QMP 7.5 R/C-1 Rev.1

Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Approved by AICTE, New Delhi)

(**NAAC Accredited & ISO 9001:2015 Certified Institution)**

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

Department of Civil Engineering

CONCRETE AND HIGHWAY MATERIALS LABORATORY

18CVL58

B.E - V Semester

Laboratory Manual 2022-23

Name: ____________________________________

USN: ____________________________________

Batch: ________________ **Section:** ____________

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CONCRETE AND HIGHWAY MATERIALS LABORATRY

18CVL58

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DEPARTMENT OF CIVIL ENGINEERING

SYLLABUS

Subject code	**: 18CVL58**	**Exam Hours**	**: 03**
No. of Practical Hours	**: 03**	**IA Marks**	**: 40**
Teaching Hours/Week(L:T:P):	**(0:2:2)**	**Exam Marks**	**: 60**
Credits	**: 02**	**Total Marks**	**: 100**

PART A: Concrete Lab

1. Tests on Cement:

a. Normal Consistency

b. setting time

c. compressive strength

d. fineness by air permeability test

e. specific gravity.

2. Tests on Concrete:

a. Design of concrete mix as per IS-10262

b. Tests on fresh concrete:

i. Slump,

ii. Compaction factor and

iii. Vee Bee test

c. Tests on hardened concrete:

i. Compressive strength test,

ii. Split tensile strength test,

iii. Flexural strength test

d. NDT tests by rebound hammer and pulse velocity test.

3. Tests on Self Compacting Concrete:

- **Design of Self Compacting Concrete, as per IS 10262:2019**

a. Design of self compacting concrete,

b. Slump flow test,

c. V-funnel test,

d. J-Ring test,

e. U Box test and

f. L Box test

Part B: Highway Materials Lab

1. Tests on Aggregates

a. Aggregate Crushing value

b. Los Angeles abrasion test

c. Aggregate impact test

d. Aggregate shape tests (combined index and angularity number)

2. Tests on Bituminous Materials

a. Penetration test

b. Ductility test

c. Softening point test

d. Specific gravity test

e. Viscosity test by tar viscometer

f. Bituminous Mix Design by Marshall Method (Demonstration only)

3. Tests on Soil

a. Wet sieve analysis

b. CBR test

Course objectives

- To learn the procedure of testing concrete ingredients and properties of concrete as per standard code recommendations.
- To learn the procedure of testing bituminous materials as per standard code recommendations.
- To relate material characteristics to various application of construction.

Course outcome

- **Identify** the quality and suitability of cement and Bitumen.
- **Design** appropriate concrete mix Using Professional codes and demonstration of Bituminous mix by Marshal method
- **Identify** strength and quality of concrete and Aggregates.
- **Evaluate** the strength of structural elements using NDT techniques.
- **Evaluate** the soil for its suitability as sub grade soil for pavements.
- **Interpret** the experimental results of concrete and highway materials based on laboratory tests.

INDEX PAGE

Sl. No	Name of the Experiment	Date			Manual Marks (Max . 20)	Record Marks (Max. 10)	Signature (Student)	Signature (Faculty)
		Conduction	Repetition	Submission of Record				
Average								

- **Note: If the student fails to attend the regular lab, the experiment has to be completed in the same week. Then the manual/observation and record will be evaluated for 50% of maximum marks.**

‘Instructions to the Candidates’

1. **Students should come with thorough preparation for the experiment to be conducted.**

