ATRIA INSTITUTE OF TECHNOLOGY

Affiliated to VTU

LABORATORY MANUAL

18CVL58- Concrete and Highway Materials Laboratory

2021-2022

DEPARTMENT OF CIVIL ENGINEERING

AKSB Campus, 1st Main Road, Anand Nagar,

Hebbal, Bengaluru 560024

List of experiments

PART-A: CONCRETE LAB

1. Test on cement:

1. Specific gravity of cement Specific Gravity Bottle
2. Standard / Normal Consistency of Cement.
3. Initial and Final setting time of cement.
4. Compressive Strength of Cement
5. Fineness of Cement by Air permeability test.

2. Tests on Concrete:

a. Design of concrete mix as per IS-10262

b. Test on workability of fresh concrete:

1. Slump cone method.
2. Compaction Factor test.
3. Vee Bee tests.

c. Test on hardened concrete:

1. Compressive Strength
2. Split tensile Strength
3. Flexural Strength

d. NDT tests by re bound hammer and pulse velocity test.

e. Tests on Self Compacting Concrete:

1. Design of self compacting concrete, As per Is 10262:2019
2. slump flow test,
3. V-funnel test,
4. J-Ring test,
5. U Box test and
6. L Box test

PART-B: HIGHWAY MATERIALS LAB

1. **Test on aggregates:**
   a. Aggregate crushing value

   b. Aggregate abrasion value (Los Angels Abrasion Test).
   c. Aggregate Impact value.
   d. Shape tests on aggregates (Flaky, elongation, angularity number).

2. **Test on bituminous materials:**
   a. Specific gravity of bitumen.
   b. Penetration test on bitumen.
   c. Ductility test on bitumen.
   d. Viscosity test on bitumen.
   e. Softening point, flash and fire point test on bitumen.
   f. Marshall Stability tests on bituminous (Demonstration only)

3. **Tests on Soil**
   a. Wet sieve analysis
   b. CBR test

PART-A: CONCRETE LAB

1. Test on cement:

EXPERIMENT NO: 1

AIM: To determine specific gravity of cement by using specific gravity bottle.

APPARATUES: Specific gravity bottle, weighing balance and kerosene (free from water).

DIAGROM:

Specific gravity bottle

PROCEDURE:

1. The Flask should be free from the liquid that means it should be fully dry. Weigh the empty flask. This is W1.
2. Next, fill the cement on the bottle up to half of the flask around 50gm and weigh with its stopper. And it is W2.

3. Add Kerosene to the cement up to the top of the bottle. Mix well to remove the air bubbles in it. Weigh the flask with cement and kerosene. And it is W3.
4. Empty the flask. Fill the bottle with kerosene up to the top and weigh the flask for counting W4.

OBSERVATION AND CALCULATIONS:

1. Mass of empty bottle W_1, gm =
2. Mass of bottle + cement W_2, gm =
3. Mass of bottle +cement + kerosene W_3, gm =
4. Mass of bottle + kerosene W_4, gm =
5. Sp gravity of kerosene = 0.79
6. Sp gravity of cement

$$S_g = \frac{W2 - W1}{(W2 - W1) - (W3 - W4) \times 0.79}$$

RESULT:

Specific gravity of the sample of cement =

EXPERIMENT NO: 2

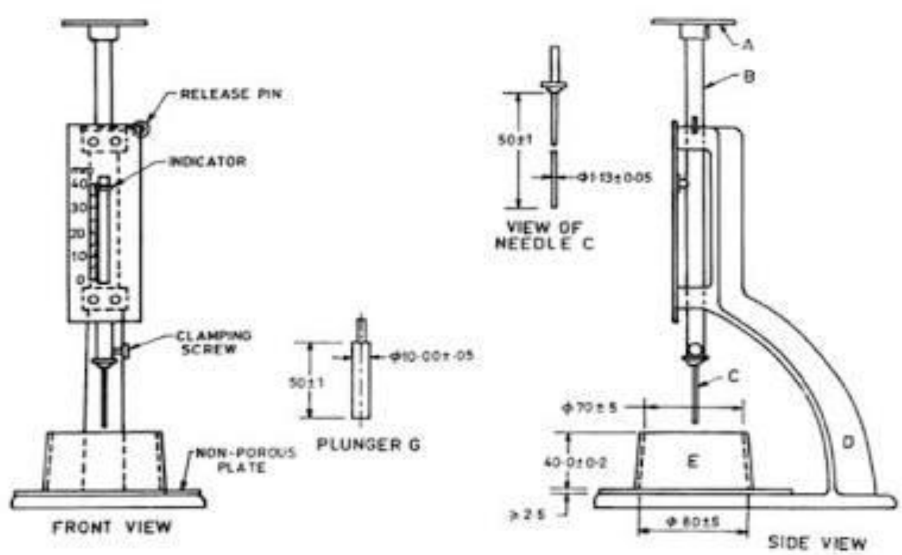
AIM: To determine the percentage of water for normal consistency for a given sample of cement

THEORY: Normal consistency of cement is the amount of water required to prepare a paste of standard consistency, which would give penetration value of 33 to 35 mm from the top of the vicat mould. The consistency cement paste is expressed as a percentage by weight of dry cement. Usually this percentage varies from 26% to 33%. Normal consistency is useful to determining the water content to be added to cement in setting time, soundness and compressive strength that are conducted to tast in cement for its quality.

APPARATUES: Weighing balance of 1000g with accuracy 1g and Measuring cylinder of 200ml, VICAT apparatus, VICAT Mould, Glass plate, the plunger of 10mm dia and Hand Trowel.

VICAT'S APPARATUS: As vicat's apparatus consist of a frame bearing a movable rod of weight 300 grams. At the upper end of this rod a cap is provided lower end 1.13mm of weight 300 grams.

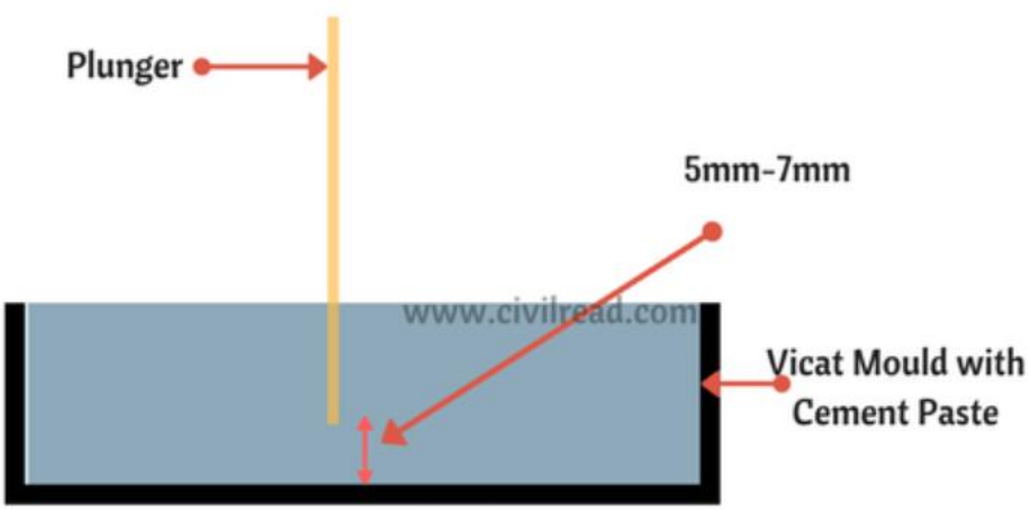
DIAGRAM:



All dimensions in millimetres.
FIG. 1 VICAT APPARATUS (*Continued*)

PROCEDURE:

1. Take 400g of cement and place it in a bowl or tray.
2. Now Assume standard consistency of water is 28% and add the same quantity of water in cement and mix it.
3. Mix the paste thoroughly within 3-5 minutes. The time taken to obtain cement paste after adding water is called gauging time.
4. Now fill the paste in Vicat mould correctly any excessive paste remained on Vicat mould is taken off by using a trowel.
5. Then, place the VICAT mould on Glass plate and see that the plunger should touch the surface of VICAT mould gently.
6. Release the Plunger and allow it to sink into the test mould.
7. Note down the penetration of the plunger from the bottom of mould indicated on the scale.
8. Repeat the same experiment by adding different percentages of water until the reading is in between 5-7mm on the Vicat apparatus scale.



OBSERVATION AND CALCULATIONS:

1. Weight of cement taken (g) = __________
2. Initial percentage of water added to cement = ___________

3. Quantity of water added to cement =_______

TABULAR COLUMN:

Sl No	Quantity Of Water Added (ml)	Depth Of Penetration (mm)

Standard Consistency of Cement "P" = (Quantity of water for 5-7 mm penetration/Weight of cement) X 100

PRECAUTION:

1. The procedure should be conducted within 3-5 min after mixing water
2. The reading should be taken carefully

RESULT:

The percentage of water for normal consistency for the given sample of cement is ……..

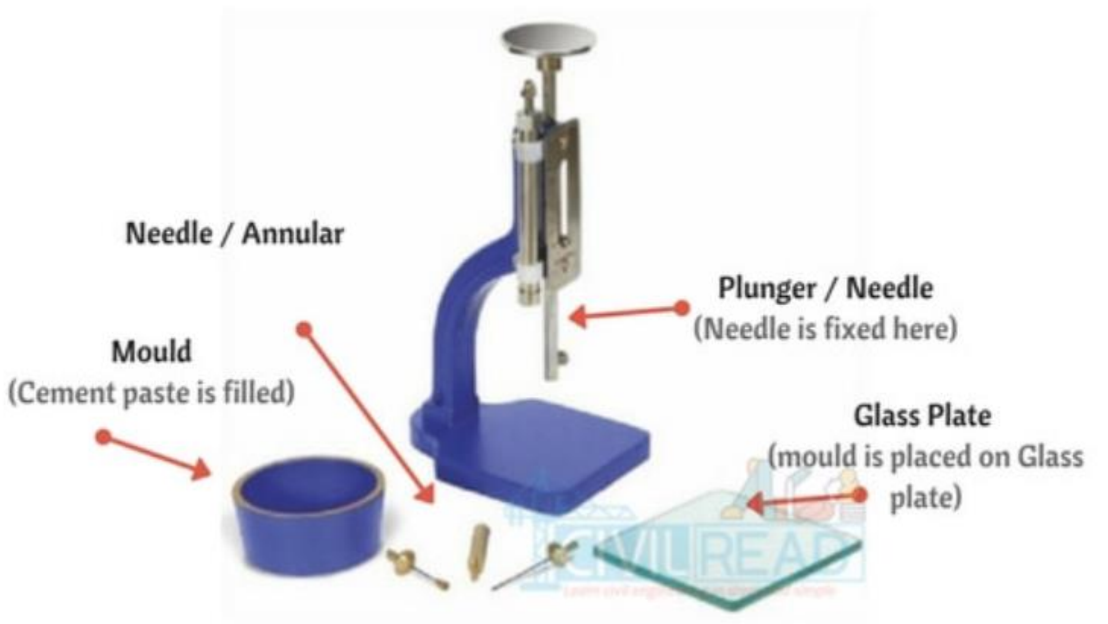
EXPERIMENT NO.3

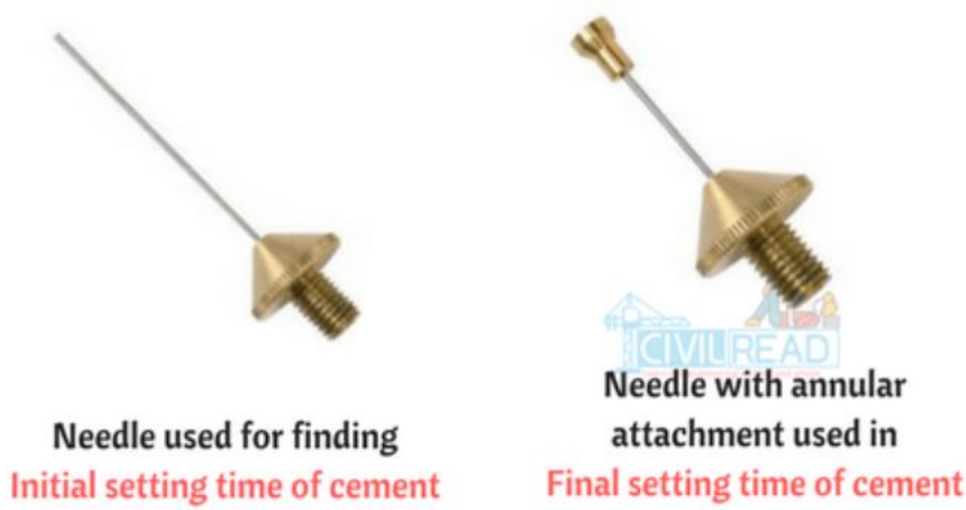
AIM: To determine the initial and final setting time of a given sample of cement.

THEORY: Cement losses its plasticity when the water is added to it and finally becomes a solid mass. Setting time may be split into initial and final setting time. The time at which the cement paste loses its plasticity till the needle fails to penetrate the cement paste about 5 mm from the bottom of the mould. The period lapsed between water added to cement and till the needle fails to penetrate 5 mm from the bottom is measured as initial setting time. The size of needle being 1 mm^2 or 1.13 mm ϕ. The cement is said to have finally set when the needle projecting 0.5 mm beyond the annular attachment penetrate into the cement paste but the annular attachment fails to make any impression on it.

