminar flow.

TRANSPORTATION LABORATORY.....

PENETRATION TEST OF BITUMEN .(EX-3.1)

10.1.1 General requirements

10.1.1.1 Scope. This is a basic test for determining the grades of bitumen. In effect, the test is an indirect determination of high temperature viscosity and low temperature stiffness. The scope of this is to provide a method for determining the consistency of semi-solid and solid bituminous materials in which the sole or major constituent is either bitumen or tar pitch.

10.1.1.2 Definition. The penetration of bituminous material is its consistency expressed asthe distance in tenths of a millimeter that a standard needle penetrates vertically intoa specimen of the material under specified conditions of temperature, load and duration of loading.

Grades of straight-run bitumen are designated by two penetration values, for example, 40/50, 60/80, 80/100 etc.; the penetration of an actual sample of the bitumen in any grade should fall between the lower and upper value given.

10.1.1.3 Apparatus

a) The test apparatus consists of a right frame which holds the needle spindle in a vertical position and allows it to slide freely without friction. A dial gauge calibrated in millimeters measures the penetration. The total weight of the needle and spindle must be 50 ± 0.05 grams and facilities for adding additional weightsof 50 ± 0.05 grams and 100 ± 0.05 grams must be provided. The surface on which the sample container rests must be flat and at right angles to the needle.

b) A penetration needle made of fully hardened and tempered stainless steel of 1.00mm in diameter and 50mm in length, with one end ground to a truncatedcone as shown in Figure 10.1.1. The needle is held by brass or stainless steel ferrule. The test is shown diagrammatically in Figure 10.1.1.

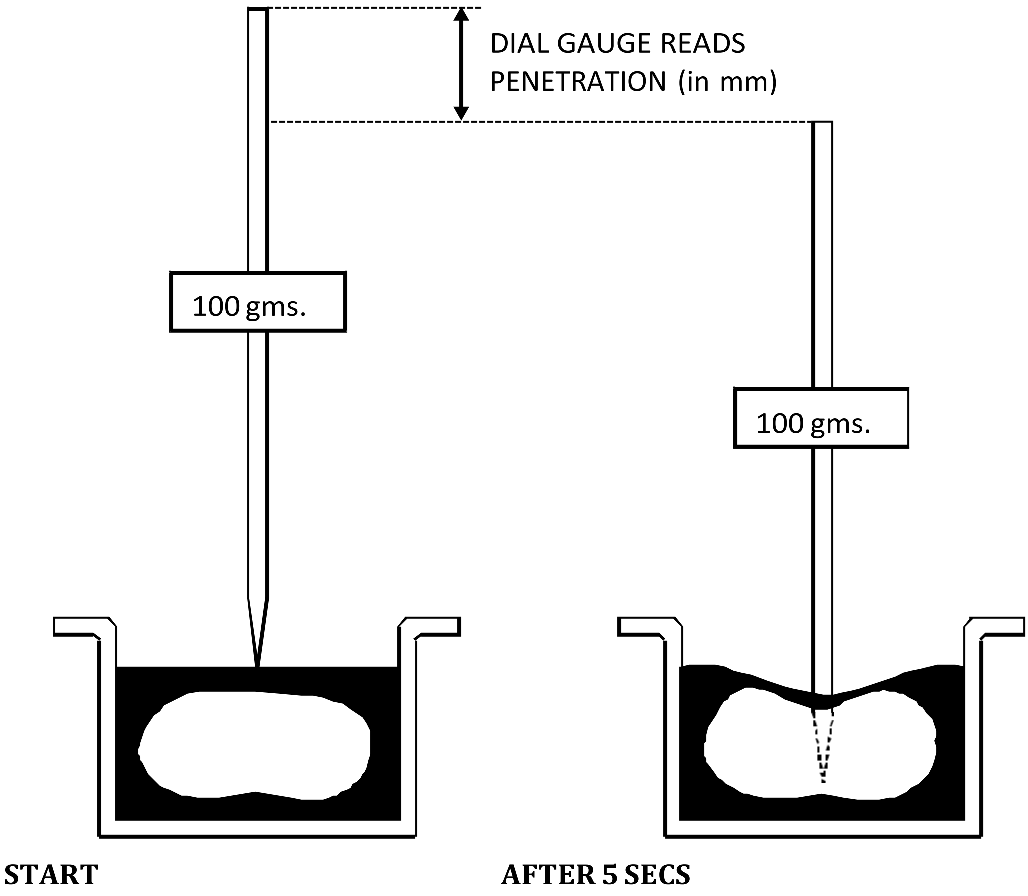
c) The sample is placed in a metal or glass flat bottom container of the following dimensions:-

For penetrations below 200 mm:
Diameter 55 mm
Internal depth 35 mm

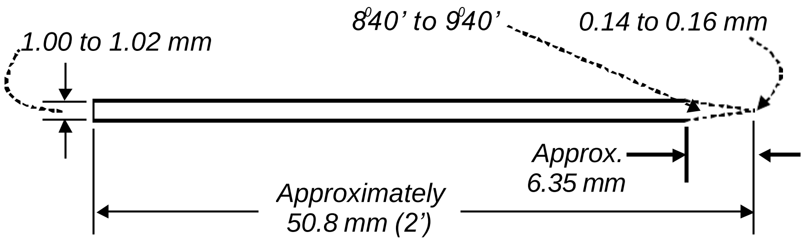
For penetrations between 200 and 350
mmDiameter 70 mm

Internal depth	45 mm

The sample and dish are brought to the required temperature in a water bathwhich is maintained at a temperature within ±0.1/°C of the test temperature. The sample container must be placed on a perforated shelf which is between 50 and 100 mm below the surface of the water.



Penetration Test



Penetration Needle

Figure 10.1.1 Penetration needle

d) To maintain the sample at the correct temperature during the test, a glass transfer dish is used. This dish of at least 350 ml capacity is fitted with a suitable support to hold the sample container firm and level during testing.
e) A stopwatch is required to measure the time of penetration.

10.1.2 *Sample preparation*

a) A sample of bitumen is first heated carefully in an oven or on a hotplate until it has become sufficiently fluid to pour. When using a hotplate, the bitumen should be stirred as soon as possible to prevent local overheating. In no case should the temperature be raised more than 90⁰C above the softening point, and samples must not be heated for more then 30 minutes.
b) When sufficiently fluid a portion of the sample is poured into the sample container to a depth of at least 10mm greater than the depth to which the needle is expected to penetrate.
c) The sample is then covered loosely to protect against dust, and allowed to cool in the atmosphere between 15 and 30⁰C for 1 to 1½ hours for the small containerand 1½ to 2 hours for the large container.
d) After cooling in air, the sample containers together with the transfer dishes should be placed in the water bath at the required temperature, for a period of 1to 1½ hours for the small container and 1½ to 2 hours for the large container.

10.1.3 *Conditions of test*

The test is normally carried out at a temperature of 25⁰C with the total weight of the needle, spindle and added weights being 100 grams, the needle is released for a period of 5 seconds. If it is not possible to obtain these conditions or if there are special circumstances, one of the following alternative conditions may be used:-

Temperature, ⁰C (⁰F)	Total sliding weights, grams	Time, seconds
0 (32)	200	60
4 (39.2)	200	60
46.1 (115)	50	5

It will be noted that, to obtain the standard temperature of 25⁰C in Bangladesh, cooling of the water bath is normally required, it may, therefore, be more convenientin many cases to use a temperature of 46.1⁰C.

10.1.4 *Test procedure*

a) The needle should be examined for damage or surface roughness; it should be dry and clean. To ensure the needle is perfectly cleaned, it should be wiped with a cloth soaked in toluene or another suitable bitumen solvent and then dried witha clean cloth.
b) The clean needle should be inserted into the penetrometer apparatus and the total sliding weight made up to the required value, if necessary by adding additional weights. For example, if 100 grams is required, and the needle and spindle weigh 50 grams, an additional weight of 50 grams must be added.
c) The sample container is then placed in the transfer dish complete with water at the required temperature from the constant temperature bath, the sample being completely covered with water at all times. The transfer dish is then placed on the stand of the apparatus.

d) The penetrometer needle is then slowly lowered until it just touches the surface of the sample. This point is best judged by using a strong source of light and determining the point where the tip of the needle just meets its image reflected by the surface of the sample. The initial dial gauge reading is taken.

e) The needle is then released for the specified time and re-locked immediately at the end of the period. Care should be taken not to disturb or jolt the apparatus when releasing the needle, if this occurs or the sample moves, the test must be repeated. The final dial gauge reading is taken.

f) The transfer dish should then be returned to the water bath and a clean needle fitted to the machine. The test is then repeated on the same sample. This procedure is repeated so that at least 3 determinations are made on each sample, taking care that each point is at least 10mm from the side of the sample container and at least 10mm from the other determinations. If the penetration exceeds 200mm, the needles should be left in the sample until all three determinations have been completed.

10.1.5 *Calculation*

The penetration is given by:

Penetration = (Initial dial gauge reading (mm) - Final dial gauge

reading (mm)) x 10A typical worksheet is shown as Form 10.1.1.

The three penetration values obtained on the sample must agree to within thefollowing limits:-

Penetration	0 to 49	50 to 149	150 to 249	250
Maximum difference between highestand lowest determination	2	4	6	8