2. **Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.**

3. **All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.**

4. **Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.**

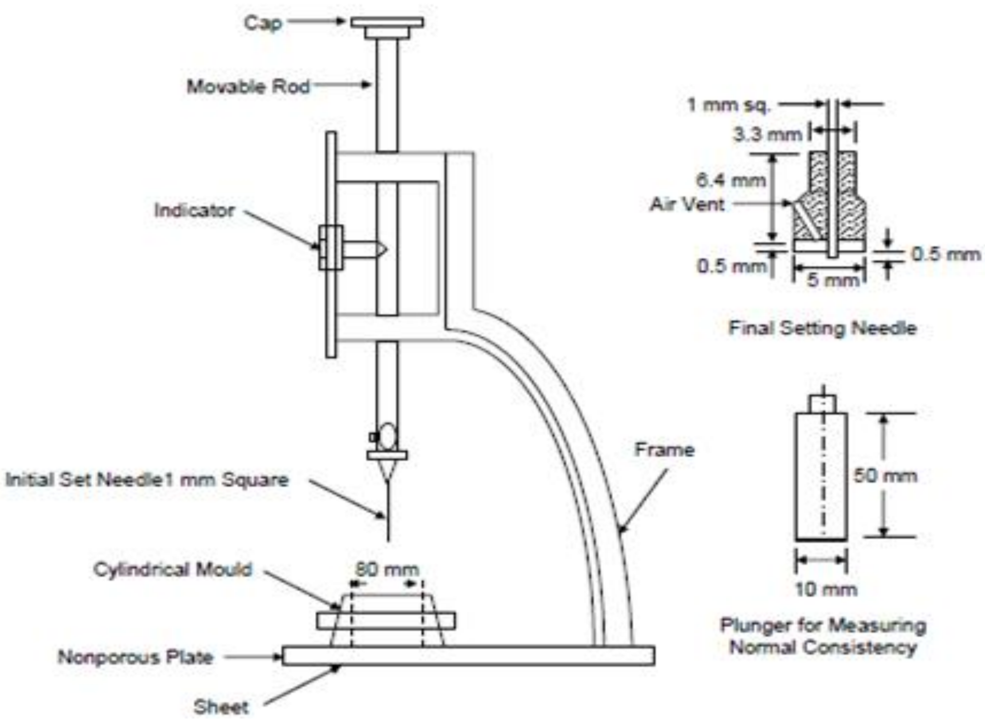
5. **Practical record should be neatly maintained.**

6. **They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.**

7. **Theory regarding each experiment should be written in the practical record before procedure in your own words.**

DEPARTMENT OF CIVIL ENGINEERING

CONTENTS



VICAT APPARATUS

OBSERVATIONS:

S. No	Weight of cement taken in gms (a)	Weight of water taken in gms (b)	Plunger penetration (mm)	Consistency of cement in % by weight b/a * 100

Exp No: Date:

NORMAL CONSISTENCY OF CEMENT

AIM: To determine the quantity of water required to produce a cement paste of standard consistency.

APPARATUS: Vicat apparatus (conforming to IS: 5513 - 1976) with plunger (10 mm in diameter) balance, weights, gauging trowel.

THEORY: The standard consistency of a cement paste is defined as that consistency which will permit the vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the vicatmould. For finding out initial setting time, final setting time, soundness of cement and compressive strength of cement, it is necessary to fix the quantity of water to be mixed in cement in each case. This experiment is intended to find out the quantity of water to be mixed for a given cement to give a cement paste of normal consistency and can be done with the help of vicat apparatus.

PROCEDURE:

1. Prepare a paste of weighed quantity of cement (300 grams) with a weighed quantity of potable or distilled water, starting with 26% water of 300g of cement.
2. Take care that the time of gauging is not less than 3 minutes, not more than 5 minutes and the gauging shall be completed before setting occurs.
3. The gauging time shall be counted from the time of adding the water to the dry cement untilcommencing to fill the mould.
4. Fill the vicat mould with this paste, the mould resting upon a non porous plate.
5. After completely filling the mould, trim off the surface of the paste, making it in level with the top of the mould. The mould may slightly be shaken to expel the air.
6. Place the test block with the mould, together with the non-porous resting plate, under the rod bearing the plunger (10mm diameter), lower the plunger gently to touch the surface of the test block and quickly release, allowing it to penetrate into the paste.
7. This operation shall be carried out immediately after filling the mould.

8. Prepare trial pastes with varying percentages of water and test as described above until the amount of water necessary for making the standard consistency as defined above is obtained

9. Express the amount of water as a percentage by weight of the dry cement.

PRECAUTIONS:

Clean appliances shall be used for gauging. In filling the mould the operator hands and the blade of the gauging trowel shall alone be used. The temperature of cement, water and that of test room, at the time when the above operations are being performed, shall be 27 + 2^{o}C. For each repetition of the experiment fresh cement is to be taken.

RESULT: Normal consistency for the given sample of cement is…………………..

COMMENTS:

Grades of Cement	IS Code
33	
43	
53	

Exp No: Date

INITIAL AND FINAL SETTING TIMES OF CEMENT

AIM: To determine the initial and final setting times for the given sample of cement.

APPARATUS: Vicat apparatus (conforming to IS: 5513-1976) with attachments, balance, weights, gauging trowel.

INTRODUCTION: In actual construction dealing with cement, mortar or concrete, certain time is required for mixing, transporting and placing. During this time cement paste, mortar, or concrete should be in plastic condition. The time interval for which the cement products remain in plastic condition is known as the setting time. Initial setting time is regarded as the time elapsed between the moments that the water is added to the cement to the time that the paste starts losing its plasticity. The final setting time is the time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain pressure. The constituents and fineness of cement is maintained in such a way that the concrete remains in plastic condition for certain minimum time. Once the concrete is placed in the final position, compacted and finished it should lose its plasticity in the earliest possible time so that it is least vulnerable to damages from external destructive agencies. This time should not be more than 10 hours which is referred to as final setting time. Initial setting time should not be less than 30 minutes.