APPARATUS: Weighing balance of 1000g with accuracy 1g and Measuring cylinder of 200ml, VICAT apparatus, VICAT Mould, Glass plate, the plunger of 10mm dia and Hand Trowel, stop watch

DIAGRAM:





PROCEDURE:

1. Take 400g of cement and place it in a bowl or tray.

2. Now add water of Start the stopwatch at the moment water is added to the cement. Water of quantity 0.85P.times (Where P is the Standard consistency of cement) is considered.
3. Now fill the mix in Vicat mould. If any excessive paste remained on Vicat mould is taken off by using a trowel.
4. Then, place the VICAT mould on non porous plate (Glass plate) and see that the plunger should touch the surface of VICAT mould gently.
5. Release the Plunger and allow it to sink into the test mould.
6. Note down the penetration of the plunger from the bottom of mould indicated on the scale.
7. Repeat the same experiment at different positions on the mould until the plunger should stop penetrating 5 from the bottom of the mould.

OBSERVATION AND CALCULATIONS:

1. Quantity of cement =
2. Water for standard Consistency P =
3. Quantity of water to be added =

TABULAR COLUMN:

Sl No	Quantity Of Water Added (ml)	Depth Of Penetration (mm)

Test Result

1. **Initial Setting Time** of Cement **–** Note down the time, when needle fails to penetrate 5 – 7 mm from the bottom of the test block. This time is denoted as an initial setting time of cement.
2. **Final Setting Time** of Cement **–** Note down the time, when needle fails to make an impression on the surface of the test block. This time is denoted as a final setting time of cement.

RESULT:

1. The initial setting time of the cement …..
2. The final setting time of the cement …..

Acceptance criteria – Recommended result for various types of cement to their setting time gives by standard guidelines are as follows:

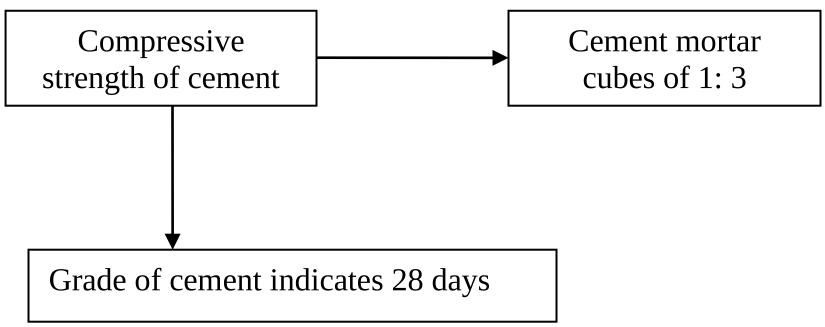
Sr. No.	Type of Cement (Guidelines)	Setting Time	
		Initial Time Min. (minutes)	Final Time Max. (minutes)
1	33 Grade OPC (IS 269-1989)	30	600
2	43 Grade OPC (IS 81112-1989)	30	600
3	53 Grade OPC (12269-1987	30	600
4	SRC (IS 12330-1988)	30	600
5	PPC (IS 1489-1991) Part I	30	600
6	Rapid Hardening (IS 1489-1991) Part I	30	600
7	Slag Cement (IS 445-1989)	30	600
8	High Alumina Cement (IS 6452-1989)	30	600
9	Super Sulphated Cement (IS 6909-1990)	30	600
10	Low Heat Cement (IS 12600-1989)	60	600
11	Masonry Cement (IS 3466-1988)	90	600
12	IRS-T-40	60	600

EXPERIMENT NO.4

AIM: To determine Compressive Strength of Cement

THEORY: This measures development of strength depends on fineness of cement. Finer the cement quicker is the action with water and gains early strength. But shrinkage and cracking of finished surface will increase with fines of cement.

CONCEPT STRUCTURE:

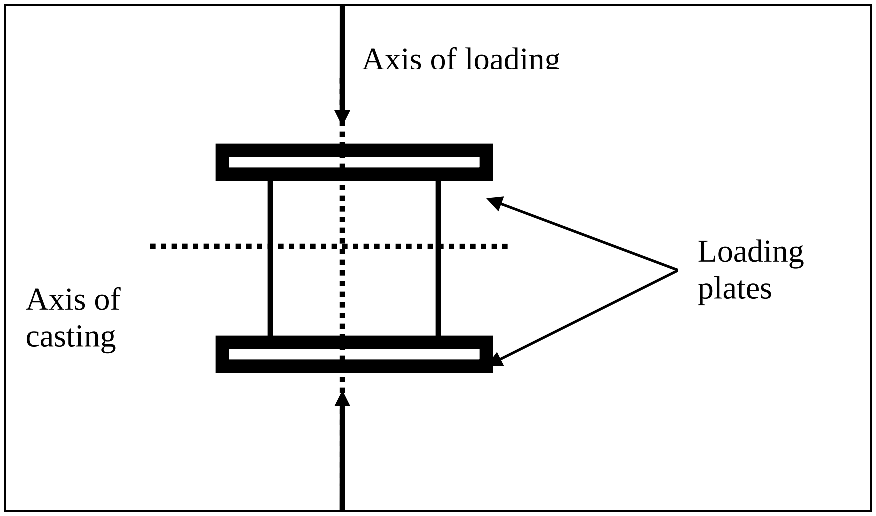


APPARATUS:

Compression testing machine, Cube mould of size 7.07x 7.07 x 7.07cm with base plates, Crucible to mix cement and sand, weighting balance accurate up to 0.1gm, Motored cube vibration machine, Measuring cylinder, Trowel and tray etc.

Materials: Cement sample, water and standard sand.

DIAGRAM:



PROCEDURE:

1. The weight of cement required is 200 grams and 600 gms of standard sand and mix them first dry.

2. Calculate the water content required for one cube specimen and mix this water to dry mortar keeping in view the gauge time as 3 – 5 minutes.

3. Apply thin layer of oil to the interior faces of the mould and fill the mortar mix in the mould, Place it on the table of the vibration machine about 2 minutes at 12000 ± 400 RPM.

4. Air cure the specimens at 27°C for 24 hours in room with 90 % relative humidity.

5. After air curing keep the specimen in water total period 3 to 7 days to determine the compressive strength.

6. The cubes are removed from water, drained and placed between testing plates of compression testing machine and a load of 35 N /mm^2 /minute is applied.

7. Compressive strength of cement is calculated as failure load divided by area of cube be 50 cm^2.

OBSERVATIONS:

1. Type and brand of cement = ------------------------

2. Grade of cement = ------------------------

3. Standard consistency of cement sample (P) = --------------------%

4. Area of sample = ------------------------

5. Quantities of ingredients required for each sample cube -

Cement = 200 gram

Standard sand = 600 gram

Water = (P/4+3) % of (Wt. Of cement + Wt. Of sand)

6. Date of casting the cubes:

7. Date of testing cubes:

1. After 3 days --------------------
2. After 7 days ---------------------
3. After 28 days --------------------

FOR COMPRESSIVE TEST ON CEMENT:

Sl. No.	3 days		7 days	
	Load (KN)	Strength (N/ mm^2)	Load (KN)	Strength (N/ mm^2)
1				
2				
3				
Average strength				

RESULTS:

The average comp. Strength of the cement sample is found to be

1. At the end of 3 days of curing = ---------------------------- N/ mm^2

2. At the end of 7 days of curing = ------------------------------N/mm^2

3. At the end of 28 days of curing = ------------------------------N/mm^2

CONCLUSION:

The compressive strength of given cement sample is ……………………………..

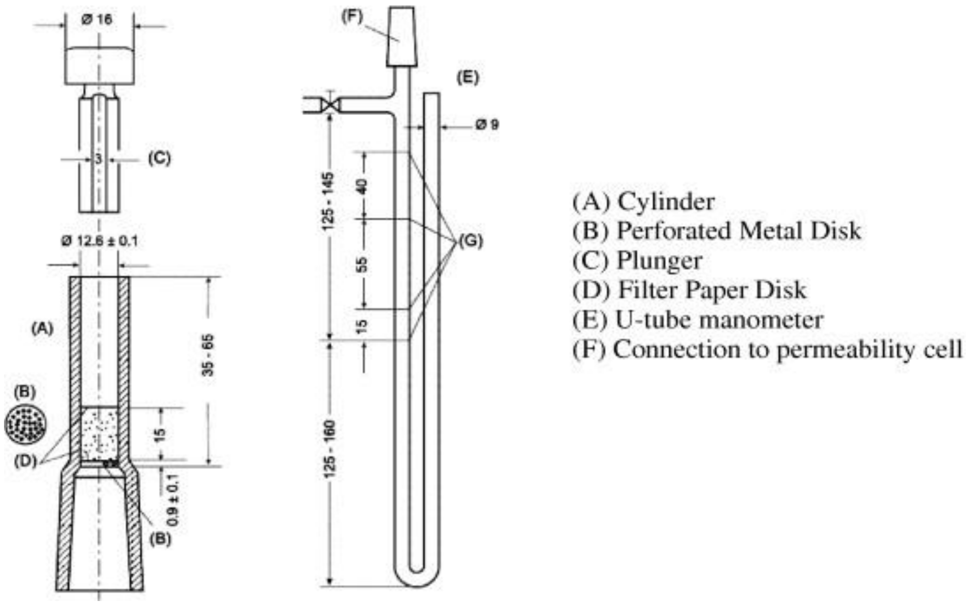
EXPERIMENT NO.5

AIM: To determine fineness of Cement by Air permeability test.

THEORY: This measure the mean size of particles of cement, the development of strength depends on fines of cement. Finer the cement quicker is the action with water and gains early strength. But shrinkage and cracking of finished surface will increase with finess of cement.

APPARATUS: Permeability cell, perforated disc, plunger, filter paper, manometer, weighing balance accurate up to 0.1 gm, stop watch, mercury, crucible, trowel and brush and tray.

DIAGRAM:



PROCEDURE:

Procedure consists of 4 steps

A. DETERMINATION OF THE DENSITY OF CEMENT

To determine the density or specific gravity of cement.

B. DETERMINATION OF THE BED VOLUME

1. Apply a very thin film of light mineral oil to the cell interior. Place the perforated disc on the ledge in cell. Place two new filter paper discs on the perforated disc.
2. Fill the cell with mercury. Level the mercury to the top of the cell with a glass plate.
3. Remove the mercury from cell and it, $\mathbf{M_1}$.
4. Remove the top filter paper from the permeability cell and compress a trial quantity of 2.80 g of cement into the space above filter paper to the gauge line in the cell. Place the other filter paper above the cement bed.
5. Fill the remaining space in the cell above the filter paper with mercury. Level the mercury to the top of the cell with a glass plate and remove mercury from the cell and weigh it, $\mathbf{M_2}$.
6. Calculate the volume occupied by the cement bed in the cell from the following equation. $\mathbf{V = (M_1-M_2)/D}$, Where D = Density of mercury (13.54 g/cm^3)

7. Average at least two volume determinations that agree to within ±0.005cm^3 and record this value.

C. DETERMINATION OF APPARATUS CONSTANT

1. Take an amount (W) of standard cement so as to give the cement bed of porosity e=0.500. i.e. **W = (1-e)ρV** or **W = 0.500ρV**
2. Place the perforated disc on the ledge at the bottom of the cell and place on it a new filter paper disc. Place the weighed quantity of standard cement, W, in the cell taking care to avoid loss.
3. Tap the cell to level the cement. Place a second new filter paper disc on the leveled cement.
4. Compress the cement with the plunger until the plunger collar is in contact with the top of the cell. Slowly withdraw the plunger a short distance, rotate 90^0, repress the cement bed, and then slowly withdraw.
5. Attach the permeability cell to the manometer tube with an air tight connection and slowly evacuate the air in the manometer U-tube until the liquid reaches the top mark, then tightly close the valve.
6. Start the timer when the bottom of the meniscus reaches next to the top mark and stop the timer when the bottom of the meniscus reaches the bottom mark. Record the time t and temp. of test.
7. Repeat the whole procedure on two further samples of the same reference cement. Calculate the average time of the three determinations. Then calculate the apparatus constant using the formula given below.

$$K = 1.414 S_0 \rho_0 \frac{\sqrt{0.1}\eta_0}{\sqrt{t_0}}$$

Where,

K=Apparatus constant

S_0=Specific surface of reference cement

ρ_0=Density of reference cement

t_0=Mean of three measured times

η_0=Air viscosity at the mean of the three temperatures.

D. DETERMINATION OF FINENESS

1. Repeat the steps (1 to 6) as done in determination of apparatus constant, but this time using the cement whose fineness is to be calculated.
2. Calculate fineness of cement using following formula.

Where,

S = Specific surface area

K = Apparatus constant

ρ = Density of cement

t = Time

OBSERVATIONS:

Blaine's air permeability method:

1. Weight of empty crucible (W_1) = ………. …. ……g.
2. Weight of crucible + mercury filling permeability cell (W_2) = ………. …….. g.
3. Weight of mercury filling cell (WA) = (2) - (1) = …………………g.
4. Weight of crucible + mercury filling portion above cement bed (W_3) = ………g
5. Mass of mercury required to fill the portion of cell above the cement bed (W_4) = ………g
6. Bulk volume of compacted bed of cement, V cm
7. Mass of the sample W gm
8. Average time taken by the manometer liquid to fall from second to third line, T_S seconds. Specific surface of standard cement, S_S cm^2/gm.
9. Temperature of the laboratory = …………………… °C

For fineness of cement:

1. Mass of sample W gram
2. Mean time for liquid to fall through, the middle interval $\frac{T_1 + T_2 + T_3}{3}$ = T seconds
3. Specific surface cm^2/gm.