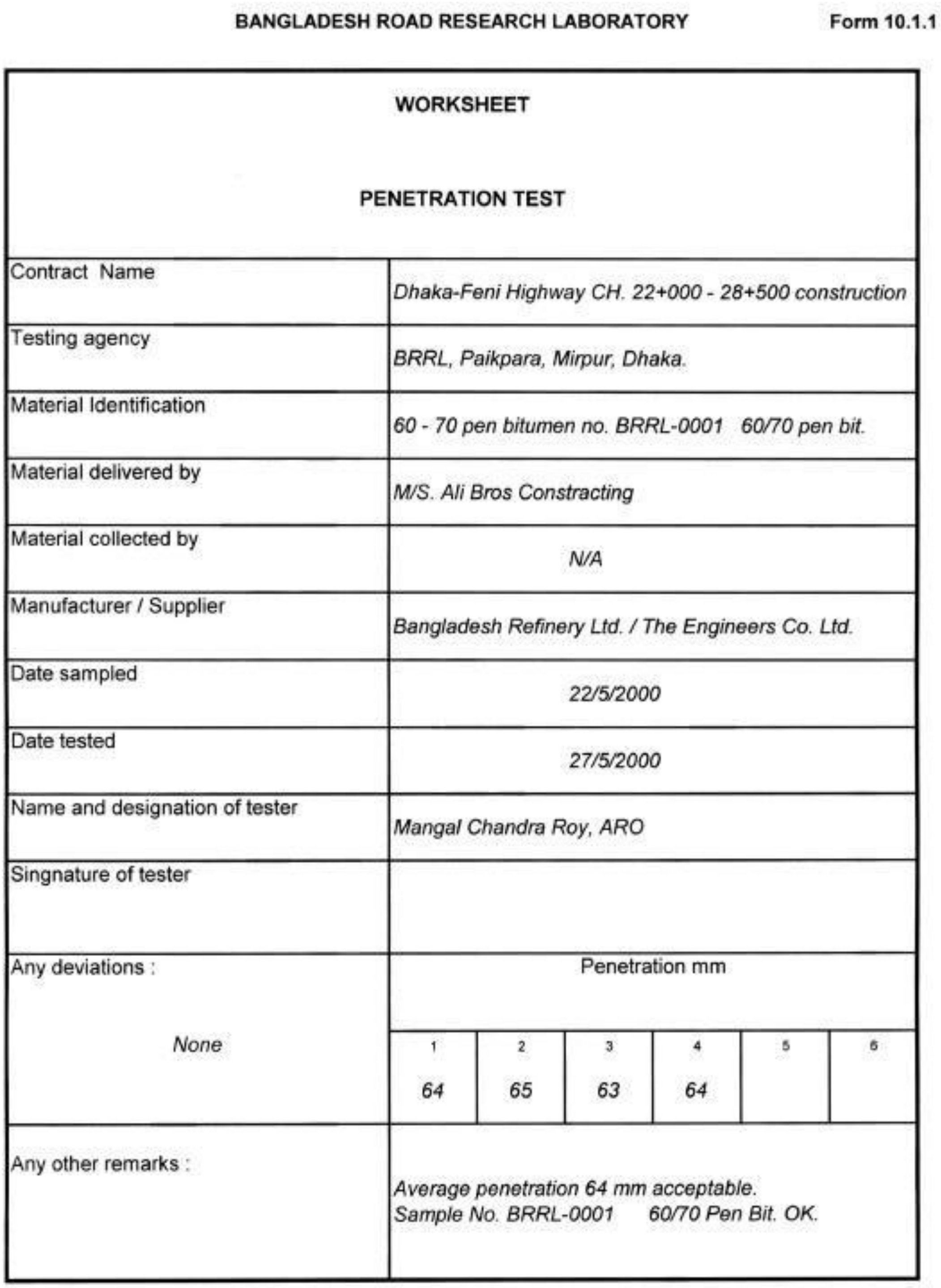
If the differences exceed the above values, the results are ignored and the test must be repeated on the second sample. If the differences are again exceeded by the second sample, the results must be ignored and the test completely repeated.

If the determinations are within the above tolerances, the penetration is quoted asthe average of the individual results.

10.1.6 *Test report*

The report shall contain at least the following information:

a) Identification of the material tested
b) A reference to the test method used.
c) A statement of any deviation from the method stated for 25C/100g/5 seconds.
d) The test result
e) Date of test.



BANGLADESH ROAD RESEARCH LABORATORY **Form 10.1.1**

WORKSHEET

PENETRATION TEST

Contract Name	*Dhaka-Feni Highway CH. 22+000 - 28+500 construction*
Testing agency	*BRRL, Paikpara, Mirpur, Dhaka.*
Material Identification	*60 - 70 pen bitumen no. BRRL-0001 60/70 pen bit.*
Material delivered by	*M/S. Ali Bros Constracting*
Material collected by	*N/A*
Manufacturer / Supplier	*Bangladesh Refinery Ltd. / The Engineers Co. Ltd.*
Date sampled	*22/5/2000*
Date tested	*27/5/2000*
Name and designation of tester	*Mangal Chandra Roy, ARO*
Singnature of tester	
Any deviations : *None*	Penetration mm
Any other remarks :	*Average penetration 64 mm acceptable.* *Sample No. BRRL-0001 60/70 Pen Bit. OK.*

1	2	3	4	5	6
64	*65*	*63*	*64*		

DUCTILITY TEST OF BITUMEN.(EX-3.2)

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 thebitumen sample will elongate before breaking when it is pulled by standard specimen at specifiedspeed 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 theapproximate 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 interiorsurface 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 levelingthe 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

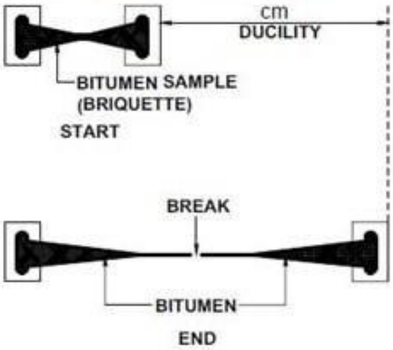
9. Hook the clips carefully on the machine without causing any initial strain

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 __________

VISCOSITY TEST OF BITUMEN (EX-3.3)

10.6.1 Introduction

Viscosity is reverse of fluidity. It is a measure of the resistance to flow. Higher the viscosity of liquid bitumen, the more nearly it approaches a semi-solid state in consistency. Thick liquid is said to be more viscous than a thin liquid of the road pavement. The bitumen binders of low viscosity, simply lubricate the aggregate particles instead of providing a uniform thin film for binding action, similarly high viscosity does not allow full compaction and the resulting mix exhibits heterogeneous character and thus low stability values.

Saybolt Furol viscosity test is used to determine viscosity of liquid bitumens.

10.6.2 *Scope*

In this test, time in seconds is noted for 60 ml of the liquid bitumen at specified temperature to flow through an orifice of a specific size. The higher the viscosity ofthe bitumen more time will be required for a quantity to flow out.

10.6.3 *Apparatus*

a) Saybolt Viscometer and Bath.

Viscometer- The viscometer, illustrated in Figure 10.6.1 shall be constructed entirely of corrosion resistant metal, conforming to dimensional requirements shown in Figure 10.6.1. The orifice tip, Universal or Furol may be constructed as a replaceable unit in the viscometer. Provide a nut at the lower end of the viscometer for fastening it in the bath. Mount vertically in the bath and test the alignment with a spirit level on the plan test; a small chain or cord may be attached to the cork to facilitate rapid removal.

Bath- The bath serves both as a support to hold the viscometer in a vertical position as well as the container for the bath medium. Equip the bath effective insulation and with an efficient stirring device Provide the bath with a coil for heating and coolingand with thermostatically controlled heaters capable on maintaining the bath within the functional precision given in Table 10.6.2. The heaters and coil should be locatedat least 3 in. (75 mm) from the viscometer. Provide a means for maintaining the bath medium at least 6 mm (0.25 in.) above the overflow rim. The bath media are given in Table 10.6.2.

b) Withdrawal Tube, as shown in Figure 10.6.2 or other suitable device.
c) Thermometer Support. One suitable design is shown in Figure 10.6.3
d) Saybolt Viscosity Thermometers, as listed in Table 10.6.1.
e) Bath Thermometers - Saybolt Viscosity thermometers, or any other temperature-indicating means of equivalent accuracy.
f) Filter Funnel, as shown in Figure 10.6.4 equipped with interchangeable 850 µm (N0. 20), 150µm (N0. 100) and 75µm (N0. 200) wire-cloth inserts meeting the requirements of M 92 with respect to the wire cloth Filter funnels of a suitable alternate design may be used.
g) Receiving Flask, as shown in Figure 10.6.5Timer, graduated in tenths of a second, and

accurate to within 0.1% when tested over a 60min interval. Electric timers are acceptable if operated on a controlled frequency circuiT

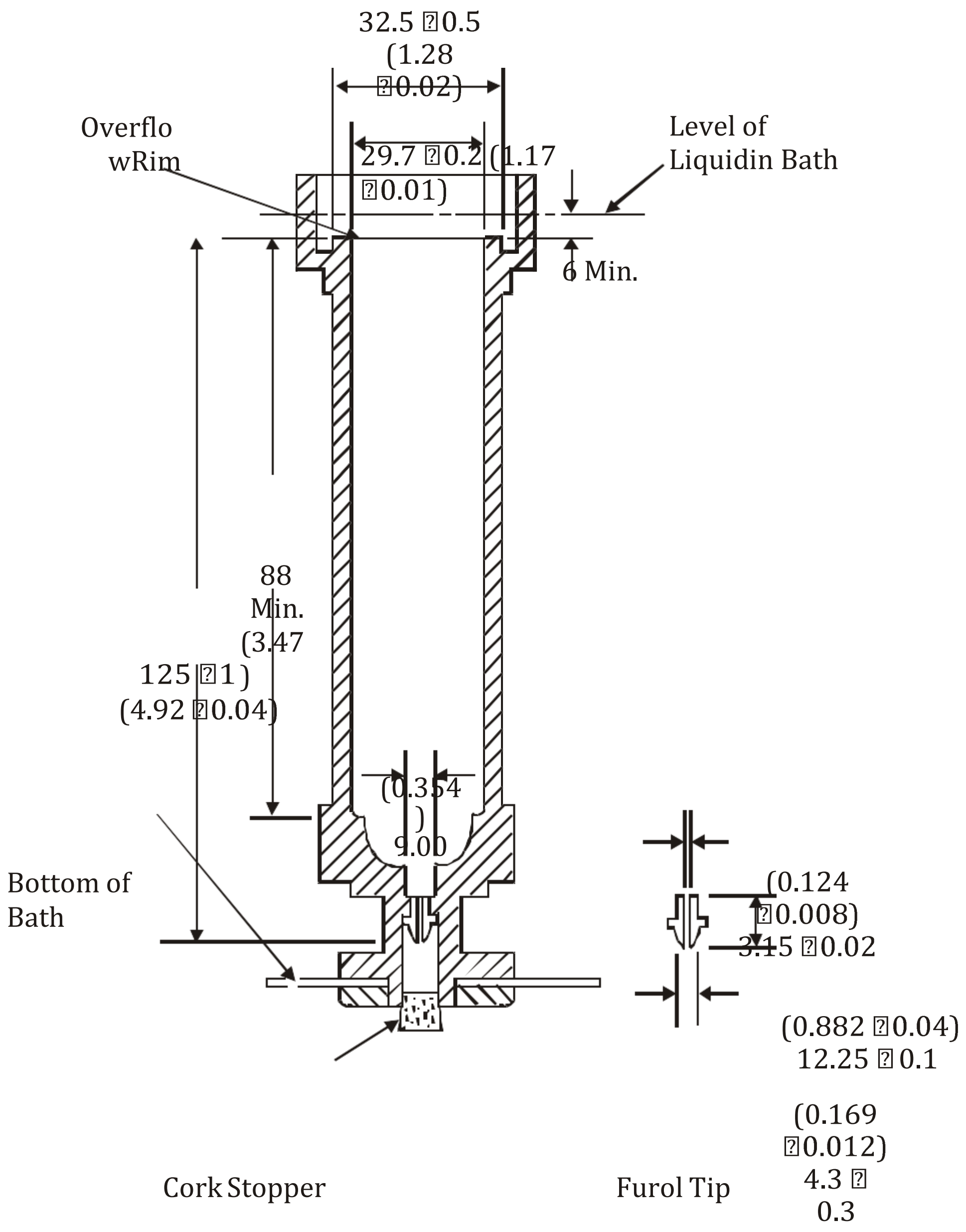
Table 10.6.1 Saybolt Viscosity Thermometer