PROCEDURE:

Preparation of Test Block:

1. Prepare a neat cement paste by gauging 300 grams of cement with 0.85 times the water required to give a paste of standard consistency.
2. Potable or distilled water shall be used in preparing the paste.
3. The paste shall be gauged in the manner and under the conditions prescribed in determination of consistency of standard cement paste.
4. Start a stop-watch at the instant when water is added to the cement.
5. Fill the mould with the cement paste gauged as above the mould resting on a nonporous plate.
6.Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared in the mould is the test block

OBSERVATIONS

Time in minutes				
Height in mm fails to penetrate				

DETERMINATION OF INITIAL SETTING TIME:

1. Place the test blocks confined in the mould and rest it on the non-porous plate, under the rod bearing initial setting needle, lower the needle gently in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block.

2. In the beginning, the needle will completely pierce the test block.

3. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block to a point 5 to 7 mm measured from the bottom of the mould shall be the initial setting time.

DETERMINATION OF FINAL SETTING TIME:

1. Replace the needle of the Vicat apparatus by the needle with an annular attachment.

2. The cement shall be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression there on, while the attachment fails to do so.

3. The period elapsed between the time when water is added to the cement and the time at which the needle makes an impression on the surface of test block while the attachment fails to do so shall be the final setting time.

PRECAUTIONS: Clean appliances shall be used for gauging. All the apparatus shall be free from vibration during the test. The temperature of water and that of the test room, at the time of gauging shall be $27^0C \pm 2^0C$. Care shall be taken to keep the needle straight.

RESULT: Initial setting time for the given sample of cement =

Final setting time for the given sample of cement =

COMMENTS:

Compression Strength Machine

CALCULATION:

Calculate the compressive strength from the crushing load and the average area over which the load is applied. Express the results in N/mm^2 to the nearest 0.05 mm^2. Compressive strength in N/mm^2 = P/A =

Where P is the crushing load in Nand A is the area in mm^2 (5000 mm^2)

Exp No: Date:

COMPRESSIVE STRENGTH OF CEMENT

AIM: To determine the compressive strength of standard cement mortar cubes compacted by means of standard vibration machine.

APPARATUS: Vibration machine and cube moulds of size 7.06 cms (Conforming to IS: 4031 1988)

STANDARD SAND: The standard sand to be used in the test shall conform to IS: 650-1991 or sand passing 100 percent through 2 mm sieve and retained 100 percent on 90 micron IS sieve.

2mm to 1mm	33.33 percent
1mm to 500 microns	33.33 percent
500mm to 90 microns	33.33 percent

INTRODUCTION: The compressive strength of cement mortars is determined in order to verify whether the cement conforms to IS specifications and whether it will be able to develop the required compressive strength of concrete. The average compressive strength of at least three mortar cubes (area of the face 50 cm^2) composed of one part of cement and three parts of standard stand should satisfy IS code specifications.

PROCEDURE:

Mix proportions and mixing:

1. Clean appliances shall be used for mixing and the temperature of the water and that of the test room at the time when the above operations are being performed shall be $27^0 + 2^0$C.
2. Place in a container a mixture of cement and standard sand in the proportion of 1:3 by weight mix it dry, with a trowel for one minute and then with water until the mixture is of uniform color.
3. The quantity of water to be used shall be as specified below.
4. In any element, it should not take more than 4 minutes to obtain uniform colored mix.
5. If it exceeds 4 minutes the mixture shall be rejected and the operation repeated with a fresh quantity of cement, sand and water.
6. The material for each cube shall be mixed separately and the quantity of cement standard sand and water shall be as follows:

Cement 200grms

Standard sand 600 grms

Water (P/4 + 3.0) percent of combined weight of cement and sand, where p is the percentage of water required to produce a paste of standard consistency.

MOULDING SPECIMENS:

1. In assembling the moulds ready for use, cover the joints between the halves of the mouldwith a thin film of petroleum jelly and apply a similar coating of petroleum jelly between the contact surfaces of the bottom of the mould and its base plate in order to ensure that no water escapes during vibration.
2. Treat the interior faces of the mould with a thin coating of mould oil.
3. Place the assembled mould on the table of the vibration machine and firmly hold it isposition by means of suitable clamps.
4. Securely attach a hopper of suitable size and shape at the top of the mould to facilitatefilling and this hopper shall not be removed until completion of the vibration period.
5. Immediately after mixing the mortar, place the mortar in the cube mould and rod with arod.
6. The mortar shall be rodded 20 times in about 8 seconds to ensure elimination of entrainedair and honey combing.
7. Place the remaining quantity of mortar in the hopper of the cube mould and rod again asspecified for the first layer and then compact the mortar by vibrations.
8. The period of vibration shall be two minutes at the specified speed of 12,000 + 400vibrations per minute.
9. At the end of vibration remove the mould together with the base plate from the machineand finish the top surface of the cube in the mould by smoothing surface with the blade ofa trowel.