RESULT:

The fineness of the cement is ________ cm^2/gm.

CONCLUSION:

The fineness of the given sample of cement is --------- (within / not within) the limit specified by B. I. S. The finess is given,

1. For ordinary Portland cement = 2250 cm^2/gm.
2. For rapid hardening cement = 3250 cm^2/gm.
3. For low heat cement = 3200 cm^2/gm.

2. Tests on Concrete:

Test on Fresh Concrete

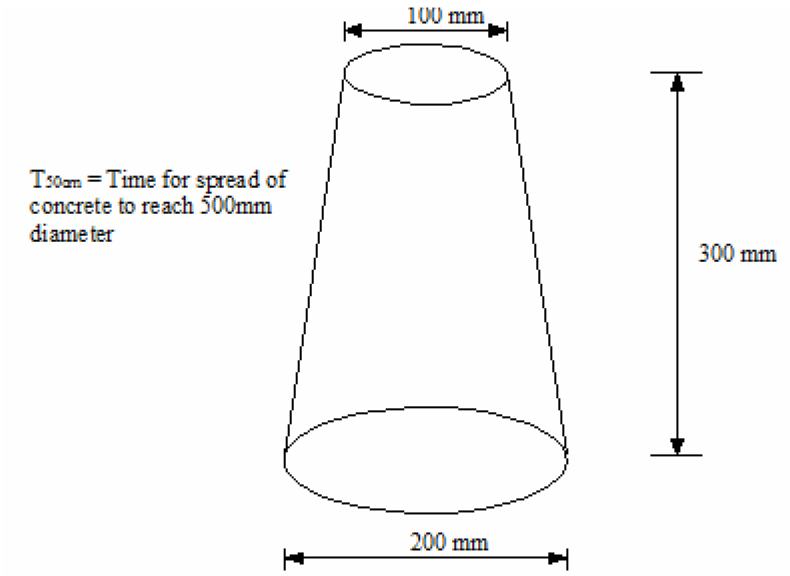
EXPERIMENT NO 6

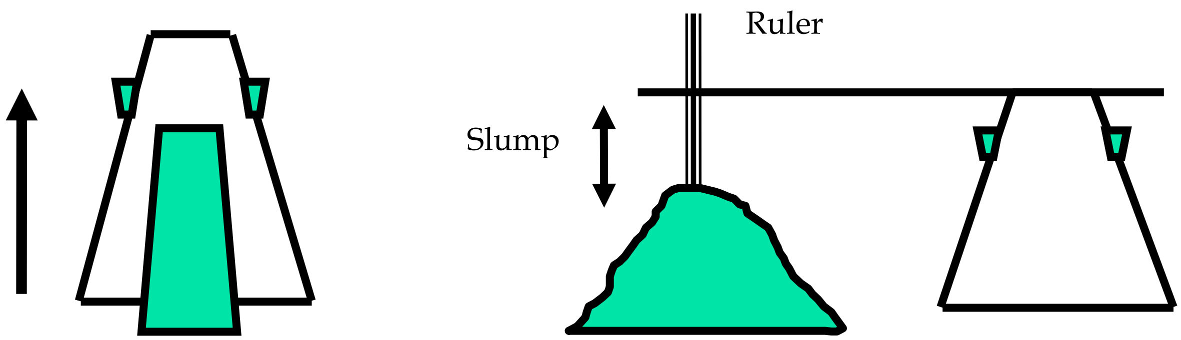
AIM: To determine workability of concrete by slump cone method.

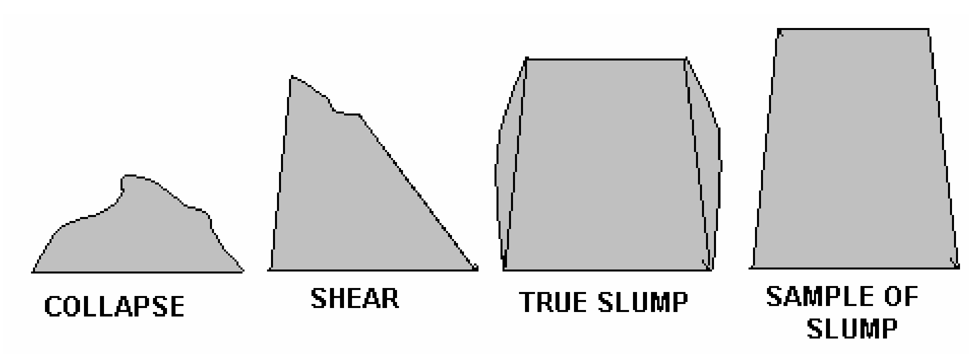
THEORY: Unsupported fresh concrete will flow to the sides and this vertical settlement is known as slump. Slump increases with increase in water/cement ratio. Different slump values are recommended for different concrete works. Slump value is a measure of workability of concrete. Concrete is said to be workable, if it can be easily mixed, place, compacted and finished. A workable concrete should not show any segregation or bleeding.

APPARATUES: Concrete mixing pan, balance, trowels, slump cone apparatus, tampering rod 60 cm long and 1 cm ϕ and graduated cylinder.

DIAGROM:







PROCEDURE:

1. Calculate the quantities of materials required for slump test and weigh them separately.

2. Adopt the given water cement ratio as recommended and calculate the water required.
3. Mix sand and cement dry thoroughly and thus prepare a dry mix. Spread the aggregates on the iron pan evenly to about 5 cm layer and on this spread cement sand mix. Sprinkle about 1/3 water calculated for the experiment and mix uniformly.
4. Add again water about 1/3 and mix the concrete thoroughly. This procedure is repeated for third time and concrete should look uniform.
5. Fix the truncated cone to the stand after applying the inner surface with oil and till the concrete in 4 equal layers each layer giving 25 blows uniformly all over the surface.
6. Fill the space and level the surface of striking off extra concrete.
7. Remove the cone raising it slowly without jerks.
8. Note the reading after the settlement is over, this value gives the slump value of concrete.

OBSERVATION AND CALCULATIONS:

W/c ratio	**Slump**
0.5	
0.55	
0.6	
0.65	

Recommended values of slump:

Sl. No.	Name of work	Slump mm	W/c ratio
1	CC for roads and mass concrete	25 – 50	0.70
2	RCC beams and slab	50 – 100	0.55

3	Column and retaining walls	75 – 125	0.45
4	Foundation mass concrete	25 – 50	0.70

RESULT:

Slump of fresh concrete sample =

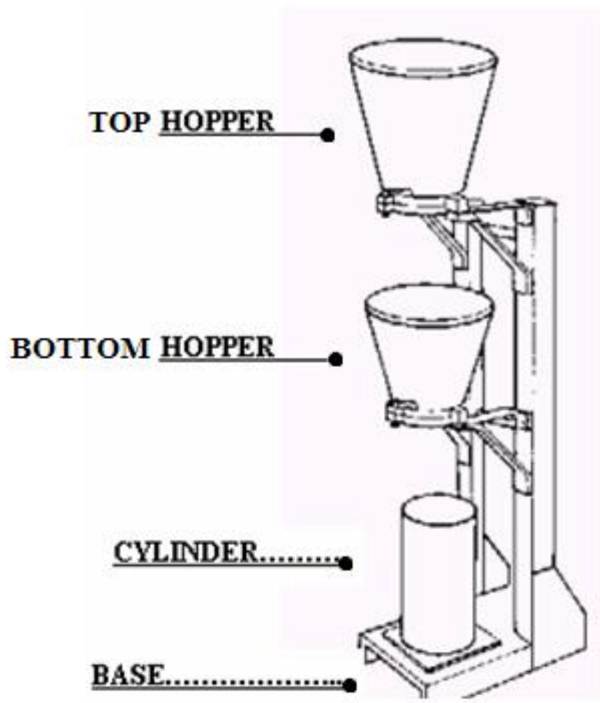
EXPERIMENT NO: 7

AIM: To determine the workability of concrete by Compaction Factor test.

THEORY: This workability test determines the amount of work required to produce full compaction for a concrete which partially compacted during the test by allowing it to fall from a predetermined height.

APPARATUES: Compaction factor test apparatus, Concrete mixing pan, balance to 30 Kg, trowels, tampering rod and graduated cylinder of 1 liter capacity.

DIAGRAM:



PROCEDURE:

1. Mix suffient quantity of concrete as explained in slump cone test and fill the top hopper of the compaction factor equipment.
2. Allow the concrete into bottom hopper by opening the flip of top hopper which the flip of bottom hopper is closed
3. Now allow the concrete to fall into the cylinder the weight of concrete required to fill the cylinder is determined, let it be W_2
4. Remove the concrete from cylinder and fill the same concrete into it in 14 layers each layer is tampered 25 times uniformly all over the surface, now find the weight of cylinder W_3
5. Compaction factor = $\frac{W_2 - W_1}{W_3 - W_1} = \frac{\text{Weight of partially complete concrete}}{\text{Weight of fully compacted concrete}}$

   Where W_1 = Weight of empty cylinder

OBSERVATION TABLE:

W/c ratio	Compaction

0.5	
0.55	
0.6	
0.65	

RESULT:

The compaction factor of fresh concrete =

EXPERIMENT NO.8

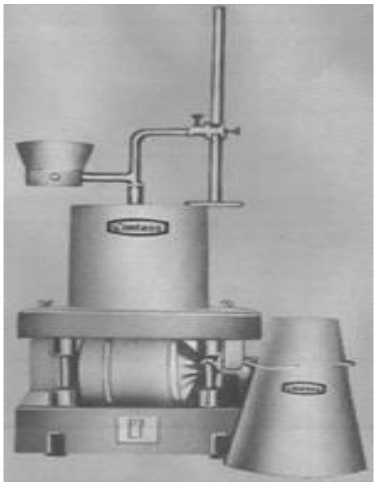
AIM: To determine the workability of concrete by Vee Bee Consistometer test.

THEORY: This test measures in relative effort required to change a mass of concrete called remolding effort is taken as time in seconds required to complete the change. This test is useful in standing the mobility of the masses of the concrete made with varying amounts of water, cement and various types grading of aggregate

The time required for complete remolding in seconds is considered as a measure of workability and is expressed as the number of vee bee seconds. This test is suitable for dry mixes.

APPARATUS: Vee Bee vibrating table**,** slump cone, tampering rod, trowels and balance.

DIAGRAM:



PROCEDURE:

1. Place the slump cone in the VB consistometer and compact the mixed concrete in equal 4 layers, each layer giving 25 blows using a tamping rod uniformly all over the surface. Fill the concrete full in the cone using trowel.
2. Adjust the glass disc to the initial reading on the graduated rod.
3. Raise the cone slowly in the vertical direction without any jerks. Lower the transparent discs on the top of concrete and note down the reading on the graduated rod and calculate the slump.
4. Switch on the electrical vibrations and also a stopwatch simultaneously, after complete remoudling task. Stop the watch and find the time required for complete remoulding in VB seconds.

OBSERVATION:

Observations	Trail 1	Trail 2	Trail 3
Initial reading on graduated rod, mm			
Final reading on graduated rod, mm			
Slump, mm			
Time for complete remoulding seconds			

RESULT:

The slump of fresh concrete by Vee Bee factor =

Test on Hardened Concrete:

EXPERIMENT NO: 9

AIM: To determine Compressive Strength of hardened concrete.

APPARATUES: Cube mould of 15 cm side, tamping rod 60 cm long and 1.6 cm diameter, balance, mixer, trowel and compressive testing machine.

PROCEDURE:

1. Calculate the materials required for one cube/cylinder for a given concrete mix proportion, weigh them separately.
2. Calculate the water required for a given water cement ratio.
3. Mix the cement and sand separately in dry state and spread this on aggregate evenly.
4. Add 1/3 water by sprinkling it evenly on the mixture and mix thoroughly to attain consistency.
5. Cure the concrete specimen in air for 24 hours and in water up to 28 days before testing.
6. After curing takeout the concrete specimen and drain the water before testing.
7. Record the mass of the specimen before testing.
8. Place the specimen centrally in the compression testing machine and apply uniform rate of load of 14 N/mm^2/minute.
9. Record the maximum load for failure of the specimen.

OBSERVATION AND CALCULATIONS:

Specimen No	1	2	3	Mean
Load (Tone/KN) 1. Cube 2. Cylinder				

$$\text{Cube/cylinder strength} = \frac{\text{Average load}}{\text{C/S area of specimen}}$$

RESULT:

Compressive strength of hardened concrete sample cube/cylinder is _____________

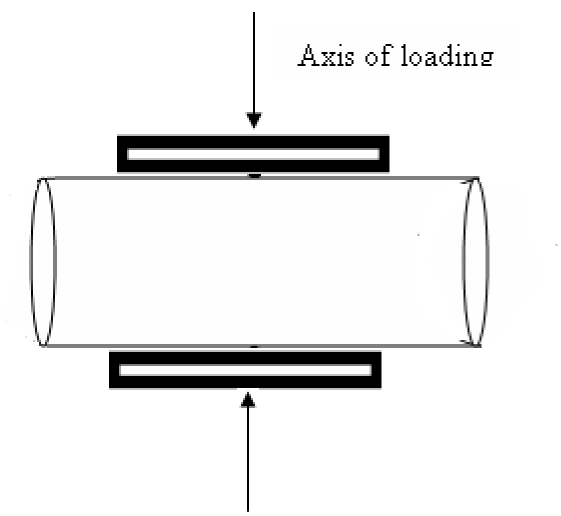
EXPERIMENT NO: 10

AIM: To determine Split tensile Strength of hardened concrete.