Standard Test Temperature, C (F)	Thermometer No.	Thermometer	
		Range C (F)	SubdivisionC (F)
21.11 (70)	17C (17F)	19 to 27 (66 to 80)	0.1 (0.2)
25.0 (77)	17C (17F)	19 to 27 (66 to 80)	0.1 (0.2)
37.8 (100)	18C (18F)	34 to 42 (94 to 108)	0.1 (0.2)
50.0 (122)	19C (19F)	49 to 57 (120 to 134)	0.1 (0.2)
54.4 (130)	19C (19F)	49 to 57 (120 to 134)	0.1 (0.2)
60.0 (140)	20C (20F)	57 to 65 (134 to 148)	0.1 (0.2)
82.2 (180)	21C (21F)	79 to 87 (174 to 188)	0.1 (0.2)
98.9 (210)	22C (22F)	95 to 103 (204 to 218)	0.1 (0.2)

Table 10.6.2 Recommended bath Media

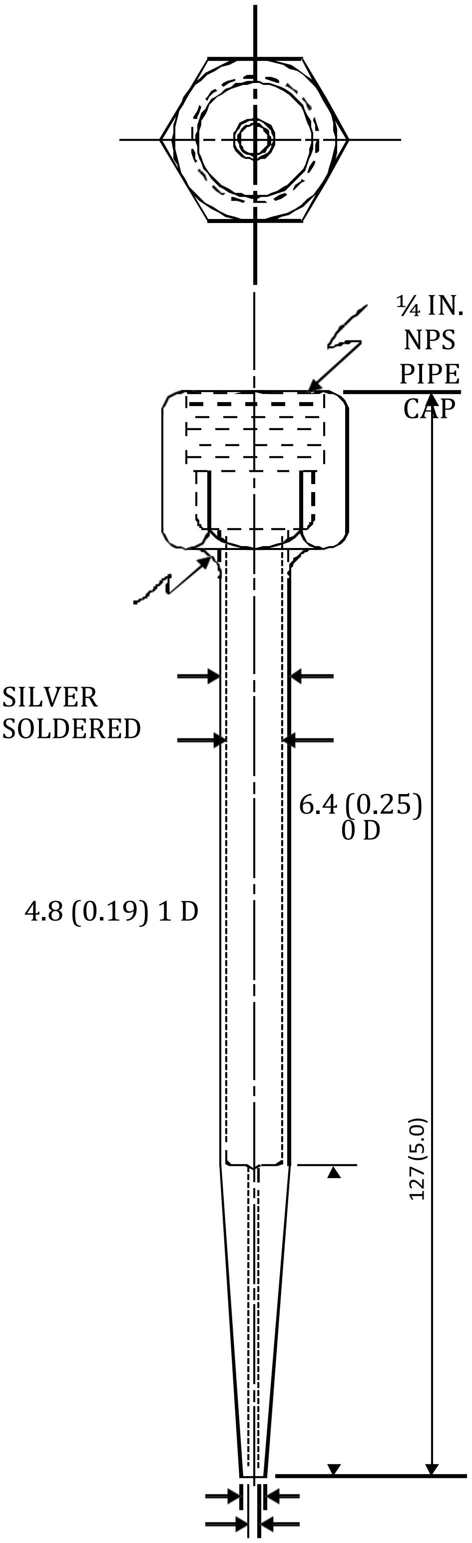
Standard Test Temperature, C (F)	Recommended Bath Medium	Max Temp Differential,C (F)	Bath Temperatures Control Functional Precision, C (F)
21.1 (70)	Water	±0.05 (0.10)	±0.05 (0.10)
25.0 (77)	Water	±0.05 (0.10)	±0.05 (0.10)
37.8 (100)	Water, or oil of 50 to 70 SUS viscosity at 37.8^{0}C (100^{0}F)	±0.15 (0.25)	±0.05 (0.10)
50.0 (122)	Water, or oil of 120 to 150 SUS viscosity at 37.8^{0}C (100^{0}F)	±0.20 (0.35)	±0.05 (0.10)
54.4 (130)	Water, or oil of 120 to 150 SUS viscosity at 37.8^{0}C (100^{0}F)	±0.30 (0.50)	±0.05 (0.10)
60.0 (140)	Water, or oil of 120 to 150 SUS viscosity at 37.8^{0}C	±0.50 (1.0)	±0.05 (0.10)
82.2 (180)	Water, or oil of 120 to 150 SUS viscosity at 37.8^{0}C (100^{0}F)	±0.80 (1.5)	±0.05 (0.10)
98.9 (210)	Oil of 330 to 370 SUS viscosity at 37.8^{0}C	±1.10 (2.0)	±0.05 (0.10)

*Maximum permissible difference between bath and sample temperatures at time of the test.



All dimensions are in millimitres (inches)

Figure 10.6.1 Saybolt Viscometer with Furol or Fice


¼ IN.
NPS
PIPE
CAP
SILVER
SOLDERED
6.4 (0.25)
0 D
4.8 (0.19) 1 D
127 (5.0)

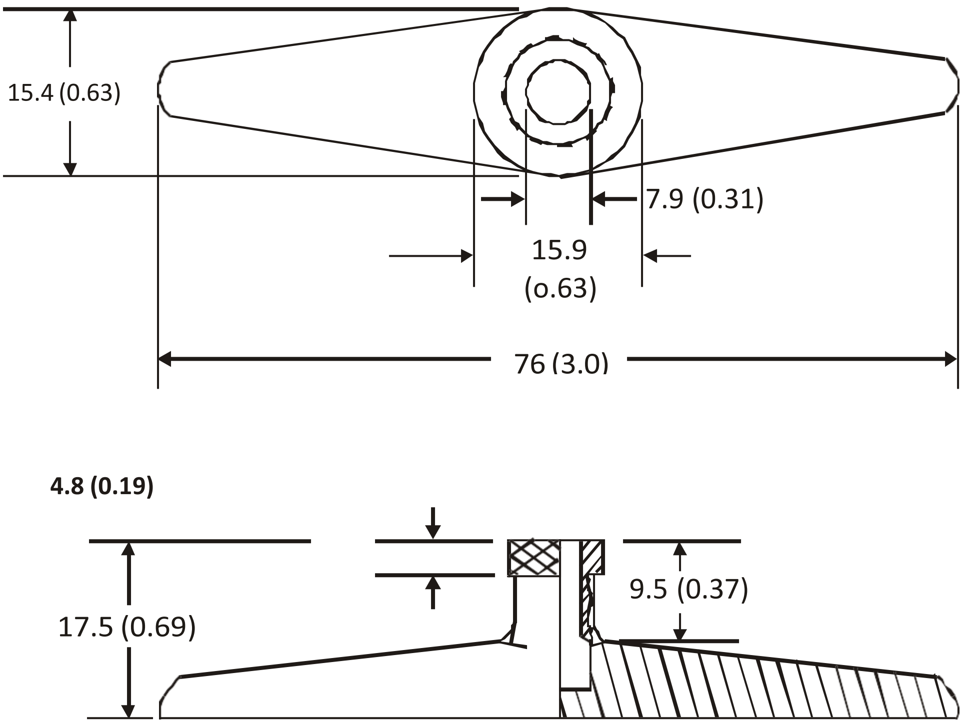
38 (1.5)

3.2 (0.13) 0 D

1.6 (0.06) 1 D

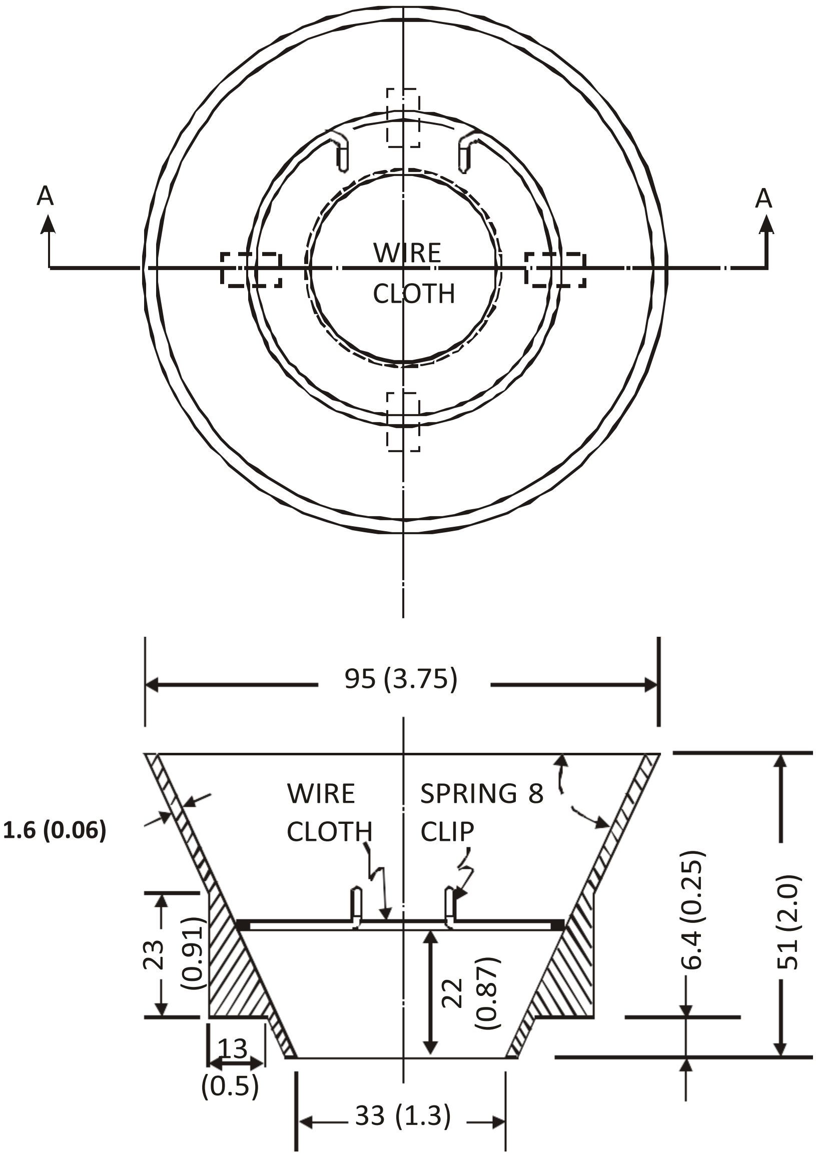
Note : All dimensions are in millimetres (inches)