CURING SPECIMEN:

1. Keep the filled moulds at a temperature of 27^0 + 20^0 C in an atmosphere of at least 90 relative humidity for about 24 hours after completion of vibration.
2. At the end of that period remove them from the moulds.
3. Immediately submerge in clean fresh water and keep them under water until testing.

4. The water in which the cubes are submerged shall be renewed every 7 days and shall be maintained at a temperature of 27^0C + 2^0C.
5. After they have been taken out and until they are tested the cubes shall not be allowed to became dry.

TESTING:

1. Test three cubes for compressive strength at the periods mentioned under the relevant specification for different hydraulic cements, the periods being reckoned from the completion of vibration.
2. The compressive strength shall be the average of the strengths of three cubes for each period of curing.
3. The cubes shall be tested on their sides without any packing between the cube and the steel plates of the testing machine.
4. One of the platens shall be carried base and shall be self-adjusting and the load shall be steadily and uniformly applied starting from zero at a rate of 350 Kgs/Cm^2/ min.

The cubes are tested at the following periods

Ordinary portland cement	3, 7 and 28 days.
Rapid hardening portland cement	1 and 3 days.
Low heat portland cement	3 and 7 days.

PRECAUTIONS: Inside of the cube moulds should be oiled to prevent the mortar fromadhering to the sides of the mould.

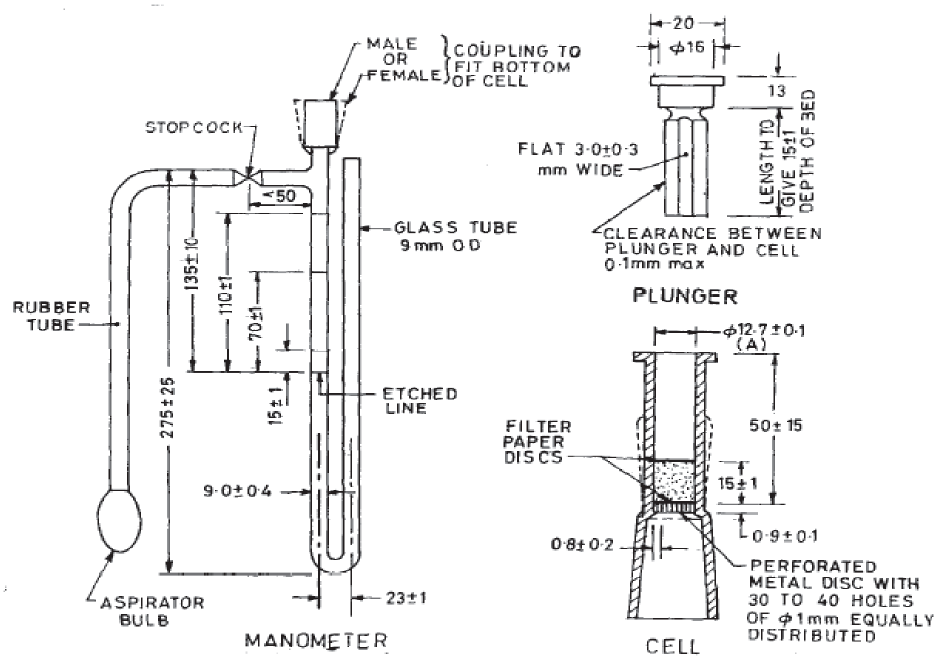
RESULT: The average compressive strength of the given cement

at 3 days ………………………. N/mm^2

at 7 days……………………….. N/mm^2

at 28 days……………………… N/mm^2

COMMENTS:



Variable Flow Type Air Permeability Apparatus (Blain Type)

Specific surface is calculated by the formula:

$S_w = K \sqrt{h_1/h_2}$

Where K = $\frac{14}{D(1-\xi)} \times \frac{\sqrt{\xi^3}\ A}{\sqrt{CL}}$

ξ = porosity i.e. o.475

D = Density of cement

A = Area of the cement bed

C = Flow meter constant

L = Length of the cement bed

Result: The Specific surface of the cement is = **..** sq. cm / gm

IS 5516: 1996 Specification for variable flow type air permeability apparatus (Blaine type)