THEROY: It is one of the important properties of hardened concrete. Through concrete is not expected to take any tensile stress in structures. It determines the load at which the concrete members may crack which indicates the tensile strength of concrete. It is difficult to determine the tensile strength of concrete due to difficulty in gripping the specimen during testing. Even a small eccentricity in loading would result in failure due to combined action of bending and compression. By applying pure compression load on the cylindrical specimen laid horizontally would generate tensile stress and hence tensile failure.

APPARATUES: Cylinder mould of 15 cm ϕ and 30 cm in height, tampering rod 60 cm long and 1.6 cm diameter, balance, mixer, trowel and compressive testing machine.

DIAGRAM:



PROCEDURE:

1. Calculate the weight of materials required for casting 3 specimens.
2. Prepare the concrete by adopting the given water cement ratio.
3. Apply oil/Greece to the inside surface of the mould.

4. Fill the concrete in the mould in 3 layers each layer tampering 35 times distributed uniformly all over the surface.
5. Finish the top of the surface of the specimen.
6. Air cure the specimen for 24 hours and in water for 28 days.
7. After curing remove the specimen from water and drain for some time.
8. Place the specimen at the center of the disc in a horizontal position with caping device.
9. Ensure central position for the specimen.
10. Apply a uniform rate of loading of 14 N/mm^2/minute till failure.
11. The following formula as recommended by IS 5816-1970 may be used to calculate the split tensile strength of concrete.

$$\alpha_{sp} = 2P/\pi dl$$

Where, α_{sp} = tensile strength of concrete, N/mm^2

P = Mean failure load, Newton

d = diameter of the specimen, mm

l = length of the specimen, mm

RESULT:

Split tensile strength of hardened concrete sample cube/cylinder is ________

EXPERIMENT NO: 11

AIM: To determine Flexural Strength of RCC beams on plane concrete.

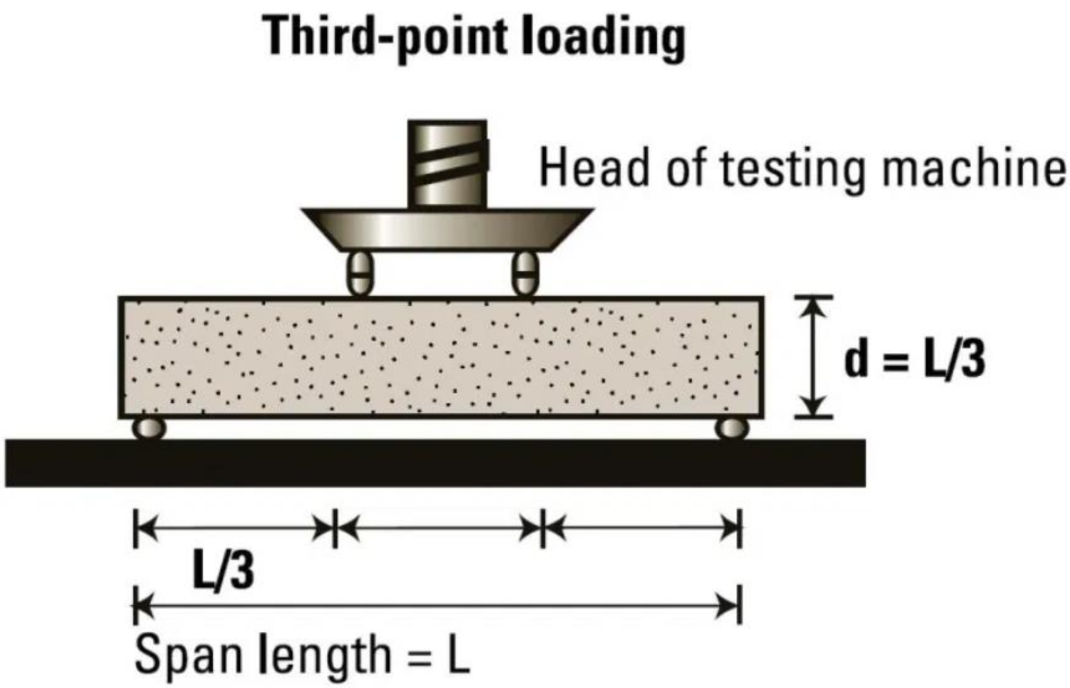
THEORY: Flexural test is intended to give the flexural strength of concrete in tension. The testing of concrete in flexure yields more consistent results than those obtained with tensile test on mortar; the flexure test is also more easily carried out and may even be more convenient than the crushing test for the use in the field, since in this test much smaller loads are required. The standard specimen measures are:

a. 100 X 100 X 500 mm, when maximum size of aggregate is less than 20 mm.

b. 150 X 150 X 700 mm, when maximum size of aggregate is less than 30 mm.

APPARATUES: Cylinder moulds 150 mm diameter and 500 mm height, ramming rods, mixer, weighing machine, capping apparatus, 200 tones compression testing machine, buckets and base plate.

DIAGROM:



Flexural Strength Test Arrangement

PROCEDURE:

1. Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tamping should be distributed uniformly over the entire crossection of the beam mould and throughout the depth of each layer.
2. Clean the bearing surfaces of the supporting and loading rollers , and remove any loose sand or other material from the surfaces of the specimen where they are to make contact with the rollers.

3. Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be **3d** and the distance between the inner rollers shall be **d**. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.
4. The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centered with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading.
5. The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

OBSERVATION AND CALCULATIONS:

1. Identification mark or Sl No
2. Date of test
3. Age of specimen
4. Curing condition
5. Weight of specimen
6. Dimension of specimen
7. Cross sectional area
8. Maximum load
9. Crushing strength
10. Appearance of fractured surface of concrete and type of fracture

Specimen No.	1	2	3	Average

Load on cylinders, Tones				

The Flexural Strength or modulus of rupture (**f_b**) is given by

f_b = pl/bd² (when **a** > 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen)

or

f_b = 3pa/bd² (when **a** < 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

Where,

a = the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen

b = width of specimen (cm)

d = failure point depth (cm)

l = supported length (cm)

p = max. Load (kg)

RESULT:

1. The cylindrical strength of concrete specimen is ______
2. The flexural strength of concrete specimen is ______

NDT tests by re bound hammer and pulse velocity test.

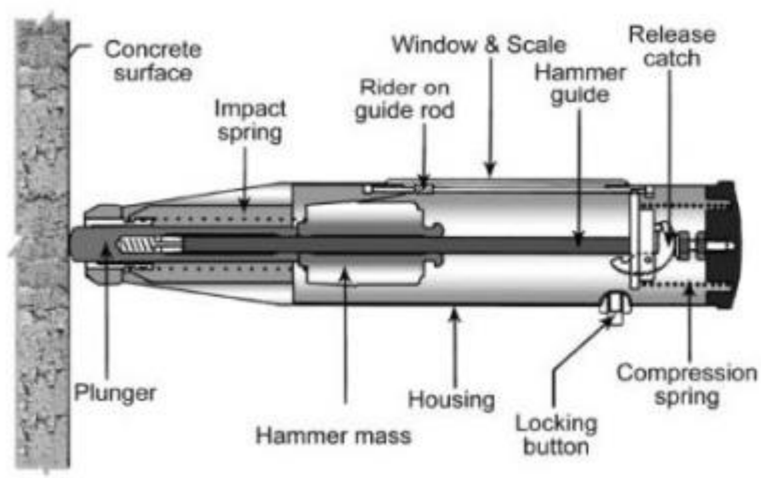
EXPERIMENT NO: 12

AIM:

The rebound hammer method could be used for:

a. Assessing the likely compressive strength of concrete with the help of suitable corelations between rebound index and compressive strength,
b. Assessing the uniformity of concrete,
c. Assessing the quality of the concrete in relation to standard requirements, and
d. Assessing the quality of one element of concrete in relation to another.

PRINCIPLE: When the plunger of rebound hammer is pressed against the surface of the concrete, the spring controlled mass rebounds and the extent of such rebound depends upon the surface hardness of concrete. The surface hardness and therefore the rebound is taken to be related to the compressive strength of the concrete. The rebound is read off along a graduated scale and is designated as the rebound number or rebound index.



It consists of a spring controlled mass that slides on a plunger within a tubular housing. The impact energy required for rebound hammers for different applications is given in Table 1.

S. No.	Application	Approx. Impact Energy required for Rebound hammer (Nm)
1	For Testing Normal Weight Concrete	2.25
2	For light-weight concrete or small and impact sensitive parts of concrete	0.75
3	For testing mass concrete for example, in roads, air field pavements and hydraulic structures	2.25

Table 1 : Impact Energy for Rebound hammer for different Applications.

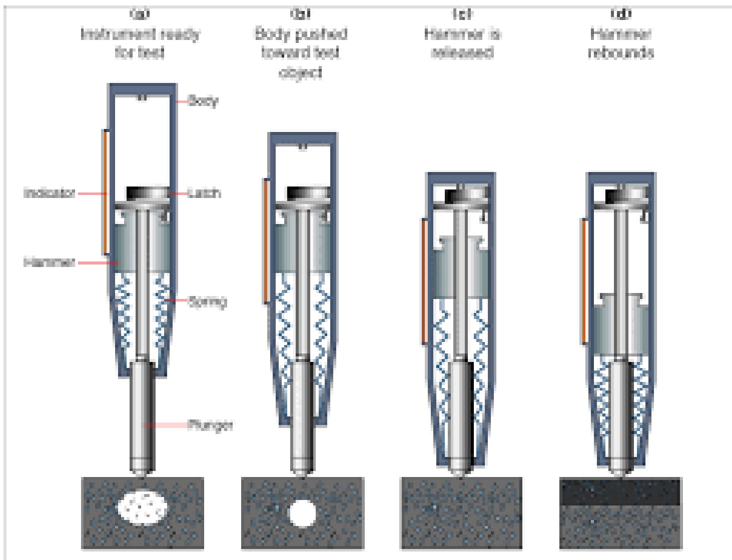
PROCEDURE:

a. Checking of Apparatus: It is necessary that the rebound hammer is checked against the testing anvil before commencement of a test to ensure reliable results. The testing anvil should be of steel having Brinell hardness of about 5000 N/mm2. The supplier/manufacturer of the rebound hammer should indicate the range of readings on the anvil suitable for different types of rebound hammers.

b. Procedure of obtaining Correlation between Compressive Strength of Concrete and Rebound Number:

- The most satisfactory way of establishing a correlation between compressive strength of concrete and its rebound number is to measure both the properties simultaneously on concrete cubes.
- The concrete cube specimens are held in a compression testing machine under a fixed load, measurements of rebound number taken and then the compressive strength determined as per IS: 516- 1959.
- The fixed load required is of the order of 7 N/mm2 when the impact energy of the hammer is about 2.2 Nm.
- The load should be increased for calibrating rebound hammers of greater impact energy and decreased for calibrating rebound hammers of lesser impact energy.
- The test specimens should be as large a mass as possible in order to minimise the size effect on the test result of a full scale structure.
- 150 mm cube specimens are preferred for calibrating rebound hammers of lower impact energy (2.2 Nm),
- Where as for rebound hammers of higher impact energy, for example 30 Nm, the test cubes should not be smaller than 300 mm.
- If the specimens are wet cured, they should be removed from wet storage and kept in the laboratory atmosphere for about 24 hours before testing.
- To obtain a correlation between rebound numbers and strength of wet cured and wet tested cubes, it is necessary to establish a correlation between the strength of wet tested cubes and the strength of dry tested cubes on which rebound readings are taken.
- A direct correlation between rebound numbers on wet cubes and the strength of wet cubes is not recommended.

- Only the vertical faces of the cube as cast should be tested.
- At least nine readings should be taken on each of the two vertical faces accessible in the compression testing machine when using the rebound hammers.
- The points of impact on the specimen must not be nearer an edge than 20 mm and should be not less than 20 mm from each other.
- The same points must not be impacted more than once.



Rebound Hammer Positions for Testing Concrete Structure

c. Test Procedure:

1. For testing, smooth, clean and dry surface is to be selected. If loosely adhering scale is present, this should be rubbed of with a grinding wheel or stone. Rough surfaces resulting from incomplete compaction, loss of grout, spalled or tooled surfaces do not give reliable results and should be avoided.
2. The point of impact should be at least 20 mm away from any edge or shape discontinuity.
3. For taking a measurement, the rebound hammer should be held at right angles to the surface of the concrete member. The test can thus be conducted horizontally on vertical surfaces or vertically upwards or downwards on horizontal surfaces. If the situation demands, the rebound hammer can be held at intermediate angles also, but in each case, the rebound number will be different for the same concrete.