Figure 10.6.2 Withdrawal Tube for Use with Saybolt Viscometer



Note : All dimensions are in millimetres (inches)

Figure 10.6.3 Thermometer Support



Note : All dimensions are in millimetres (inches)

Figure 10.6.4 Filter Funnel for Use with Saybolt Viscometer

10.6.4 Preparation of apparatus

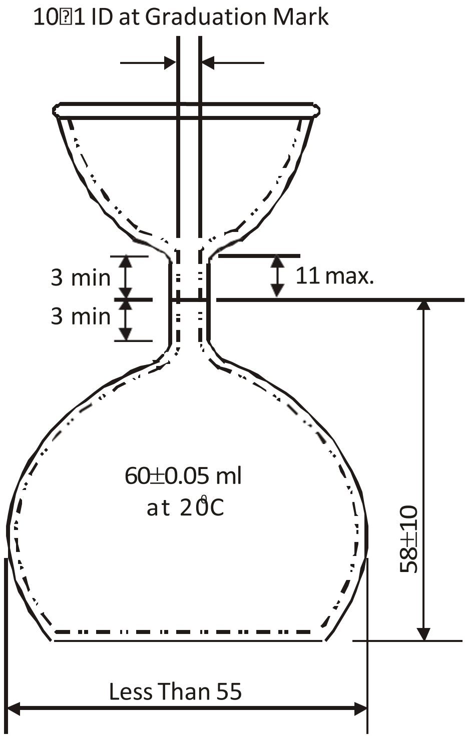
a) A Furol orifice tip is used for residual materials with efflux times greater than 25 sto give the desired accuracy.

b) The viscometer is thoroughly cleaned with an appropriate solvent of low toxicity; then all solvent is removed from the viscometer and its gallery. The receivingflask is cleaned in the same manner.

Note 1. The plunger commonly supplied with the viscometer should never be used for cleaning; its use might damage the overflow rim and walls ofthe viscometer.

c) The viscometer and bath are set up in an area where they will not be exposed to drafts or rapid changes in air temperature, and dust or vapours that might contaminate a sample.

d) The receiving flask (Figure 10.6.5) is placed beneath the viscometer so that the graduation mark on the flask is from 100 to 130 mm (4 to 5 in.) below the bottomof the viscometer tube, and so that the stream of oil will just strike the neck of the flask.



Note. All dimensions are in Millimetres

Figure 10.6.5 Receiving Flask

e) The bath is filled to least 6 mm ($^1/_4$ in.) above the overflow rim of the viscometerwith an appropriate bath medium selected from Table 10.6.2

f) Adequate stirring and thermal control are provided for the bath so that the temperature of a test sample in the viscometer will not vary more than ⍰0.05 C (⍰ 0.10 F) after reaching the selected test temperature.

g) Viscosity measurements should not be made at temperatures below the dew pointof the room's atmosphere.

h) For calibration and referee tests, the room temperature is kept between 20 and30 ^{0}C (68 and 86 ^{0}F), and the actual temperature is recorded. However room temperatures up to 38 ^{0}C (100 ^{0}F) will not introduce errors in excess of 1%.

10.6.5 *Calibration and standardization*

1. **The Saybolt Furol** Viscometer is calibrated at intervals of not more than 3 years by measuring minimum efflux time of 90s at 50 ^{0}C (122 ^{0}F) of an appropriate viscosity oil standard, following the procedure given in Section 10.6.6

Saybolt Viscosity Standards - The approximate Saybolt viscosity's are shown in Table 10.6.3.

Table 10.6.3 Saybolt Viscosity Oil standard

Viscosity Oil Standards	SUS at 37.8^{0}C (100^{0}F)	SUS at 98.9^{0}C (210^{0}F)	SFS at 50^{0}C (122^{0}F)
S3	36	…	…
S6	46	…	…
S20	100	…	…
S60	290	…	…
S200	930	…	…
S600	…	150	120

Standards Conforming to ASTM Saybolt Viscosity Standards -The viscosity standards may also be used for routine calibrations at other temperatures as shown in Table 10.6.3. Other reference liquids, suitable for routine calibrations may be established by selecting stable oils covering the desired range and determining their viscosities in a viscometer calibrated with a standard conforming to ASTM requirements.

Routine Calibrations- The viscosity standards may also be used for routine calibrations at other temperatures as shown in Table 10.6.3.

2. The efflux time of the viscosity oil standard shall equal the certified Saybolt viscosity value. If the efflux time differs from the certified value by more than 0.2% calculate a correction factor, F for the viscometer as follows:

$F = V/t$

Where,
V = certified Saybolt viscosity of the standard, and
t = measured efflux time at 50^{0}C (122 ^{0}F)

Note 2. If the calibration is based on a viscosity oil standard having and efflux time between 200 and 600 s, the correction factor applies to all viscosity levels at all temperatures.

3. Viscometers or orifices requiring corrections grater than 1.0% shall not be used in referee testing.

10.6.6 *Procedure*

a) The bath temperature is established and controlled at the selected test temperature. Standard test temperatures for measuring Saybolt Furol viscosity's are 25.0, 37.8 50.0, and 98.9 ^{0}C (77, 100, 122, and 210 ^{0}F).

b) A cork stopper is inserted having a cord attached for its easy removal, into the air chamber at the bottom of the viscometer. The cork shall fit tightly enough to prevent the escape of air, as evidenced by the absence of oil on the cork when it is withdrawn later as described.

c) If the selected test temperatures is above room temperature, the test may be expedited by preheating the sample in its original container to not more than 1.7^{0}C (3.0 ^{0}F) above the test temperature.

d) The sample is stirred well, then strain it through a wire cloth of appropriate mesh directly into the viscometer until the level is above the overflow rim. The wire cloth shall be 150µm (No. 100) mesh except as noted in T 59 (Testing Emulsified Asphalt) and Note 3.

e) For liquid asphaltic road materials having highly volatile components such as the rapid curing and medium curing cut-backs, preheating in an open container shall not be permitted.

The material shall be poured at room temperature into the viscometer of if the material is too viscous to pour conveniently at room temperature, it shall be warmed sufficiently by placing the sample in the original container in a 50 ^{0}C (122 ^{0}F) water bath for a few minutes prior to pouring. Filtering through a wire cloth shall be omitted.

For tests above room temperature, greater temperature differential than indicated in Table 10.6.2 be permitted during the heating period, but the bath temperature must be adjusted to within the prescribed limits prior to the final minute of stirring during which the temperature of the sample remains constant.

Note 3. The viscosity of steam-refined cylinder oils, black lubrication oils, residual fuel oils and similar waxy products can be affected by the previous thermal history. The following preheating procedure should be followed to obtain uniform results for viscosity below 95 ^{0}C (200 ^{0}F).

To obtain a representative sample, heat the sample in the original container to about 50 ^{0}C (122 ^{0}F) with stirring and shaking. Probe the bottom of the container with a rod to be certain that all waxy materials are in solution. Pour 100 ml into a 125 ml Erlenmeyer flask. Stopper loosely with a cork or rubber stopper. Immerse the flask in a bath of boiling water for 30 min. Mix well, remove the sample from the bath, and strain it through a 0.07mm (No. 200) sieve directly into the viscometer already in the thermostat bath. Complete the viscosity test within 1 hr. after preheating.

f) The sample in the viscometer is stirred with the appropriate viscosity thermometer equipped with the thermometer support (Fig. 10.6.3) a circular motion at 30 to 50 rpm is used in a horizontal plane. When the sample temperature remains constant within 0.05 C (0.10 F) of the test temperature during 1 min of continuous stirring, the thermometer is removed.

Note 4. Never attempt to adjust the temperature by immersing hot or cold bodies in the sample. Such thermal treatment might affect the sample and the precision of the test.

g) The tip of the withdrawal tube is immediately placed (Fig. 10.6.2) in the gallery at one point, and suction is applied to remove oil until its level in the gallery is below the overflow rim. Do not touch the overflow rim with the withdrawal tube; the effective liquid head of the sample would be reduced.
h) The receiving flask must be in proper position; then the cork is snapped form the viscometer using the attached cord and the timer is started at the same instant.
i) The timer is stopped instant the bottom of the oil meniscus reaches the graduation mark on the receiving flask. The efflux time is recorded in seconds to the nearest 0.1 s.

10.6.7 Calculation and report

1. The efflux time is multiplied by the correction factor for the viscometer in 2 of 10.6.5.
2. The corrected efflux time is reported as the Saybolt Furol viscosity of the oil atthe temperature at which the test was made.
3. Values to the nearest whole second are reported.

PUBLIC HEALTH ENGINEERING LABORATORY

DETERMINATION OF TURBIDITY OF WATER SAMPLE USING.(EX-4.1)

AIM

To determine the turbidity of the given water sample as per **IS: 3025 (Part 10) -Reaffirmed 2002.**

5.2 INTRODUCTION

Turbidity is the technical term referring to the cloudiness of a solution and it is a qualitative characteristic which is imparted by solid particles obstructing the transmittance of light through a water sample. Turbidity often indicates the presence of dispersed and suspended solids like clay, organic matter, silt, algae andother microorganisms.

When the turbid water in a small, transparent container such as drinking glass is held up to the light, an aesthetically displeasing opaqueness or milky coloration is apparent. The colloidal material which exerts turbidity provides adsorption sites forchemicals and for biological organism that may not be harmful. They may be harmful or cause undesirable tastes and odours. Disinfection 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 color 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. Knowledge of the turbidity variation in raw water supplies is useful to determine whether a supply requires special treatment by chemical coagulation and filtration before it may beused for a public water supply. Turbidity measurements are used to determine theeffectiveness of treatment produced with different chemicals and the dosages needed.

Turbidity measurements help to gauge the amount of chemicals needed from day-to-day operation of water treatment works.

Measurement of turbidity in settled water prior to filtration is useful in controlling chemical dosages so as to prevent excessive loading of rapid sand filters. Turbiditymeasurements of the filtered water are needed to check on faulty filter operation.

Turbidity measurements are useful to determine the optimum dosage of coagulantsto treat domestic and industrial wastewaters. Turbidity determination is used to evaluate the performance of water treatment plants.

PRINCIPLE

Turbidity is based on the comparison of the intensity of light scattered by the sample under defined conditions with the intensity of the light scattered by a standard reference suspension under the same conditions. The turbidity of the sample is thus measured from the amount of light scattered by the sample taking areference with standard turbidity suspension. The higher the intensity of scatteredlight the higher is the turbidity. Formazin polymer is used as the primary standard reference suspension.

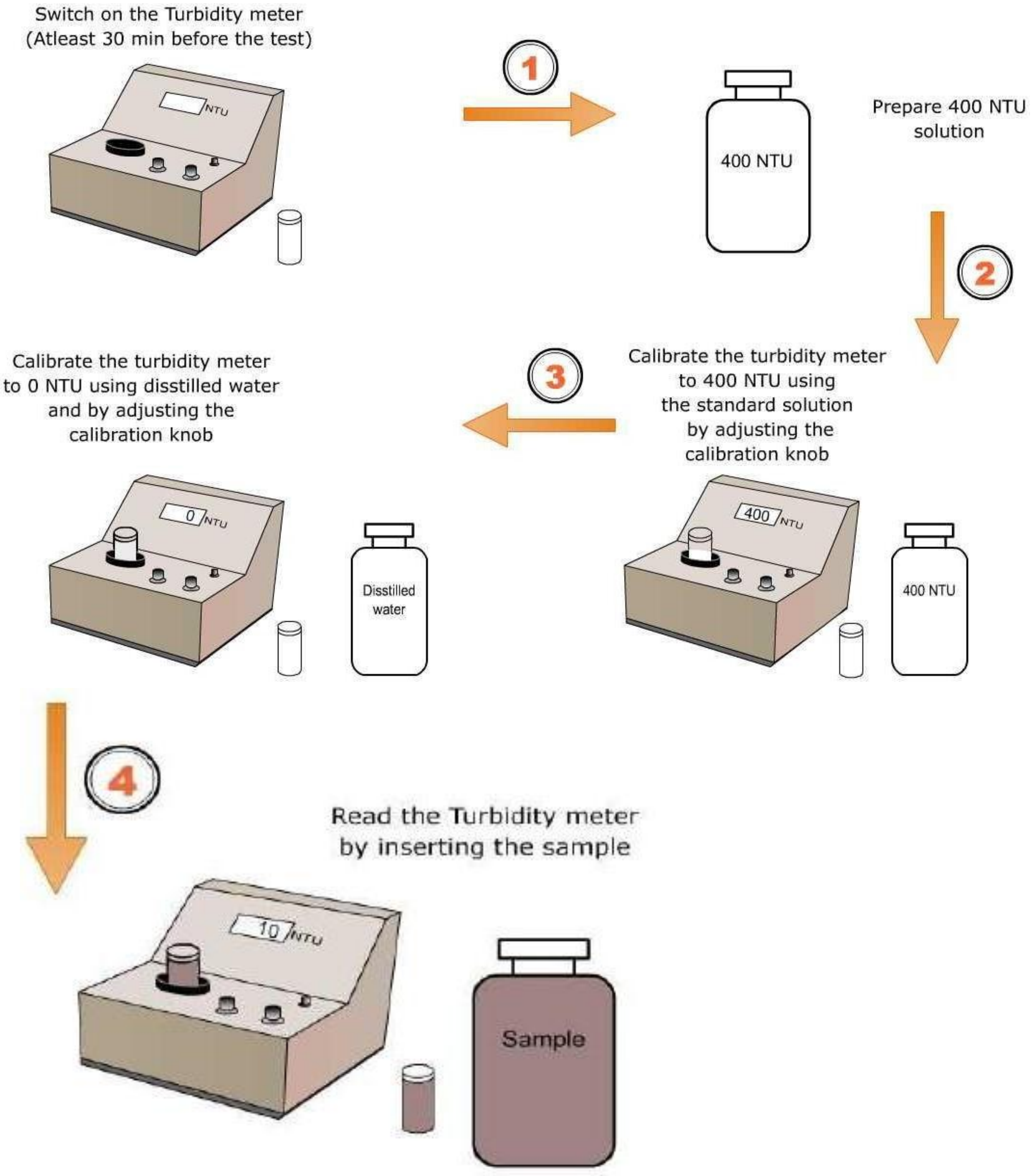
Equipments Required

1. Turbidity Meter
2. Sample Cells
3. Standard flasks
4. Funnel
5. Wash Bottle
6. Tissue Papers

Chemicals Required

1. Hexamethylenetetramine
2. Hydrazine sulphate
3. Distilled Water.

Experimental Steps



NOTE:- IN STEP 3, USE SET ZERO KNOB TO ADJUST THE READINGTO ZERO WITH

DISTILLED WATER

PREPARATION OF REAGENTS

1. Hydrazine Sulphate

Weigh accurately 1 g of hydrazine sulphate and dissolve it in turbidity freedistilled water.

Take 100 mL standard measuring flask and place a funnel over it.

Transfer it to a 100 mL standard flask and make up to 100 ml using turbidity freedistilled water.

2. Hexamethylene Tetramine

Weigh accurately 10 g of Hexamethylene tetramine and dissolve it in turbidity freedistilled water.

Take 100 mL standard measuring flask and place a funnel over it.Transfer it to a 100 mL standard flask and make up to 100 ml

3.Standard 4000 NTU Solution

Mix 5 mL of hydrazine sulphate solution and 5 mL of Hexamethylenetetraminesolution in a 100 mL standard measuring flask.

Allow the mixture to stand for 24 hours.

After 24 hours, make up the volume to 100 mL using turbidity free distilled water.The standard **4000 NTU** solution is ready.

NOTE:- FOR MAKING SOLUTIONS OF LOWER TURBIDITY VALUES,USE THE NORMALITY EQUATION, $N_1V_1 = N_2V_2$ USING DISTILLED WATER FOR DILUTION PURPOSES
example :- N_1=4000, N_2 required=200 NTU for experiment, V_1=say 10ml, then$V_2 = N_1V_1 / N_2$ = (4000 X 10) / 200 = 400 ml. Hence to make a solution of 200NTU, you need to dilute 10 ml of 4000 NTU to 400 ml.

DETERMINATION OF PH OF WATER SAMPLE USING (a) ph meter (b)colour comparator (EX-4.2)

INTRODUCTION :-

The term "pH" refers to the measurement of hydrogen ion activity in the solution. Since the direct measurement of the pH is very difficult, specific electrodes are needed for quick and accurate pH determination. pH is measured on a scale of 0 to14, with lower values indicating high H+ (more acidic) and higher values indicating low H+ ion activity (less acidic). A pH of 7 is considered as neutral.
Every whole unit in pH represents a ten-fold increase in or decrease in hydrogenion concentration. Most natural waters possess the pH values ranging from 5.0 to 8.5. Rain water have a pH value of 5.4 to 6.0 which then reacts with the soils and minerals causing the reduction in H+ ion concentration and thus the water may become alkaline with a pH 0f 8.0-8.5. More acid water (pH<5) and more alkaline (pH >9) and other

immediate changes in the hydrogen ion concentration (pH) suggest that the quality of the water is adversely affected due to the introduction ofsome toxic contaminants in water bodies.

pH is measured using pH meter, which comprises a detecting unit consisting of a glass electrode, reference electrode, usually a calomel electrode connected by KClBridge to the pH sensitive glass electrode and an indicating unit which indicates the pH corresponding to the electromotive force is then detected. Before measurement, pH meter should be calibrated by using at least two buffers.

Precautions

1. The pH meter can be standardized by measuring the 7-pH buffer solution or anyother solution of standard pH. Sometimes, the manufacturer of the pH meter may suggest other methods of standardizing, which too have to be followed.
2. The electrodes have to be inserted into the water so that it does not touch the bottom of the beaker. Bottom contact with damage may cause damage to the electrodes.
3. Any cause of slow response due to the polarization can be solved by washing the electrodes thoroughly.
4. Periodic check has to be conducted to check the electrodes

5. During the electrode storage, they have to be kept moist. And also follow the instructions of the manufacturer.

EQUIPMENT REQUIRED:-

1. pH meter
2. pH electrode filled with KCL solution
3. Buffer solutions of pH4 and pH 7
4. Clean beakers
5. Tissue papers
6. Distilled water
7. Thermometer

Procedure:-

* Plug in the pH meter to power source and let it warm up for 5 to 10 minutes

* Wash the glass electrode with distilled water and clean slowly with a soft tissue.

* Note the temperature of water and set the same on the pH meter

* Place the electrode in pH 7 buffer solution and set the value of 7 on the pH meterturning the Calibrate knob on the meter.

* Take out the electrode, wash with DW and clean.

* Dip the electrode in the pH 4 buffer solution. Adjust the value on the pH readoutmeter by the Slope switch . Repeat with pH 7 and pH4 buffers till a correct and stable reading is displaced.

* While moving and cleaning the electrode, put the selector switch on standbymode. Turn to pH mode for recording the pH.

- Now place the electrode in the water sample whose pH is to be determined.
- You can take a number of simultaneous readings for different samples until thepower is on

pH Meter

RESULT- THE VALUE IS …………

DETERMINATION OF CHLORIDE CONTENT OF A WATER SAMPLE USING METHOD OF TITRATION .(EX-4.3)

INTRODUCTION-

Background:

Chloride in the form of chloride (Cl$^-$) ion is one of the major inorganic anions in water and wastewater. The chloride concentration is higher in wastewater than in raw water because sodium chloride is a common article of diet and passes unchanged through the digestive system (Average estimate of excretion: 6 g of chlorides/person/day; additional chloride burden due to human consumption on wastewater: 15 mg/L). Along the sea coast chloride may be present in high concentration because of leakage of salt water into the sewage system. It also may be increased by industrial process. In potable water, the salty taste produced by chloride concentration is variable and depends on the chemical composition of water. Some waterscontaining 250 mg/L Cl$^-$ may have a detectable salty taste if sodium cation is present. On the other hand, the typical salty taste may be absent in waters containing as much as 1000 mg/L when the predominant cations are calcium and magnesium. In addition, a high chloride contents may harm metallic pipes and structures as well as growing plants.

The measured chloride ions can be used to know salinity of different water sources. For brackish water (or sea water or industrial brine solution), it is an important parameter and indicates the extent of desalting of apparatus required. It also interferes with COD determination and thus it requires a correction to be made on the basis of amount present or else a complexing agent, such as $HgSO4$ can be added. Further, chloride ions are used as tracer ions in column studies to model fate of different contaminants in soil and liquid media.

Lab Procedure

The Mohr Method uses silver nitrate for titration (normality: 0.0141) This corresponds to1 mL of 0.0141 equals to 1 mg chloride in solution. The silver nitrate solution is standardized against standard chloride solution, prepared from sodium chloride (NaCl). During the titration, chloride ion is precipitated.