4. Rebound hammer test is conducted around all the points of observation on all accessible faces of the structural element. Concrete surfaces are thoroughly cleaned before taking any measurement. Around each point of observation, six readings of rebound indices are taken and average of these readings after deleting outliers as per IS:8900-1978 becomes the rebound index for the point of observation.

d. Influence Of Test Conditions:

The rebound numbers are influenced by a number of factors like types of cement and aggregate, surface condition and moisture content, age of concrete and extent of carbonation of concrete.

1. **Influence of Type of Cement:** Concretes made with high alumina cement can give strengths 100 percent higher than that with ordinary Portland cement. Concretes made with super sulphated cement can give 50 percent lower strength than that with ordinary Portland cement.
2. **Influence of Type of Aggregate**: Different types of aggregate used in concrete give different correlations between compressive strength and rebound numbers. Normal aggregates such as gravels and crushed rock aggregates give similar correlations, but concrete made with light weight aggregates require special calibration.
3. **Influence of Surface Condition and Moisture Content of Concrete:**
   - The rebound hammer method is suitable only for close texture concrete. Open texture concrete typical of masonry blocks, honeycombed concrete or no-fines concrete are unsuitable for this test. All correlations assume full compaction, as the strength of partially compacted concrete bears no unique relationship to the rebound numbers. Trowelled and floated surfaces are harder than moulded surfaces, and tend to over estimate the strength of concrete.
   - A wet surface will give rise to under estimation of the strength of concrete calibrated under dry conditions. In structural concrete, this can be about 20 percent lower than in an equivalent dry concrete.
4. **Influence of Curing and Age of Concrete:**

The relationship between hardness and strength varies as a function of time. Variations in initial rate of hardening, subsequent curing and conditions of exposure also influence the relationship. Separate calibration curves are required for different curing regimes but the effect of age can generally be ignored for concrete between 3 days and 3 months old.

5. **Influence of Carbonation of Concrete Surface:**

   The influence of carbonation of concrete surface on the rebound number is very significant. Carbonated concrete gives an overestimate of strength which in extreme cases can be up to 50 percent. It is possible to establish correction factors by removing the carbonated layer and testing the concrete with the rebound hammer on the uncarbonated concrete.

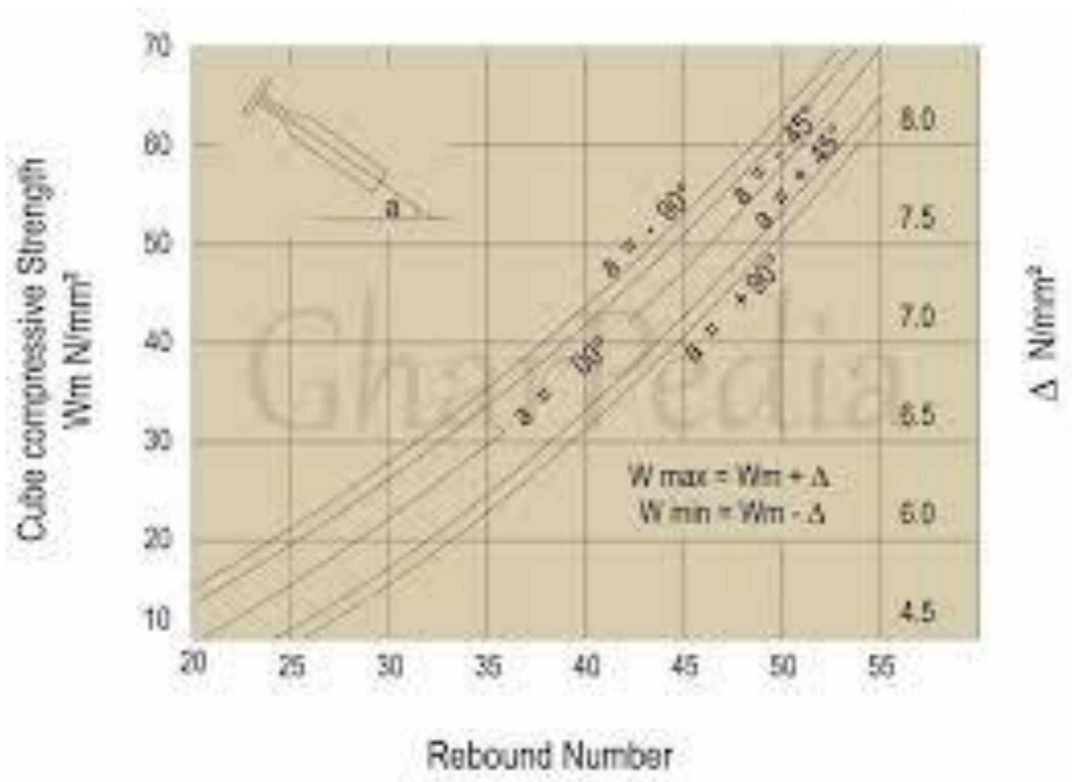
e. Interpretation Of Result

1. The rebound hammer method provides a convenient and rapid indication of the compressive strength of concrete by means of establishing a suitable correlation between the rebound index and the compressive strength of concrete. The procedure of obtaining such correlation is given in 4.2.
2. It is also pointed out that rebound indices are indicative of compressive strength of concrete to a limited depth from the surface. If the concrete in a particular member has internal microcracking, flaws or heterogeneity across the cross-section, rebound hammer indices will not indicate the same.
3. As such, the estimation of strength of concrete by rebound hammer method cannot be held to be very accurate and probable accuracy of prediction of concrete strength in a structure is ±25 percent. If the relationship between rebound index and compressive strength can be checked by tests on core samples obtained from the structure or standard specimens made with the same concrete materials and mix proportion, then the accuracy of results and confidence thereon are greatly increased.
4. Table-1: Impact Energy for Rebound Hammers for Different Applications as per IS: 13311(2)-1992

Sl.No	Applications	Approximate Impact Energy for Rebound Hammer in Nm
1.	For Normal Weight Concrete	2.25
2.	For light weight concrete / For	0.75

	small and impact resistive concrete parts	
3.	For mass concrete testing Eg: In roads, hydraulic structures and pavements	30.00

5.
6.
7. Graph 1: Rebound Number



EXPERIMENT NO: 13

ULTRASONIC PULSE VELOCITY

AIM: This test is done to assess the quality of concrete by ultrasonic pulse velocity method as per IS: 13311 (Part 1) – 1992. The underlying principle of this test is –
The method consists of measuring the time of travel of an ultrasonic pulse passing through the concrete being tested. Comparatively higher velocity is obtained when concrete quality is good in terms of density, uniformity, homogeneity etc.

Procedure to determine strength of hardened concrete by Ultrasonic Pulse Velocity.

i) Preparing for use: Before switching on the ‘V’ meter, the transducers should be connected to the sockets marked “TRAN” and ” REC”.

The ‘V’ meter may be operated with either:

a) The internal battery,

b) An external battery or

c) The A.C line.

ii) Set reference: A reference bar is provided to check the instrument zero. The pulse time for the bar is engraved on it. Apply a smear of grease to the transducer faces before placing it on the opposite ends of the bar. Adjust the ‘SET REF’ control until the reference bar transit time is obtained on the instrument read-out.

iii) Range selection: For maximum accuracy, it is recommended that the 0.1 microsecond range be selected for path length upto 400mm.

iv) Pulse velocity: Having determined the most suitable test points on the material to be tested, make careful measurement of the path length ‘L’. Apply couplant to the surfaces of the transducers and press it hard onto the surface of the material. Do not move the transducers while a reading is being taken, as this can generate noise signals and errors in measurements. Continue holding the transducers onto the surface of the material until a consistent reading appears on the display, which is the time in microsecond for the ultrasonic pulse to travel the distance ‘L’. The mean value of the display readings should be taken when the units digit hunts between two values.

Pulse velocity=(Path length/Travel time)

v) Separation of transducer leads: It is advisable to prevent the two transducer leads from coming into close contact with each other when the transit time measurements are being taken. If this is not done, the receiver lead might pick-up unwanted signals from the transmitter lead and this would result in an incorrect display of the transit time.

ultrasonic-pulse-velocity-apparatus

Interpretation of Results

The quality of concrete in terms of uniformity, incidence or absence of internal flaws, cracks and segregation, etc,indicative of the level of workmanship employed, can thus be assessed using the guidelines given below, which have been evolved for characterizing the quality of concrete in structures in terms of the ultrasonic pulse velocity.

Pulse Velocity (km/second)	Concrete Quality (Grading)
Above 4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
Below 3.0	Doubtful

Ultrasonic-pulse-velocity-table

Tests on Self Compacting Concrete:

Experiment No 14

Slump flow test:

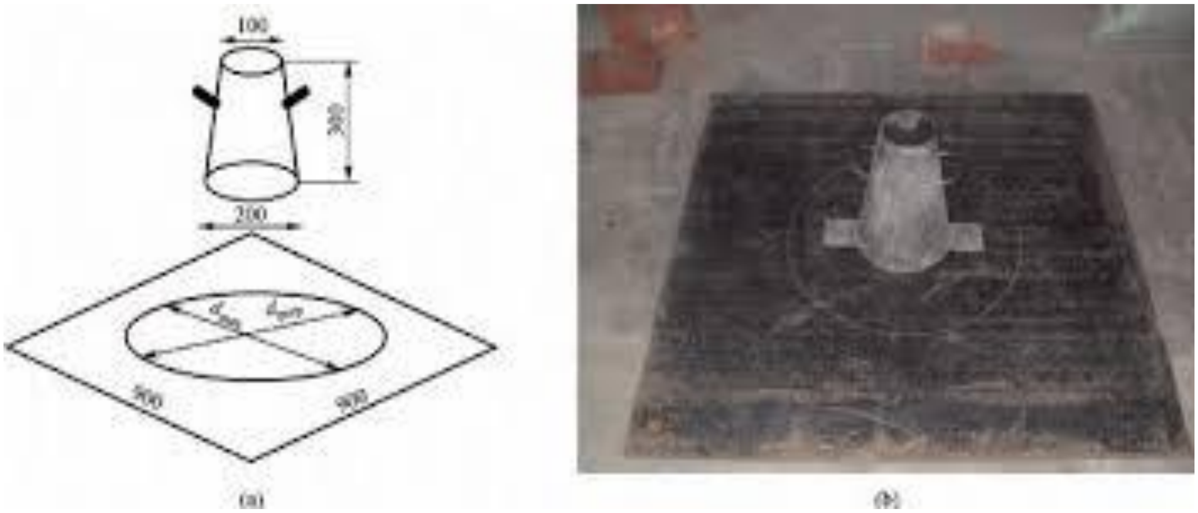
Aim: To determine the flowing ability of self-compacting concrete.

Theory: The slump flow test is used assess the horizontal free flow of self-compacting concrete in the absence of obstructions. It was first developed in Japan for use in assessment of underwater concrete.

The test method is based on the test method for determining the slump. T is the diameter of the concrete circle is a measure for the filling ability of the concrete.

Apparatus:

- Mould in the shape of a truncated cone with the internal dimensions 200 mm diameter at the base, 100mm diameter at the top and a height of 300 mm.
- Base plate of a stiff non-absorbing material, at least 700mm square, marked with a circle marking the central location for the slump cone, and a further concentric circle of 500mm diameter
- Trowel
- Scoop
- Ruler
- Stop watch(optional)



Procedure:

1. About 6 liter of concrete is needed to perform the test,
2. Clean the surface of instruments and grease with oil.
3. Fill the cone with the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel.
4. Remove any surplus concrete from around the base of the cone. Raise the cone vertically and allow the concrete to flow out freely.
5. Simultaneously, start the stopwatch and record the time taken for the concrete to reach the 00mm spread circle (This is the T50 time).floatable test, might be appropriate.
6. The T50 time is secondary indication of flow. A lower time indicates greater flow ability.

Observation and calculations:

d_1 = Diameter of flow of SCC

d_2 = Diameter of flow of SCC

d_0 = Flow cone diameter.

Γm = Deformability of SCC

$$\Gamma m = (d_1 d_2 - d_0^2)/d_0^2,$$

d_1, d_2: measured flow diameter;

d_0: flow cone diameter

Application:

The Brite EuRam research suggested that a time of 3-7 seconds is acceptable for civil engineering applications, and 2-5 seconds for housing applications.

Experiment No 15

V Funnel test:

Aim: To determine the viscosity and Passing ability self-compacting concrete.

Theory: The equipment for V funnel test on self compacting concrete consists of a v shaped funnel The test was developed in Japan and used by Ozawa.

The equipment consists of V-shaped funnel section is also used in Japan. The described V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 20mm.

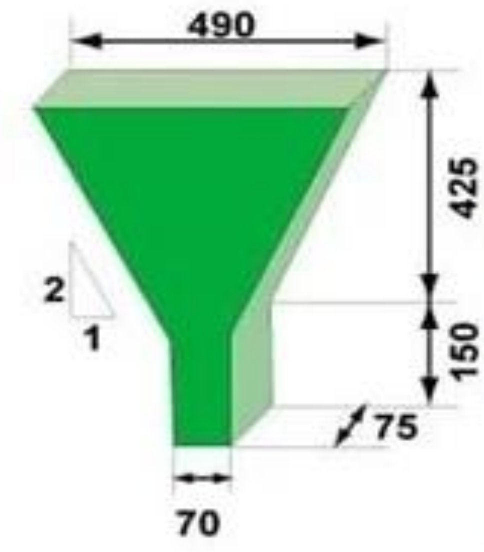
The funnel is filled with about 12 liter of concrete and the time taken for it to flow through the apparatus measured. After this the funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows segregation then the flow time will increases significantly.

Though the test is designed to measure flowability, the result is affected by concrete properties other than flow. The inverted cone shape will cause any liability of the concrete to block to be reflected in the result if, for example there is too much coarse aggregate.

High flow time can also be associated with low deformability due to a high paste viscosity, and with high inter-particle friction. While the apparatus is simple, the effect of the angle of the funnel and the wall effect on the flow of concrete is not clear.

Apparatus:

- V-funnel
- Bucket (±12 liter)
- Trowel
- Scoop
- Stopwatch



Procedure:

1. About 12 liter of concrete is needed to perform the test,
2. Set the V-funnel on firm ground. Moisten the inside surface of the funnel. Keep the trapdoor to allow any surplus water to drain. Close the trap door and place a bucket underneath.
3. Fill the apparatus completely with the concrete without compacting or tamping; simply strike off the concrete level with the top with the trowel.
4. Open within 10 sec after filling the trap door and allow the concrete to flow out under gravity. Start the stopwatch when the trap door is opened, and record the time for the complete discharge (the flow time). This is taken to be when light is seen from above through the funnel. The whole test has to be performed within 5 minutes.

Procedure flow time at T5 minutes:

1. Do not clean or moisten the inside surface of the funnel gain. Close the trapdoor and refill the V-funnel immediately after measuring the flow time. Place a bucket underneath.
2. Fill the apparatus completely with concrete without compacting or tapping, simply strike off the concrete level with the top with the trowel.
3. Open the trapdoor 5 minutes after the second fill of the funnel and allow the concrete to flow out under gravity.
4. Simultaneously start the stopwatch when the trap door is opened and record the time discharge to complete flow (the flow time at T5 minutes). This is to be taken when light is seen from above through the funnel.

Observation and Calculation:

$Rm = 10/t$,

t (sec): measured time (sec) for mortar to flow through the funnel

Rm = Viscosity of SCC.

Experiment No 16

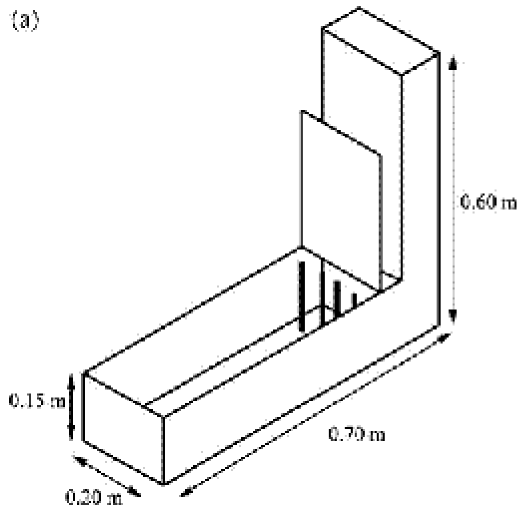
L Box

Aim: To determine the flowing ability of SCC by L Box.

Theory:

L-Box: L Box to investigating the flow rate and passing ability of SCC (self-consolidating concrete) in confined spaces. It measures the reached height of fresh SCC after passing through the specified gaps of steel bars flowing within a defined flow distance. With this reached height, the passing or blocking behavior of SCC can be estimated.

Apparatus: L box apparatus, Bucket (±15 liter), Trowel, Scoop and Stopwatch.



L box

Procedure:

1. About 14 liter of concrete needed to perform the test,.
2. Set the apparatus level on firm ground, ensure that the sliding gate can open freely and then close it.
3. Moisten the inside surface of the apparatus, remove any surplus water, fill the vertical section of the apparatus with the concrete sample.
4. Leave it stand for 1 minute. Lift the sliding gate and allow the concrete to flow out into the horizontal section. Simultaneously, start the stopwatch and record the time for the concrete to reach the concrete 200 and 400 marks.
5. When the concrete stops flowing, the distances 'H1' and 'H2' are measured. Calculate H2/H1, the blocking ratio. The whole has tom performed within 5 minutes.

Observation and Calculation:

If the concrete flows as freely as water, at rest it will be horizontal, so H2/H1=1. Therefore the nearest this test value, the 'blocking ratio', is unity, the better the flow of concrete.

The EU research team suggested a minimum acceptable value of 0.8. T20 and T40 time can give some indication of ease of flow, but no suitable values have been generally agreed. Obvious blocking of coarse aggregate behind the reinforcement bars can be detected visually.

Experiment No 17

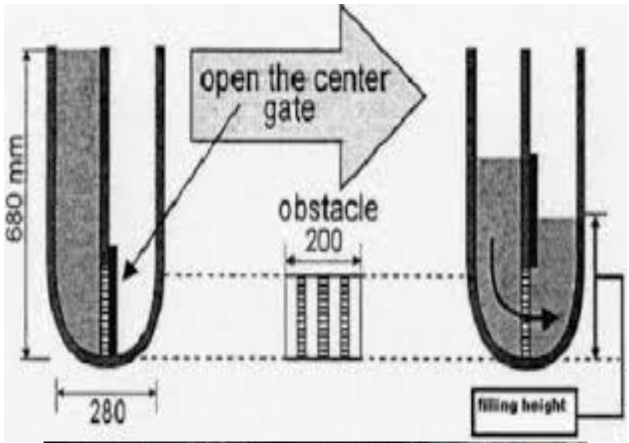
U box:

Aim: To determine the flowing ability of SCC by U box.

Theory:

U-Box: The U Shape Box is used to determine the confined flowablity and the capacity of SCC concrete to flow within confined space. The box is made of steel frame consisting of three bars. In this test the degree of compatibility can be indicated by the height that the concrete reaches after flowing through an obstacle. The quality of the concrete can be judged by the height reached.

Apparatus: U box apparatus, Bucket (±12 liter), Trowel, Scoop and Stopwatch.



U box

Procedure:

1. About 20 liter of concrete is needed to perform the test, sampled normally. Set the apparatus level on firm ground, ensure that the sliding gate can open freely and then close it.
2. Moisten the inside surface of the apparatus, remove any surplus water, fill the vertical section of the apparatus with the concrete sample.
3. Leave it stand for 1 minute. Lift the sliding gate and allow the concrete to flow out into the other compartment.
4. After the concrete has come to rest, measure the height of the concrete in the compartment that has been filled, in two places and calculate the mean (H1).

5. Measure also the height in the other equipment (H2). Calculate H1-H2, the filling height. The whole test has to be performed within 5 minutes.

Observation and calculation:

If the concrete flows as freely as water, at rest it will be horizontal, so H1-H2=0. Therefore the nearest this test value, the ‘filling height’, is to zero, the better the flow and passing ability of the concrete**.**

Experiment No 18

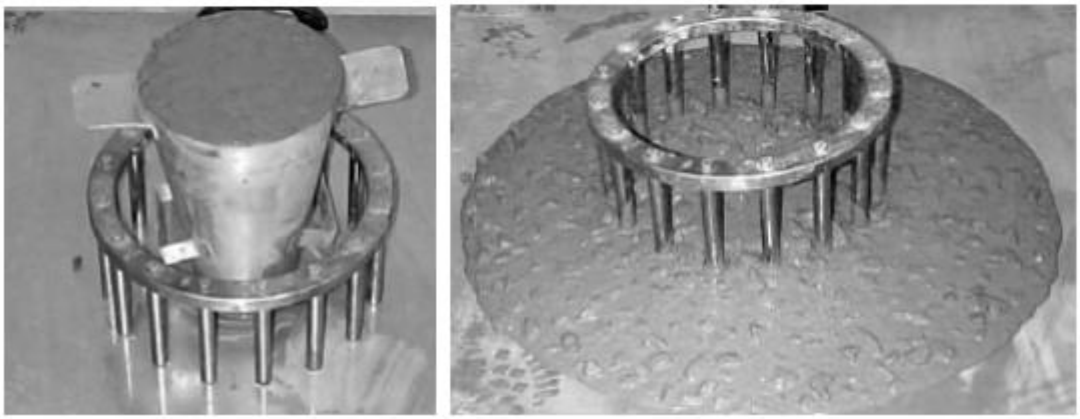
J ring:

Aim: To determine the flowing ability of SCC by J ring.

Theory:

J ring: This test method provides a procedure to determine the passing ability of self consolidating concrete mixtures. The difference between the slump flow and J-Ring flow is an indication of the passing ability of the concrete. The test method is applicable for laboratory use in comparing the passing ability of different concrete mixture. It is also applicable in the field as a quality control test. It can also be used to investigate the resistance of SCC to segregation by comparing test results from two different portions of sample. The J-Ring test measures three parameters: flow spread, flow time and blocking step. The J-Ring flow spread indicates the restricted deformability of SCC due to blocking effect of reinforcement bars and the flow time indicates the rate of deformation within a defined flow distance. The blocking step quantifies the effect of blocking.

Apparatus: J ring apparatus, Slump Mold, Base Plate, Bar, Measuring Device, Bucket (±20 liter), Trowel, Scoop and Stopwatch.



J ring

Procedure:

1. Perform the test on a flat, level, and nonabsorbent base plate.
2. Dampen the mold, and place it on the surface or base plate with the larger opening facing down and concentric with the J-Ring.
3. Hold the mold firmly in place during filling. Fill the mold in one lift. Heap the concrete above the top of the mold.
4. Strike off the surface of the concrete level with the top of the mold by a sawing motion of the strike off bar.
5. Remove concrete from the area surrounding the mold to preclude interference with the movement of the flowing concrete.
6. Raise the mold a distance of 9 ± 3 in (230 ± 75 mm) in 3 ± 1 s by a steady vertical lift with no lateral or torsional motion.
7. Complete the entire procedure from start of the filling through removal of the mold without interruption within an elapsed time of 2½ min.
8. Wait for the concrete to stop flowing and then measure the largest diameter (d1) of the resulting circular flow of concrete.
9. When a halo is observed in the resulting circular flow of concrete, it shall be included as part of the diameter of the concrete. Measure a second diameter (d2)

of the circular flow at approximately perpendicular to the first measured diameter (d1). Measure the diameters to the nearest ¼ in (5 mm).

Observation and Calculation:

1. Calculate J-Ring flow according to the following equation:

$$\text{J-Ring flow} = \frac{d^1 + d^2}{2}$$

2. Calculate the slump flow according to the following equation:

$$\text{Slump flow} = \frac{d^1 + d^2}{2}$$

3. Calculate the difference between slump flow and J-Ring flow to the nearest ½ in (10 mm). This number represents the passing ability of the concrete.

PART-B: HIGHWAY MATERIALS LAB

1. **Test on aggregates:**

EXPERIMENT NO: 19

AIM: To determine aggregate crushing value

THEOREY: Aggregates should have enough resistance to crushing under the roller during construction and abrasion during test measures the suitability of aggregates under the action of such loads.

APPARATUES: Cylinder both ends open of 15.2cm diameter with a square base plate, plunger of 15cmϕ and height of 11.5cm, measuring cylinder of 11.5 cm diameter and 18 cm height, tamping rod of 1.6 cm diameter and 45 – 60 cm length, compression testing machine of suitable capacity having 4t/minute rate of loading (minimum capacity 40t).

DIAGROM:

PROCEDURE:

1. The aggregates passing through 12.5mm and retained on 10mm IS Sieve are oven-dried at a temperature of 100 to 110°C for 3 to 4hrs before testing.
2. The cylinder of the apparatus is filled in 3 layers, each layer tamped with 25 strokes of a tamping rod.

3. After third layer is tamped; lose aggregates are filled and leveled by moving the tampering rod.
4. The weight of aggregates is measured (W_1).
5. The aggregate are transferred to the cylinder with base plate, aggregate are placed in 3 layers and each layer giving 25 blows uniformly all over the surface.
6. The surface of the aggregates is then leveled and the plunger inserted. The apparatus is then placed on the compression testing machine and loaded at a uniform rate so as to achieve 40 t loads in 10 minutes. After this, the load is released.
7. The sample is then sieved through a 2.36mm IS Sieve and the fraction passing through the sieve is weighed (W_2).
8. Two tests should be conducted to determine the average value.

OBSERVATION AND CALCULATIONS:

Aggregate crushing value = W_2/ W_1 X 100

Sample No	Total weight of dry sample W_1	weight of fines passing 2.36 mm sieve W_2	Aggregate crushing value = W_2/ W_1 X 100	Mean crushing value

RESULT:

Mean crushing value of aggregate =

Application:

1. for cement concrete roads as per ISI and IRC crushing value should not be more than 30%
2. For surfaces other than wearing surface 45%.

EXPERIMENT NO: 20

AIM: To determine the abrasion value aggregate (Los Angels Abrasion Test)..

THEORY: Due to the movement of traffic the top surface is subjected to wearing action and hence resistance to wear is essential for road aggregates. During dry season soil and lose sand particles cause abrasion action on the surface. Steel tyres of animal drawn vehicles, which rub against the aggregates, can cause considerable abrasion of the stones on the road surface.

The following tests carried out on aggregates:

Los Angels Abrasion Test, Deval abrasion test and Dorry abrasion test.

Los Angels Abrasion Test is preferred as it has good correlations with field performance.