$Ag^{+}+Cl^{-} \Leftrightarrow AgCl$ (Solubility product constant, $K_{sp}=3\times10^{-10}$)

The indicator (potassium chromate) is added to visualize the endpoint, demonstrating presence of excess silver ions. In the presence of excess silver ions, solubility product of silver chromate exceeded and it forms a reddish-brown precipitate This stage is taken as evidence that all chloride ions have been consumed and only excess silver ions have reacted with chromate ions:

$$2Ag^{+}+CrO_4^{2-} \Leftrightarrow Ag_2CrO_4$$

The silver chromate produced is responsible for imparting brick red color to the solution

Apparatus: Burette, conical flask, pipette, measuring cylinder
Reagents: Potassium chromate indicator solution, standard silver nitrate as a titration agent..

Steps:

1. Take 50 ml of sample in a conical flask.
2. Add 1.0 ml indicator solution,(Potassium chromate)
3. The initial color of the mixture is slight yellow
4. Titrate with standard silver nitrate solution to brick red end point and note down volume of titrant used.
5. Calculate chloride ion concentration using the equation :-:

   Chloride Ion Concentration (mg/L) =(Ml of $AgNO_3$ used-0.2) X500 / ML of sampleused

Precautions:

1. A uniform sample size must be used, preferably 50 ML, so that ionic concentrations needed to indicate the end point will be constant.

2. The pH must be in the range of 7 to 8 as silver ions are precipitated as AgOH at high pH levels and the chromate ions are converted to $Cr_2O_7^{2-}$ at low pH values.

3. A definite amount of indicator must be used to provide a certain concentration of chromate ions, otherwise silver chromate may form too soon or not soon enough.

4. Caution should be made to notice indicator color change as it can varies person-to-person. The titrant should be added drop wise and the sample shaken constantly.

5. Take at least three readings for each sample.

Answer the questions also (for Submission with Lab report):

1. Does the measured chloride ion concentration exceed the maximum concentration criteria? Compare your values with IS:- 10050 to determine whether the determined chloride content is within permissible limits.
2. What is the permissible value of Chlorides for drinking water ?
3. What does excess of Chloride content in drinking water indicate ?

DETERMINATION OF COAGULANT (ALUM)DOSE REQUIREMENT FOR A TURBID WATER SAMPLE BY JAR TEST .(EX-4.4)

INTRODUCTION

Background:

Chloride in the form of chloride (Cl^-) ion is one of the major inorganic anions in water and wastewater. The chloride concentration is higher in wastewater than in raw water because sodium chloride is a common article of diet and passes unchanged through the digestive system (Average estimate of excretion: 6 g of chlorides/person/day; additional chloride burden due to human consumption on wastewater: 15 mg/L). Along the sea coast chloride may be present in high concentration because of leakage of salt water into the sewage system. It also may be increased by industrial process. In potable water, the salty taste produced by chloride concentration is variable and depends on the chemical composition of water. Some waterscontaining 250 mg/L Cl^- may have a detectable salty taste if sodium cation is present. On the other hand, the typical salty taste may be absent in waters containing as much as 1000 mg/L when the predominant cations are calcium and magnesium. In addition, a high chloride contents may harm metallic pipes and structures as well as growing plants.

The measured chloride ions can be used to know salinity of different water sources. For brackish water (or sea water or industrial brine solution), it is an important parameter and indicates the extent of desalting of apparatus required. It also interferes with COD determination and thus it requires a correction to be made on the basis of amount present or else a complexing agent, such as $HgSO_4$ can be added. Further, chloride ions are used as tracer ions in column studies to model fate of different contaminants in soil and liquid media.

Lab Procedure

The Mohr Method uses silver nitrate for titration (normality: 0.0141) This corresponds to **1 mL of 0.0141 equals to 1 mg chloride in solution.** The silver nitrate solution is standardized against standard chloride solution, prepared from sodium chloride (NaCl). During the titration, chloride ion is precipitated.

$$Ag^+ + Cl^- \Longleftrightarrow AgCl \qquad \text{(Solubility product constant, } K_{sp} = 3\times10^{-10}\text{)}$$

The indicator (potassium chromate) is added to visualize the endpoint, demonstrating presence of excess silver ions. In the presence of excess silver ions, solubility product of silver chromate exceeded and it forms a reddish-brown precipitate This stage is taken as evidence that all chloride ions have been consumed and only excess silver ions have reacted with chromate ions:

$$2Ag^{+}+CrO4^{2-} <=> Ag2CrO4$$

The silver chromate produced is responsible for imparting brick red color to the solution

Apparatus: Burette, conical flask, pipette, measuring cylinder
Reagents: Potassium chromate indicator solution, standard silver nitrate as a titration agent..

Steps:

6. Take 50 ml of sample in a conical flask.
7. Add 1.0 ml indicator solution,(Potassium chromate)
8. The initial color of the mixture is slight yellow
9. Titrate with standard silver nitrate solution to brick red end point and note down volumeof titrant used.
10. Calculate chloride ion concentration using the equation :-:

Chloride Ion Concentration (mg/L) =(Ml of AgNO3 used-0.2) X500 / ML of sample used

Precautions:

6. A uniform sample size must be used, preferably 50 ML, so that ionic concentrations needed to indicate the end point will be constant.

7. The pH must be in the range of 7 to 8 as silver ions are precipitated as AgOH at high pH levels and the chromate ions are converted to $Cr2O7^{2-}$ at low pH values.

8. A definite amount of indicator must be used to provide a certain concentration of chromate ions, otherwise silver chromate may form too soon or not soon enough.

9. Caution should be made to notice indicator color change as it can varies person-to-person. The titrant should be added drop wise and the sample shaken constantly.

10. Take at least three readings for each sample.

Answer the questions also (for <u>Submission with Lab report</u>):

4. Does the measured chloride ion concentration exceed the maximum concentration criteria? Compare your values with IS:- 10050 to determine whether the determined chloride content is within permissible limits.
5. What is the permissible value of Chlorides for drinking water ?
6. What does excess of Chloride content in drinking water indicate ?

DETERMINATION OF DISSOLVED OXYGEN IN A WATER SAMPLE .(EX-4.5)

INTRODUCTION –

Dissolved oxygen (DO) levels in environmental water depend on the physiochemical and biochemical activities in water body and it is an important useful in pollutionand waste treatment process control. Two methods are commonly used to determine DO concentration: (1) The iodometric method which is a titration-based method and depends on oxidizing property of DO and (2) The membrane electrode procedure, which works based on the rate of diffusion of molecular oxygen across a membrane.

In the Iodometric method, divalent manganese solution is added to the solution, followed by addition of strong alkali in a glass-stopper bottle. DO rapidly oxidize an equivalent amount of the dispersed divalent manganese hydroxide precipitates to hydroxides of higher valence states. In the presence of iodide ions in an acidic solution, the oxidized manganese reverts to the divalent state, with the liberation of iodine equivalent of the original DO content. The iodine is then titrated witha stranded solution of thiosulfate. The titration end point can be detected visually with a starch indicator.

$$MnSO_4 + 2KOH \longrightarrow Mn(OH)_2 + K_2SO_4$$

$$Mn(OH)_2 + O \longrightarrow MnO(OH)_2$$

$$MnO(OH)_2 + 2H_2SO_4 + 2KI \longrightarrow MnSO_4 + K_2SO_4 + 3H_2O + I_2$$

Requirements:

Apparatus: Burette, conical flask, pipette, measuring cylinder.

Reagents: 1. Manganese sulfate solution: Dissolve 480 g $MnSO_4.4H_2O$, 400 g $MnSO_4.2H_2O$ or 364 g $MnSO_4.H_2O$ in distilled water, filter, and dilute to 1L. The $MnSO_4$ solution should not give a color with starch when added to an acidified potassium iodide (KI) solution.

2. Alkali-iodide-azide reagent

3. Sulfuric acid: One mL is equivalent to ~ 3mL alkali-iodide-azide reagent.

4. Starch solution: Dissolve 2 g laboratory-grade soluble starch and 0.2 g salicyclic acid as preservative in 100 mL hot distilled water.

5. Standard sodium thiosulfate titrant: Dissolve 6.205 g $Na_2S_2O_3$.$5H_2O$ in distiller water and add 1.5 mL 6N NaOH or 0.4 g solid NaOH and dilute to 1000 ml. Standardize with biiodate solution.

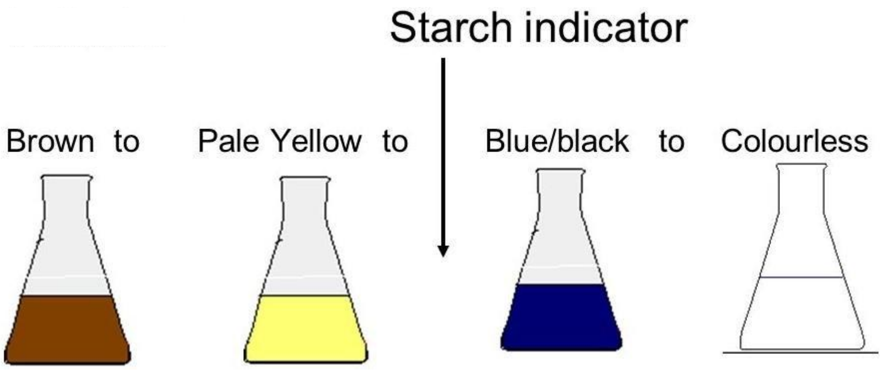
6. Standard potassium bi-iodate solution (0.0021M): Dissolve 812.4 mg $KH(IO_3)$ in distilled water and dilute to 1000 mL.

7. Standardization: Dissolve e ~ 2 g KI, free from iodate in an Erlenmeyer flask with 100 to 150mL distilled water; add 1 mL 6N H_2SO_4 or a few drops of conc. H_2SO_4 and 20.00 mL standard bi-iodate solution. Dilute to 200 mL and titrate liberated iodine with thiosulfate titrant, adding starchtoward end of titration, when a pale straw color is reached. When the solution is of equal, 20.00mL 0.025M $Na_2S_2O_3$ should be required. If not, adjust the $Na_2S_2O_3$ solution to 0.025M. **Procedure:**

1. Collect the water sample without bubbling in 200ml glass bottle.
2. Add 2 ml of manganous sulfate ($MnSO_4.H_2O$) solution inserting the tip of pipette tip into the sample because the drops of solution can allow inserting the oxygen into the solution.
3. Add 2 ml of the alkali-iodide-azide reagent by above method.
4. Allow reacting the solutions with the oxygen present in the sample.

5. When precipitates are settled down at the bottom add 2 ml of concentrated sulfuric acid byplacing the pipette tip very near to sample surface.
6. Mix well to dissolve the precipitates.
7. Take 50 ml of sample from in a flask.
8. Titrate immediately with sodium thiosulfate solution using starch indicator until blue colordisappears and note down the burette reading.
9. Determine the burette reading for blank in the same manner.

Observation:



Observation table:

S. No.	Sample (ml)	Initial Value (Burette Scale)	Final Value(Burette Scale)	Volume of Titrant Used (ml)
1	Tap Water	--	--	--
2	Pound Water	--	--	--

Calculations:

D.O. in mg/lit = 8*100*N/V * v

Where: V = Volume of sample taken (ml)v =

Volume of used titrant (ml)

N = Normality of titrant

8 is the constant since 1ml of 0.025N Sodium thiosulphate solution is equivalent to 0.2mg oxygen.

RESLUT- The result is ……………………………….

DETERMINATION OF BACTERIOLOGICAL QUALITY OF WATER SAMPLE BY COLIFORM TEST.(EX-4.6)

INTRODUCTION…..

The most common and widespread danger associated with drinking water is contamination, either directly or indirectly, by sewage, other wastes or human and animal excrement[1]. About 25 years ago, authoritative estimates indicated that each year some 500 million people are affected by water-borne or water associated disease, and as many as 10 mfflion of these die[2]. In a recent estimate based on WHO reports suggests that 80% of all human illnesses in the dcveloping world are caused by biological contamination[3]. Faecal pollution of drinking water may introduce a variety of intestinal pathogens. Their presence being related to microbial diseases and carriers present in the community, which may cause diseases from mild gastroentritis to severe and sometimes fatal dysentry, cholera or typhoid. Other organisms, naturally present in the environment and not regarded as pathogens, may also cause opportunist disease[1]. Ideally, drinking water should not contain any microorganisms known to be pathogenic. It should be free from bacteria indicative of pollution with excreta[4]. The majority of the population in developing countries is not adequately supplied with potable water, and thus obliged to use unsafe water for domestic and drinking purposes[5] Pakistan, a developing country, is also facing a problem of wholesome water supply. This study was initiated to determine bacterial loads and contaminants in drinking water in and around Islamabad as water quality guidelines form a basis for judgement of the acceptability of public drinking water supplies[5].

MATERIALAND METHODS

Sample collection:

One hundred and twelve water samples were aseptically collected in sterilized bottles from various sources in and around Islamabad. Sampling was done from May to October, 1984. Samples were collected from wells, springs, rivers and municipal tap water supplies. All samples were immediatelytransported to the laboratory and processed within two hours.

Sample Processing:

A. pH of water: pH of all the water samples was recorded by means of a pH meter.

B. Bacteriological Analysis:

i) Presumptive test for coliforms

a. Untreated water samples: Water samples were processed as described by Rand et al[6]. Briefly, five tubes of double strength lactose broth (containing durham tube) were inoculated with 10 ml water sample (in each tube) and two tubes of single strength with 1.0 ml and 0.1 ml respectively. After incubation at 35°C for 48 hours production of acid and the presence of gas in any of the durham tubes was considered positive. Number of the positive tubes was recorded and most probable number (MPN)was calculated according to MPN tables[6].

b. **Treated water samples:** In case of chlorinated or sand filtered water, 50 ml of double strength MacConkey's broth was inoculated with 25 ml ofwáter sample and incubated at 35°C for 48 hours[7]. Therest of the procedure was same as for untreated water samples.

ii) Confirmatory test for faecal coil-forms:

One ml from each positive tube of presumptive coliforms was inoculated in Brilliant Green Lactose bile Broth (BGLB) tube. After incubation at 44.5°C in a water bath for 24 hours; tubes with gas and turbidity were considered positive. Positive tubes were further cultured on Eosine Methylene Blue agar (EMB) for isolation of faecal coliforms[7]. Isolated colonies were confirmed by using biochemical tests[10] as well as Systek kit No.1.

iii) Confirmatory test for faecal streptococci:

Positive tubes of presumptive coliform test were subcultured in glucose broth and incubated for 2 hoursat 37°C. Sodium azide (0.25 gm/500 ml) was then added and incubation carried out at 44.5°C for a further 48 hours. Positive tubes showing acid were subcultured on MacConkey agar plates and incubated at 37°C for 24 hours; The presence of small red pinpoint colonies were indicative of Streptococcus faecalls. Gram staining and the production of acid in mannitol and lactose only, but not in raffinose, confirmed their presence[8].

iv) Standard Plate Count (SPC):

The standard plate count was done by pour plate technique using 10 fold dilutions (upto 10-6) in ringers solution. One ml of each dilution was poured (duplicates) in empty, sterilized petridishes. About12 to 15 ml of plate count agar (kept at 45°C in a waterbath) was added to each plate. Plates after solidification were incubated at 37°C for 24 to 48 hours. Plates showing 3 0—300 colonies were counted to determine the SPC per ml of sample tested. [9]

v) Analysis of other enteric pathogens.

Salmonella, Shigella and vibrio spp. Fifty ml of selenite broth and same quantity of alkaline peptone water in flasks were inoculated with 25ml water (in each flask). After incubation for 16-18 hours at 37°C subcultures from the former was made on Xylose Lysine Dextrose agar (XLD) plate and on Thiosulphate Citrate Bile salt Sucrose agar (TCBS) from the later. Plates were incubated at 37°C for 24hours. Suspected colonies were identified biochemically and serologically[10,11].

RESULTS

The water samples investigated in this study were mainly analysed for the bacteriological contamination. The pH of the water samples (112) fall between pH 7—8.3. Water samples wereanalysed categorized in two different groups (Table I).

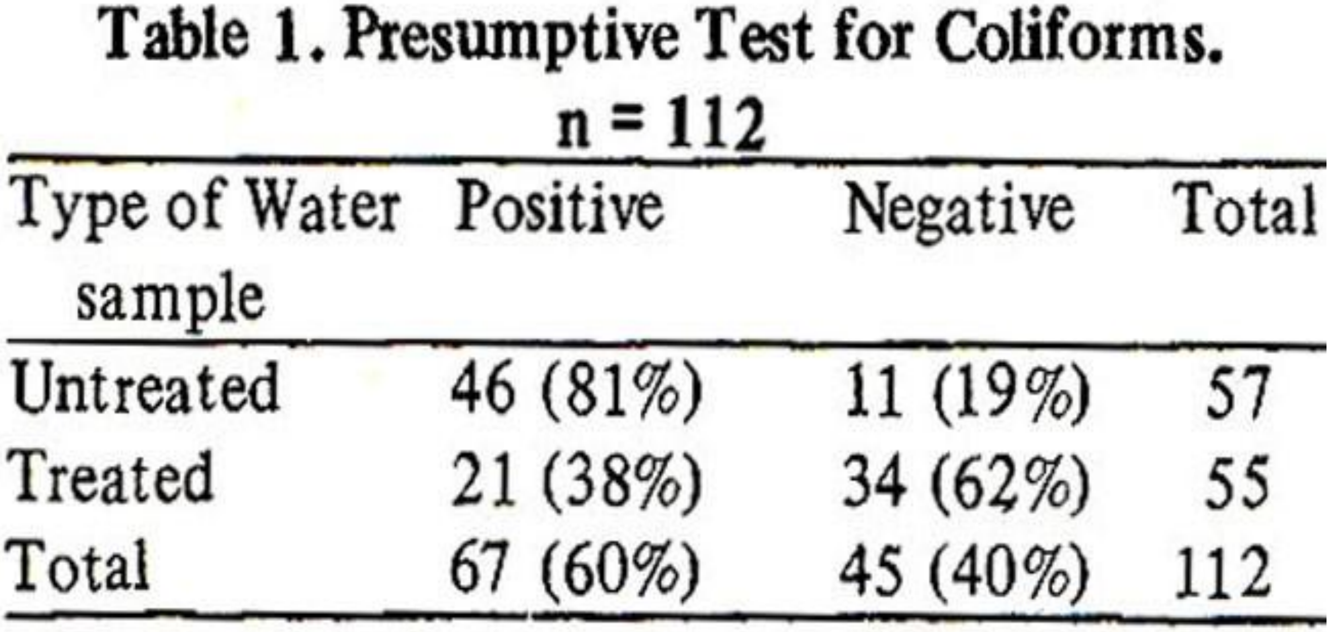


Table 1. Presumptive Test for Coliforms.

n = 112

Type of Water sample	Positive	Negative	Total
Untreated	46 (81%)	11 (19%)	57
Treated	21 (38%)	34 (62%)	55
Total	67 (60%)	45 (40%)	112

Out of 57 untreated water samples, 46 (8 1%) were found positive for the presence of coliforms while out of 55 treated water samples, 21 (38.0%) were found positive for the same. The samples which werefound positive for coliform presumptive test underwent confirmatory test. Out of 67 positive samples 26 were confirmed for the presence of faecal coliforms. In addition 6 water samples were found positive for Streptococcus faecalis. Load of Viable aerobic bacteria per ml of the water sample was determined, (Table II).