The principle of this test is that aggregates are subjected to mutual rubbing action and also pounding action with abrasive charge. The aggregates are simultaneously subjected to both abrasion and pounding action as in the field conditions. ISI has standardized this test.

APPARATUES: Los Angels Abrasion Test, sieves and changes of 4.8 cm diameter each weighing 390 – 445 grams.

DIAGRAM:

PROCEDURE:

1. Take 5/10 Kg of aggregates dried at 105-110°C confirming to grade A to G grading.
2. Put the aggregates in the drum along with required number of charge as per observation Table.
3. The machine is rotated at 30 – 33 rpm for 500/1000 revolutions for ABCD/EFG grading respectively.
4. After the test the aggregate is sieved in IS 1.7 mm sieve and weight of retained material is determined.
5. The weight of the aggregate passing 1.7 mm is taken as the difference in weight of the material taken for the test and the material retained on 1.7 mm sieve.

OBSERVATION TABLE:

Weight of the sample (W_1) gm.	
Weight of aggregate passing 1.7 mm sieve (W_2) gm.	
Loss in weight due to wear (W_1 - W_2) gm.	
Los Angeles abrasion value, $\frac{(W_1 - W_2) \times 100}{W_1}$ %	

APPLICATION:

1. WBM, Sub base course 60%
2. WBM, surface course 50%
3. CC surface (IRC/ISI) 35%/30%
4. AC surface course 30%

RESULT:

Los Angeles abrasion value, of aggregate is…….

EXPERIMENT NO. 21

AIM: To determine the aggregate Impact value.

THEORY: Due to the traffic loads, road aggregates are subjected to pounding action or impact by this the aggregate will break into smaller pieces. Hence the road aggregates should have enough resistance for repeated loads due to impact.

APPARATUS: Impact testing machine, IS Sieves of sizes – 12.5mm, 10mm and 2.36 mm, a cylindrical metal measure of 75mm diameter. and 50mm depth, Tamping rod of 10 mm ϕ and 230mm length, rounded at one end, balance to weigh 0.1 gm accuracy and oven with a temperature range of 100 to 110°C.

DIAGRAM:

PROCEDURE:

1. Aggregate passing 12.5 mm sieve and retained on 10.0 mm sieve are taken in the cylindrical measure.

2. The aggregate are tamper in 3 equal layers each layer tampering 25 times uniformly all over the surface.
3. After the third layer is tampered, the space on test cup is filled with lose aggregates and the tamper rod is floated on the cup to level it.
4. Find the weight of aggregate present in the cylinder W_1
5. Now transfer the aggregate into impact cup and tam in one layer giving 25 tam pings. Place the cup below the impact machine.
6. The hammer of weight 13.5 to 14 Kg is raised to a height of 38 cm and allowed freely to fall on the aggregate thus causing impact on the aggregate and 15 blows should be given at not less than 1 per second.
7. Then the aggregate are sieved in IS 2.36 mm sieve and then material passing is weighed W_2

CALCULATION:

4. W_1= Weight of aggregate taken for test.
5. W_2= Weight of aggregate taken for test.

Aggregate Impact value = (W_2/W_1) X 100

EXPERIMENT NO.22

AIM: To determine shape tests on aggregate (Flakiness index, elongation index and Angularity number)

THEORY: For course and construction of bituminous and CC roads, the presence of flaky and elongated particles are considered as undesirable as such aggregate cause inherent weakness and there is possibility of breakdown under heavy loads. Rounded aggregates are preferred for the base course as it increases stability due to better interlocking. Angularity number denotes the void content of single sized aggregates in excess of that obtained with spherical aggregates of same size.

1. FLAKINESS INDEX:

It may be defined as the percentage by weight of particles whose least dimension is less than 0.6 times their mean dimension.

APPARATUS: Thickness gauge, IS sieve as given in the table and balance.

PROCEDURE:

1. Sieve the aggregates in the sieves and find the weight of 200 pieces in each size.
2. Take individual aggregates and pass them in appropriate slots and the one which pass through the slot is collected separately and weight of such aggregate is determined for each size.
3. The aggregates should be passed with its least dimension i.e. with its less thickness side.
4. The flakiness index of total aggregate is determined by

$$\text{Flakiness index} = \frac{w_1 + w_2 + w_3 + \ldots\ldots\ldots\ldots}{w_1 + w_2 + w_3 + \ldots\ldots\ldots\ldots} = \frac{\Sigma w}{\Sigma w} \times 100$$

AGGREGATE SIZE, mm		Wt. of 200 pieces	Wt. of aggregate passing
Passing through	Retained on		
63	50	W_1	W_1
50	40	W_2	W_2
40	25	-	-

31.5	25	-	-
25	20	-	-
20	16.0	-	-
16	12.5	-	-
12.5	10	-	-
10	6.3	W_9	W_9

APPLICATION: On surface course, flaky materials should be avoided and presences of such material will reduce the strength of pavement layer and subsequently result in pavement failure CC road construction it reduces the workability of fresh concrete.

2. ELONGATION INDEX:

It is defined as the percentage by weight of particles whose least dimension is greater than 1.8 times their mean dimension.

APPARATUS: Length gauge, IS sieves and balance.

AGGREGATE SIZE, mm		Wt. of 200 pieces	Wt. of aggregate passing
Passing through	Retained on		
50	40	W_1	x_1
40	25	W_2	x_2
25	20	-	-
20	16	-	-
16	12.5	-	-
12.5	10	-	-
10	6.3	W_7	x_7

PROCEDURE:

1. Sieve the aggregates in the sieve sizes indicated in the above table and find the weight of 200 pieces of aggregates in each size.

2. Select individual aggregates and pass it through appropriate opening with its greatest dimension and the one which not (passing or retained) should be separated and weighted.
3. This procedure should be repeated for all aggregates and for all sizes.
4. The elongation index of total aggregate is determined by

$$\text{Elongation index} = \frac{X_1 + X_2 + X_3 + \ldots\ldots\ldots}{W_1 + W_2 + W_3 + \ldots\ldots\ldots} = \frac{X}{W} \text{ X } 100$$

APPLICATION: There are no specified values for elongation index of aggregates. However, the combined value of flakiness and elongation index should not be more than 30% in bituminous mixes used for surface covers.

3. ANGULARITY NUMBER:

Angular particles possess well defined edges formed at the intersection of plane faces. Such aggregates get crashed easily under the action of wheel loads and hence their proportion should be limited in bituminous mixes. Angularity may be explained as lack of roundness, which makes it difficult during mixing and this property depends on size and shape of aggregate.

Angularity number may be defined as the voids in excess of 33%. That is if round aggregates and packed in a container in densest form, the total volume of solids will be 67% and volume of voids is 33%. If the shape of aggregate deviates to flakey or angular on elongated or irregular then the voids increases.

APPARATUS: Cylinder of 3 liter capacity having 15.64 cm height and also equal diameter, tampering rod of 1.6 cm diameter and 45 cm – 60 cm long, balance and weights

PROCEDURE:

1. Find the weight of cylinder containing full of water and deduct the empty weight of cylinder to get the weight of water required to fill the cylinder.
2. The test sample should consists of aggregate retained between 20-16, 16-12.5, 12.5-10, 6.3-4.25 mm sizes (any one size may be selected).
3. Sieve the aggregates sufficient to fill the cylinder for three trials.

4. Take samples of single size aggregate retained between the specified pair of sieves and oven dry at 100°-110°C for 24 hours and cooled prior to testing.
5. Aggregates are filled in the cylinder using scoop in 3 layers each layer tamped 100 times by raising the tampering rod 5 cm above aggregate surface and dropping over the aggregate surface under gravity.
6. The blows should be distributed evenly over the aggregate surface and after last layer is tamped, loose aggregates are filled and tamping rod is moved on the cylinder to level the aggregates.
7. The weight of the cylinder is determined and then only the weight of aggregate is calculated.
8. The mean weight of aggregates is determined by conducting 3 trials.

CALCULATION:

1. Empty weight of the cylinder = W_1
2. W_1 + full water = W_2
3. weight of water required to fill the cylinder = $W_2 - W_1 = C$
4. W_1 + mean weight of aggregate required to fill the cylinder = W_3
5. Angularity number = $67 - \frac{100W}{C * G}$ (Expressed as a whole number)

   G = specific gravity of aggregate = 2.66 (Assumed)

Angularity number is zero for highly rounded aggregate and 11 for highly angular aggregates. higher the angularity number less workable is the bituminous mix.

Test on bituminous materials:

EXPERIMENT NO: 23

AIM: To determine specific gravity of bituminous.

THEORY: As per BIS it is defined as the ratio of the mass of given volume of substance to the mass of an equal volume of water at 27°C.

APPARATUES: Specific gravity bottle and balance.

DIAGROM:

Fig. 1. The Pycnometer

PROCEDURE:

1. Weigh a clean and dry specific gravity bottle with stopper.
2. Fill the bottle with distilled water full and keep it in water bath at 27°C for 30 minutes and remove from the water bath, wipe the outer surface and weigh again.
3. Heat the bitumen in the pouring consistency and pour about 1/3 the volume of the specific gravity bottle.
4. Keep the bottle at 27°C for 50 minutes in water bath and allow the bubble to escape. Weigh the bottle.
5. Fill the remaining portion of the bottle with water at 27°C and place the stopper and find the weight.

OBSERVATION AND CALCULATIONS:

1. Bitumen grade =
2. Test temperature =

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

Where, W_1 = Weight of specific gravity bottle only

$W_2 = W_1$+ full distilled water at 27°C

$W_3 = W_2$+ ½ of bottle with bitumen

$W_4 = W_3$ + remaining portion with water at 27°C

The specific gravity value should be determined as the mean of 3 observations.

RESULT:

The specific gravity value of bitumen is

EXPERIMENT NO: 24

AIM: To determine penetration value of bitumen and grade it.

THEORY: This test is widely used for classifying the bitumen into different grades. This test is very simple and quick.

APPARATUES: Penetrometer, penetration needle with shank, Metallic containers 55 mm diameter and 57 mm height, Water bath to maintain 25 ± 1°C and thermometer – Range 0 to 44°C, Graduation 0.2°C.

DIAGROM:

PROCEDURE:

1. Soften the bitumen above the softening point (between 75 and 100^{o}C). Stir it thoroughly to remove air bubbles and water if any.
2. Pour it into a container to a depth of at least 15mm in excess of the expected penetration.
3. Cool it at an atmospheric temperature of 15 to 30^{o}C for $1^{1/2}$ hours. Then place it in a transfer dish in the water bath at 25.0 + 0.1^{o}C for $1^{1/2}$ hrs.
4. Keep the container on the stand of the penetrometer.
5. Adjust the needle to make contact with the surface of the sample.
6. Adjust the dial reading to zero.
7. With the help of the timer, release the needle for exactly 5 seconds.
8. Record the dial reading.
9. Repeat the above procedure thrice.
10. Clean the needle with each using benzene.
11. The difference between initial and final reading of the dial gives the penetration value of the bitumen.

The values are very much affected by pouring temperature, needle size, weight on needle, test temperature, duration of needle released.

OBSERVATION AND CALCULATIONS:

1. Pouring temperature, ^{o}C
2. Period of air cooling in atmosphere, minutes
3. Room temperature, ^{o}C
4. Period of water cooling in water bath, minutes
5. Actual test temperature, ^{o}C

Readings	Trail numbers			Mean
	1	2	3	
Penetrometer dial reading 1. Initial 2. Final Penetration Value				

RESULT:

The penetration value of bitumen is

EXPERIMENT NO: 25

AIM: To determine ductility value of bitumen by ductility test.

THEORY: Bitumen forms a thin film around the aggregates and thickness of the film formed depends on the ductility of the bitumen and this provides a better inter locking between aggregates. Inadequate ductility will result in cracks in the pavement and allows percolation of water leading to pavement failure. The ductility is expressed as the distance in centimeter to which a standard briquette of bitumen can be stretched before the thread breaks. This test is conducted at 27 ^{o}C and 5 cm per minute rate of pulling.

APPARATUES: Standard briquette moulds, Water bath to maintain 27 ^{o}C, knife edge, ductility testing machine and Thermometer.

DIAGROM:

PROCEDURE:

1. Heat the bitumen to the pouring consistency to 75-100 ^{o}C above the approximate softening point and pour this bitumen into the mould placed on a brass plate applied with glycerin or dextrin.
2. While filling, pour the material in a thin stream back and forth from end to end of the mould until it is more than level full.
3. Leave it to cool at room temperature for 30 to 40 minutes and then place it in a water bath maintained at the specified temperature for 30 minutes.
4. After this cut off the excess bitumen by means of a hot, straight-edged putty knife or spatula, so that the mould is just level full.
5. Place the brass plate and mould with briquette specimen in the water bath and keep it at the specified temperature for about 85 to 95 minutes.
6. Remove the briquette from the plate; detach the side pieces and the briquette immediately.
7. Attach the rings at each end of the two clips to the pins or hooks in the testing machine and pull the two clips apart horizontally at a uniform speed, as specified, until the briquette ruptures.

8. Note the initial reading on the scale and start the machine to pull the specimen at 5 cm per minute.
9. The distance at which the bitumen thread of specimen breaks is recorded as ductility values of bitumen.

Ductility value depends on pouring temperature, briquette dimensions, test temperature and rate of pulling.