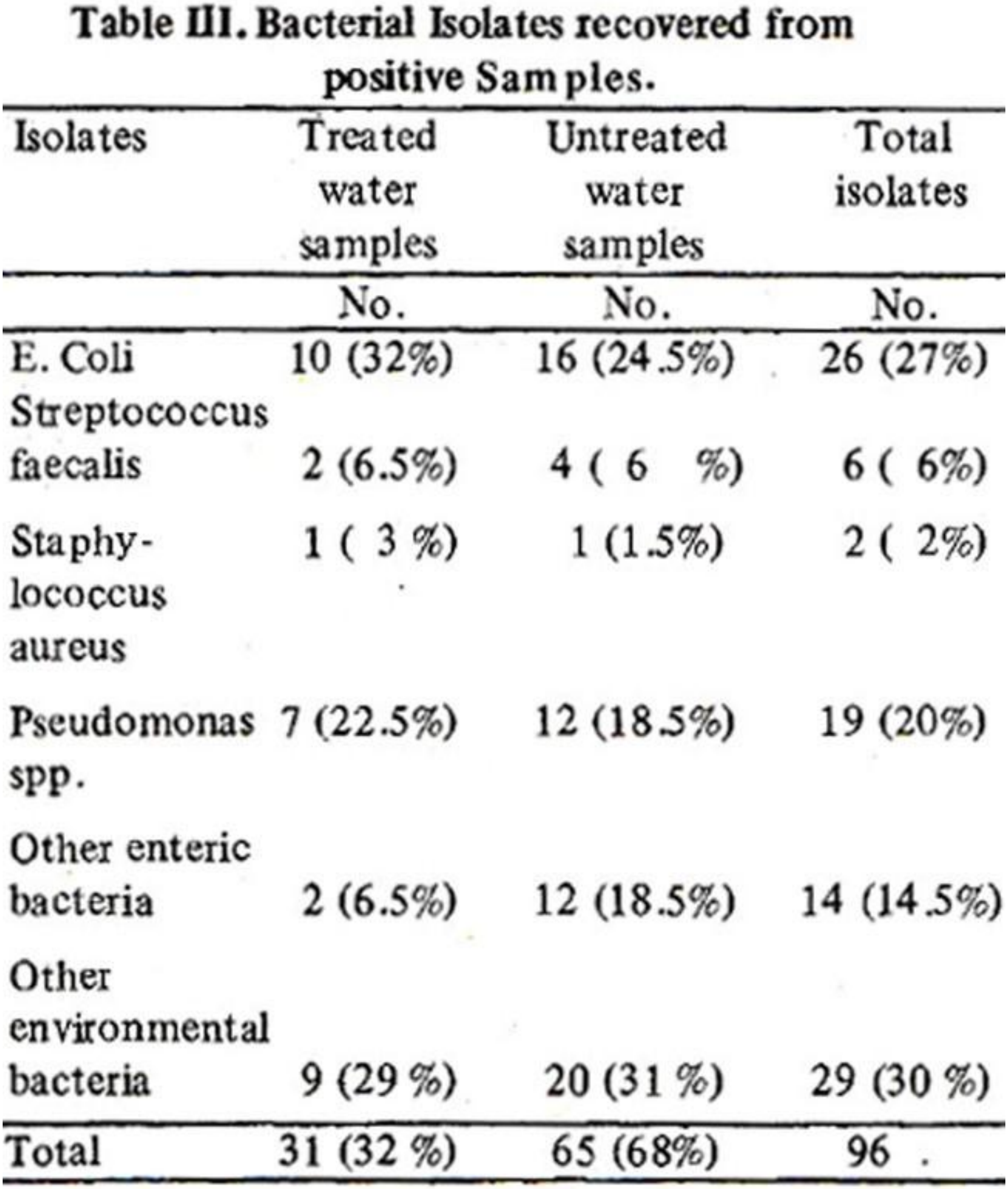
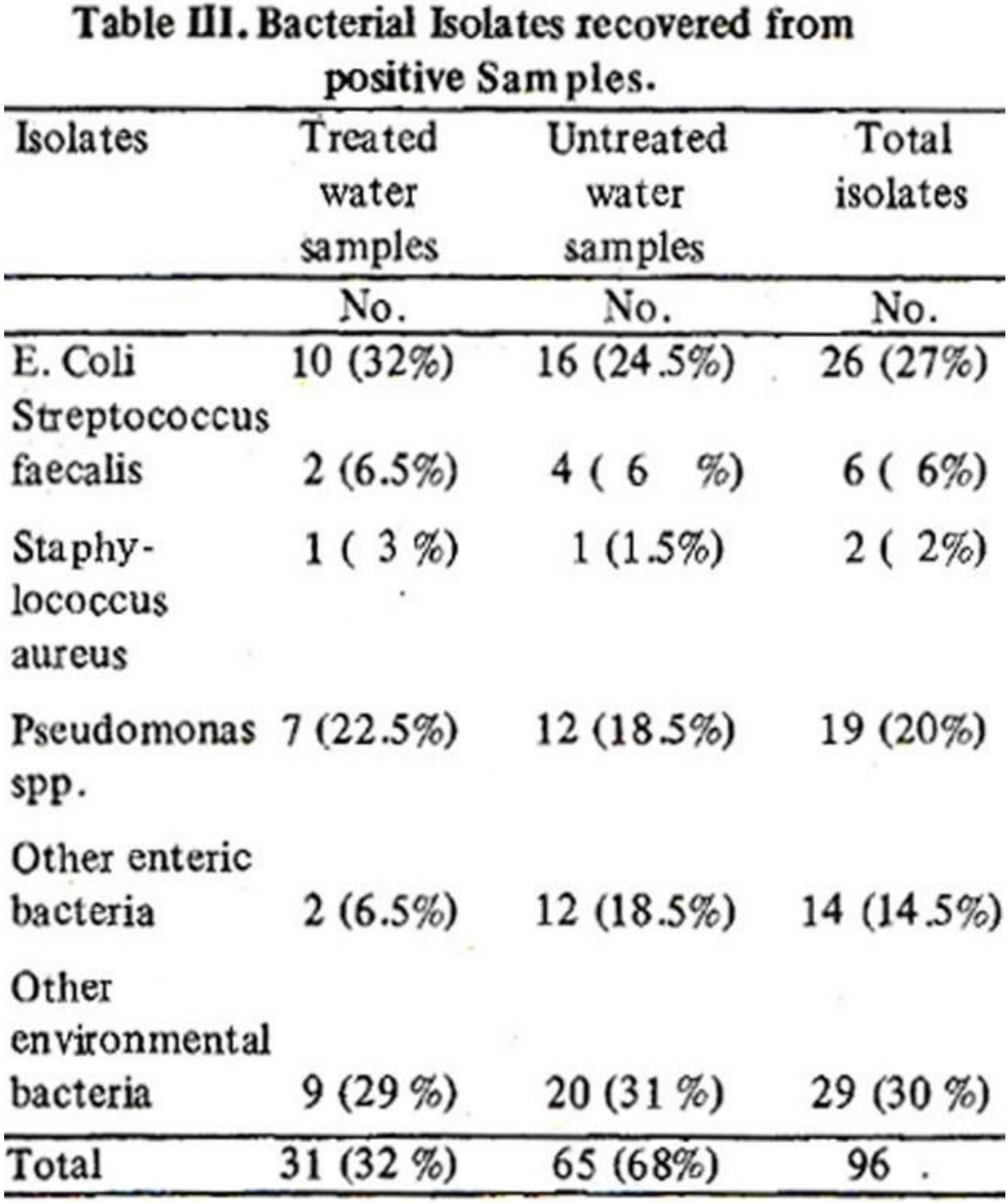


Table III. Bacterial Isolates recovered from positive Samples.

Isolates	Treated water samples	Untreated water samples	Total isolates
	No.	No.	No.
E. Coli	10 (32%)	16 (24.5%)	26 (27%)
Streptococcus faecalis	2 (6.5%)	4 (6 %)	6 (6%)
Staphylococcus aureus	1 (3 %)	1 (1.5%)	2 (2%)
Pseudomonas spp.	7 (22.5%)	12 (18.5%)	19 (20%)
Other enteric bacteria	2 (6.5%)	12 (18.5%)	14 (14.5%)
Other environmental bacteria	9 (29 %)	20 (31 %)	29 (30 %)
Total	31 (32 %)	65 (68%)	96 .

Twenty nine (26%) specimens showed no growth on the plate count agar and were mostly from treated water samples. Other samples enumerated counts between < 10 to> 106/ml. Escherichia coli (27%) wasthe major pathogen among the other bacterial isolates (Table III)



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Other environmental bacteria	9 (29 %)	20 (31 %)	29 (30 %)
Total	31 (32 %)	65 (68%)	96

followed by Streptococcus faecalis (6%) and Staphylococcus aureus (2%). Other organisms were Pseudomonas Spp. (20%), enteric bacteria (14.5) and environmental bacteria (30%). Some of the samples contained more than one isolate. All the water samples investigated for the presence of Salmonella, Shigella and Vibrio cholerae were found negative.

DISCUSSION

An acceptable pH for drinking water is between pH 6.5 to pH 8.5, recommended by WHO as a guideline value and in the absence of a distribution system acceptable range may. be broader. AU thewater samples examined in this study were in acceptable pH range.

For the presumptive coliforms test, the WHO guideline for both treated and untreated water samples is0/ 100 ml [4], but in an occasional untreated water sample 3 coliform/100 ml are allowed on the condition that these would not be found in consecutive water samples. [12] The coliform group as an indicator bacteria are used to evaluate the potability of drinking water and the presence of any coliformorganisms is an indication of a contaminated source, inadequate treatment or post treatment contamination[13]. In unpiped water supplies, sometimes upto 10 coliforms/l00 ml are allowed but they should notoccur repeatedly; if occurrence is frequent and sanitary protection cannot be improved, an alternative source must be found if possible. [12] In this study 81 % of the untreated and 38% of the treated water samples were positive for MPN, showing a high contamination and risk to public health The detection of faecal (Thermotolerant) coliform organisms provide definite evidence of faecal pollution[4] and they were found in 39% of the positive samples. Search for Streptococcus faecalis is not carried out routinely. Its main value is when doubt is expressed that large number of irregular types of coliforms found in a sample of water are of faecal origin. Confirmation of faecal pollution would then rely on finding £ faecaiis in the water[8]. Since they survive longer in water than coliform bacteria they should be referred as indicator of faecal pollution in water and shelfish.[14] In the present study they were foundonly in 6% of the water samples examined. The main value of colony counts lies in the comparison of results obtained from regular samples from the same supply so that any significant change from the normal range in a particular location can be detected.[1] As the SPC in most of the untreated water samples (Table II) was very high, it is therefore desirable to disinfect all supplies of drinking water before distribution. Supplies derived from protected sources which are distributed without disinfectionshould be similar in quality to that of disinfected drinking water. Where it is impracticable to supply water to consumers through a piped distribution network and where untreated sources such as wells, bore-holes and springs which may be naturally pure must be used, considerable reliance should be placed on sanitary examination and not exclusively on the results of bacteriological examination.[15] Thehigh percentage of E. coil (27%) provides a definite evidence of faecal pollution in water.[4] Staphylococcus aureus (2%) which is relatively recently accepted as indicator organisms in food and water, provides a useful indication that faecal contamination has occurred in water.[14] Pseudomonas spp. are common inhabitant of soil and water and found in small numbers in the faeces of man and animals. These were isolated in about 20% samples and are of public health importance as some’ species cause a variety of suppurative infections in man. Enterotoxigenic strains of pseudomonas spp. alongwith other species of Enterobacter, Kiebsiella and Acinetobacter have been isolated from cases ofinfantile diirrhoea in Addis Ababa during surveys in 1974 and 1977.[16,17,18] Enterotoxigenic species of proteus with other enterotoxigenic bacteria have also been reported in a study on food and water from an Ethiopian community.[19] Environmental bacteria (Table Ill) include Alcaligenes spp., Acinetobacter spp., Yeast spp. and Bacillus spp. which are usually found in soil. Presence of such high bacterial counts and presence of faecal coliforms and other indicator organisms as Streptococcus faecaiis, Staphy - lococcus aureus indicate inadequate treatment, post treatment contamination and contaminatedwater sources. Therefore, everything possible should be done to prevent pollution of the drinking water,special attention being given to the safe disposal of excrement. But the significance of routes of transmission other than drinking water should not be underestimated as the provision of a safe potable water supply by itself will not necessarily prevent infection without accompanying improvement in sanitation and personal habits. Education in simple hygiene is also essential.

RESULT- The result is……….