OBSERVATION AND CALCULATIONS:

1. Pouring temperature =
2. Period of air cooling: a). Before trimming = minutes

   b). After trimming = minutes
3. Room temperature =
4. Period of water cooling in water bath, minutes, ^{o}C =

Readings	Sample Number			Mean value
	1	2	3	
Ductility value, cm				

RESULT:

The ductility value of bitumen is______

EXPERIMENT NO: 26

AIM: To determine softening point of bitumen.

THEORY: Bitumen changes its states due to change in temperature from solid state to softer state. It is the point when the substance attains particular degree of softening under specified condition of test. The principle of the test is a brass/steel ring containing bitumen is suspended in a beaker containing water and glycerin is heated and the temperature at which the bitumen touches bottom of the plate is considered as the softening point. This property also indicates resistance to temperature.

APPARATUES: Ring and ball apparatus, Thermometer, metallic support, beaker containing water/glycerin and stirrer.

PROCEDURE:

1. Heat the bitumen to the pouring consistency to 75-100 ^oC above the approximate softening point and pour this bitumen into the ring mould placed on a brass plate applied with glycerin or dextrin.
2. Air cool the specimen for 30 minutes and trim the excess bitumen. Place the guide ring above this with a ball.
3. Place this assembly on the metallic support kept in beaker and assembly should be retained at 25 ^oC for 15 minutes.
4. Temperature is raised at 5 ^oC per minute till the bitumen touches the bottom plate by sinking of balls.
5. Softening point is mean temperature of two observations.

Softening point depends on the quality and type of liquid used for the test, weight of balls, distance between ring and plate, rate of heating.

OBSERVATION AND CALCULATIONS:

1. Bitumen grade =
2. Approximate Softening point =

3. Liquid used in beaker – water/glycerin
4. Period of air cooling, minutes:
5. Period of water cooling in water bath, minutes:

RATE OF HEATING:

Time, minutes	1	2	3	4	5	6	7	8	9	10
Temperature, ^{o}C										

RESULT:

Test property	Ball No 1	Ball No 2	Mean Softening point, ^{o}C
Temperature at which sample touches bottom plate.			

The Softening point of bitumen is ______ ^{o}C

EXPERIMENT NO: 27

AIM: To determine viscosity of bitumen by viscosity test.

THEORY: Viscosity defines the fluid property of bituminous material. It is defined as inverse of fluidity. This influence the ability of bituminous material to spread, penetrate in to the voids and also coat the aggregates and hence affects the strength characteristics of the result paving mixes high or low fluidity affects mixing and compaction of bituminous mixes and thus affects the stability of the mix. There is an optimum value of fluidity/viscosity for mixing and compaction of mix. High or low fluidity fails to give uniform coating around the aggregate and thus affects the stability value of the mix. The principle of the test is the time taken by the liquid to collect in a 50 cc measure is the value of viscosity.

APPARATUES: 10/4 mm orifice, tar viscometer, thermometer and stop watch.

PROCEDURE:

1. Prepare about 250 ml of cutback liquid by dissolving bitumen in kerosene at 60-70 ^{o}C in 30/70 or 40/60 proportion of kerosene and bitumen.
2. When the material reaches the testing temperature of 25^{o}C, it is poured in tar cup up to the mark, with ball end stopper placed on the orifice.
3. Take 20 ml of soap solution in graduated receiver and placed below the orifice and the stopper is raised to open the orifice. Start a stop watch when the level of liquid raises to 25 ml and stop the watch the level raises to 75 ml.
4. Make similar 2 or more observations and take the viscosity value as the mean of 3 observations.

The results may get affected due to temperature, clogging of the orifice and due to presence of the lumps in the sample.

OBSERVATION AND CALCULATIONS:

1. Material =
2. Specified test temperature, ^{o}C =
3. Orifice size, mm =
4. Actual test temperature, ^{o}C =

Test property	Test run			Mean Value
	1	2	3	

Viscosity, seconds				

RESULT:

The viscosity of bitumen is

EXPERIMENT NO: 28

AIM: To determine Marshall Stability strength of bituminous mixes.

THEORY: The resistance to plastic deformation of cylindrical specimen of bituminous mix is measured in loading at the periphery at the rate of 5 cm per minute. This test is useful in designing and evaluating bituminous paving mixes. The marshal stability test of mix is defined as the maximum load carried by a compacted specimen at a standard test temperature of 60^{o}C. The flow value is deformation of the test specimen during the loading measured in 0.25 mm.

APPARATUES: Mould assembly, sample extractor, compaction pedestal and hammer, breaking head, loading machine, flow meter, oven, mixing apparatus, Balance, thermometer 200 ^{o}C ranges and water bath.

DIAGRAM:

PROCEDURE:

1. Proportion the coarse aggregates, fine aggregates and filler material to satisfy the gradation requirements of as per IRC 29-1968.

2. The required quantity of the mix is taken to produce a compacted specimen of 63.5 mm height approximately.

3. 1200 gms of coarse aggregates and filler are taken and heated to 175-190 ^{o}C temperature. Compaction mould assembly and hammer are pre heated to 100 ^{o}C. Bitumen is heated to 121-138 ^{o}C and a trial percentage of 3.5% by weight of mineral aggregates is added to the heated aggregates and thoroughly mixed. The mixing temperature for 80/100 grade bitumen is 154 ^{o}C and for 60/70 grade bitumen is about 160 ^{o}C.

4. The mix is placed in the mould and compacted by a rammer giving 50 blows on each side.

5. The compacting temperature of 138 ^{o}C for 80/100 bitumen and 149 ^{o}C for 60/70 grade bitumen is maintained.

6. The compacted specimen should have a thickness of 63.5 mm. at least 3 specimens should be prepared in each bitumen content.

OBSERVATION AND CALCULATIONS:

Specific gravity values of aggregates, filler and bitumen are to be determined as follows.

$$G_t = \frac{100}{\dfrac{W_1 + W_2 + W_3 + W_4}{G_1 + G_2 + G_3 + G_4}}$$

W_1 = % weight of coarse aggregate

W_2 = % weight of fine aggregate

W_3 = % weight of filler

W_4 = % weight of bitumen in total mix

G_1, G_2, G_3 and G4 are apparent specific gravity values of coarse aggregate, fine aggregate and bitumen.

Density and void analysis:

$$V_V, \% = \frac{100(G_t + G_b)}{G_t}$$

$$V_b, \% = \frac{(G_b * W_4)}{G_4}$$

$$VMA, \% = \frac{100 * V_b}{VMA}$$

V_V = air voids in mix %

V_b = voids in mineral aggregate, %

VMA = voids in mineral aggregates, %

VFB = voids filled with bitumen, %

Marshall stability and flow values:

The specimens are immersed in water at 60 °C for 30-40 minutes. The Marshall stability value of each specimen is calculated and corrections applied if the average height of the specimen is not exactly 63.5 mm.

Determination of optimum bitumen content:

Graphs are plotted with values of bitumen content against the values of

i. Density G_S, g/cm^2
ii. Marshall stability, S Kg
iii. Voids in total mix, V_V %
iv. Flow value, F (0.25 mm units)
v. Voids filled with bitumen content for maximum density is given by

$$B_0 = \frac{(B_1 + B_2 + B_3)}{3}$$

B_1 = bitumen content for maximum density

B_2 = bitumen content for maximum stability

B_3 = bitumen content for specified voids content, V_V

Design requirements of the mix (IRC 29-1960):

i. Marshall stability value, Kg (minimum) = 340
ii. Marshall flow value, 0.25 mm units 0 to 16
iii. Voids in total mix, V_V %
iv. Voids in mineral aggregate filled with bitumen, VFB %

From the above graphs calculate the following.

i. Marshall stability
ii. Maximum bulk density
iii. % air voids (between 3-5)

Tests on Soil:

EXPERIMENT NO: 29

AIM: To determine wet sieve analysis of fine aggregate

THEORY: Soil gradation (sieve analysis) is the distribution of particle sizes expressed as a percent of the total dry weight. Gradation is determined by passing the material through a series of sieves stacked with progressively smaller openings from top to bottom and weighing the material retained on each sieve.

NEED AND SCOPE: The results of testing will reflect the condition and characteristics of the aggregate from which the sample is obtained. Therefore, when sampling, it is important to obtain a disturbed representative sample that is representative of the source being tested because the distribution of different grain sizes affects the engineering properties of soil.

APPARATUS REQUIRED:

- A series of sieve sets ranging from 4.75mm to 75µm (4.75mm, 2.00mm, 1.00mm, 425µm, 212µm, 150µm, 75µm)
- Balance sensitive to ± 0.01g

PROCEDURE:

Soil passing 4.75mm I.S. Sieve and retained on 75micron I.S. Sieve contains no fines. Those soils can be directly dry sieved rather than wet sieving.

Dry Sieving:

1. Take 500gm of the soil sample from disturbed representative sample.
2. Conduct sieve analysis using a set of standard sieves as given in the data sheet.
3. The sieving may be done either by hand or by mechanical sieve shaker for 10 minutes.
4. Weigh the material retained on each sieve.
5. The percentage retained on each sieve is calculated on the basis of the total weight of the soil sample taken.

6. From these results the percentage passing through each of the sieves is calculated.
7. Draw the grain size curve for the soil in the semi-logarithmic graph provided.

Wet Sieving:

If the soil contains a substantial quantity (say more than 5%) of fine particles, a wet sieve analysis is required. All lumps are broken into individual particles.

1. Take 500gm of oven dried soil sample and soaked in water.
2. For heavy clays if deflocculation is required, 2% calgon solution is used instead of water.
3. The sample is stirred and left for soaking period of at least 10 minutes.
4. The material is sieved through 75 micron sieve.
5. The material is washed until the water filtered becomes clear.
6. The soil retained on 75 micron sieve is collected and dried in oven.
7. It is then sieved through the sieve shaker for ten minutes and retained material on each sieve is collected and weighed.
8. The material that would have been retained on pan is equal to the total mass of soil taken for dry sieve analysis minus the sum of the masses of material retained on all sieves.
9. Draw the grain size distribution curve for the soil in a semi-logarithmic graph.

PRESENTATION OF DATA:

SIEVE ANALYSIS:

- Sample Details: ____________________
- Weight of Sample taken for Sieve Analysis = ______ gms.
- Location: _______________________________

TABULAR COLUMN:

S. No.	**I.S. Sieve No.**	**Weight retained in gms**	**Cumulative weight retained in gms**	**Percent (%) weight retained**	**Percent (%) weight passing**
1.	**4.75 mm**				
2.	**2 mm**				

3.	**1 mm**				
4.	**425 microns**				
5.	**212 microns**				
6.	**150 Microns**				
7.	**75 Microns**				
8.	**Pan**				

RESULT:

The Cumulative percentage of passing

EXPERIMENT NO: 30

AIM: To determine California Bearing Ratio(CBR) of given sub grade soil.

THEREOY: CBR test may be conducted in remoulded or undisturbed sample. Test consists of causing a cylindrical plunger of 50mm diameter to penetrate a pavement component material at 1.25mm/minute. The loads for 2.5mm and 5mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain CBR value.

APPARATUS FOR CBR TEST

- Loading machine-any compression machine can operate at constant rate of 1.25mm per minute can be used. Cylindrical moulds- moulds of 150mm diameter and 175mm height provided with a collar of about 50mm length and detachable perforated base.

- Compaction rammer, surcharge weight-annular weights each of 2.5kg and 147mm diameter. IS sieve 20mm, Coarse filter paper, balance etc.

PROCEDURE:

1. Sieve the sample through 20mm IS sieve. Take 5 kg of the sample of soil specimen. Add water to the soil in the quantity such that optimum moisture content or field moisture content is reached.

2. Then soil and water are mixed thoroughly. Spacer disc is placed over the base plate at the bottom of mould and a coarse filter paper is placed over the spacer disc.

3. The prepared soil water mix is divided into five. The mould is cleaned and oil is applied. Then fill one fifth of the mould with the prepared soil. That layer is compacted by giving 56 evenly distributed blows using a hammer of weight 4.89kg.

4. The top layer of the compacted soil is scratched. Again second layer is filled and process is repeated. After 3^{rd} layer, collar is also attached to the mould and process is continued.
5. After fifth layer collar is removed and excess soil is struck off. Remove base plate and invert the mould. Then it is clamped to base plate.

6. Surcharge weights of 2.5kg are placed on top surface of soil. Mould containing specimen is placed in position on the testing machine.

7. The penetration plunger is brought in contact with the soil and a load of 4kg(seating load) is applied so that contact between soil and plunger is established. Then dial readings are adjusted to zero.

8. Load is applied such that penetration rate is 1.25mm per minute. Load at penetration of 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 7.5, 10 and 12.5mm are noted.

Standard Load Values for CBR Test

Penetration(mm)	Standard Load(kg)	Unit Standard Load(kg/cm^2)
2.5	1370	70
5	2055	105
7.5	2630	134
10.0	3180	162
12.5	3600	183

OBSERVATIONS AND CALCULATIONS:

1. Weight of soil taken =
2. Weight of surcharge =
3. Area of plunger, A =
4. Proving Ring Calibration Factor =

Sl No.	Penetration(mm)	Proving dial reading	Load on plunger(kg)	Corrected load	Unit Load

RESULT:

1. California Bearing Ratio at 2.5mm penetration =
2. California Bearing Ratio at 5.0mm penetration =
3. California Bearing Ratio of sub grade soil =