IS Specification: Fineness requirement of cement as per IS 269 - 1976

	Ordinary	**Rapid Hardening**	**Low Heat**
Specific surface (sq. cm/gm) by air permeability method, not less than	2250	3250	3200

Exp No: Date:

FINENESS BY AIR PERMEABILITY TEST

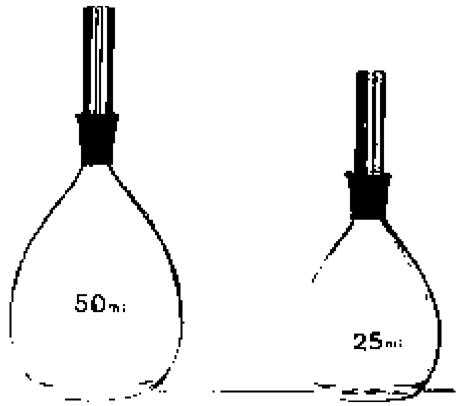
AIM: To determine the fineness value for cement as represented by specific surface expressed as total surface area in sq cm/gm by air permeability apparatus

APPARATUS: Air permeability cell, perforated disc, manometer, filter paper discs, Dibutylpthalate etc.

INTRODUCTION: The fineness of cement is a measure of the size of particles of cement and is expressed in terms of specific surface of the cement. It is an important factor in determining the rate of gain of strength and uniformity of quality. For a given weight of cement, the surface area is more for finer cement than for coarser cement. The finer the cement, the higher is the rate of hydration, as more specific area is available for chemical reaction. This results in early development of the strength. Thus the specific surface of cement is calculated based on the relation between flow air through the cement bed and the surface area of the particles comprising the cement bed. From this the surface area per unit weight of the body material can be related to the permeability of a bed of a given porosity.

PROCEDURE

1. The cement bed in the permeability cell is 12cm high and 2.5 cm in diameter.
2. Knowing the density of cement the weight required to make a cement bed of porosity of .475 can be calculated.
3. This quantity of cement is placed in the permeability cell in a standard manner.
4. Slowly pass on air through the cement bed at a constant velocity until the flow meter shows a difference in level of 30-50cm.
5. Read the difference in level h_1 of the manometer and the difference in level h_2 of the flow meter.
6. Repeat these observations to ensure that steady conditions have been obtained by a constant value of h_1/h_2. Specific surface is calculated by the formula:



Specific Gravity Bottle

OBSERVATIONS

Description of item	Trial 1	Trial 2	Trial 3
Weight of empty bottle W1 g			
Weight of bottle + Cement W2 g			
Weight of bottle + Cement + Kerosene W3 g			
Weight of bottle + Full Kerosene W4 g			
Weight of bottle + Full Water W5 g			

Specific gravity of Kerosene Sk = W_4 - W_1 / W_5 - W_1…………………

Specific gravity of Cement Sc = W_2 - W_1 / ((W4 - W1)-(W_3-W_2))*Sk……………………….

Sc = (W_2 - W_1)* (W_4 - W1) / ((W_4 - W_1)-(W_3-W_2))*(W_5 - W_1)……………………….

Exp No: Date:

SPECIFIC GRAVITY OF CEMENT

AIM: To determine the specific gravity of given sample of cement.

APPARATUS: Physical balance, specific gravity bottle of 50ml capacity, cleans kerosene.

INTRODUCTION: Specific gravity is defined as the ratio between weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of cement, kerosene is used which does not react with cement.

PROCEDURE:

1. Clean and dry the specific gravity bottle and weigh it with the stopper (W_1).
2. Fill the specific gravity bottle with cement sample at least half of the bottle and weigh with stopper (W_2).
3. Fill the specific gravity bottle containing the cement, with kerosene (free of water) placing the stopper and weigh it (W_3).
4. While doing the above do not allow any air bubbles to remain in the specific gravity bottle.
5. After weighing the bottle, the bottle shall be cleaned and dried again.
6. Then fill it with fresh kerosene and weigh it with stopper (W_4).
7. Remove the kerosene from the bottle and fill it with full of water and weigh it with stopper (W_5).
8. All the above weighing should be done at the room temperature of 27 ^{0}C $\pm$ 1^{0}C.

PRECAUTIONS

1. Only kerosene which is free of water shall be used.
2. At time of weighing the temperature of the apparatus will not be allowed to exceed the specified temperature.
3. All air bubbles shall be eliminated in filling the apparatus and inserting the stopper.

4. Weighing shall be done quickly after filling the apparatus and shall be accurate to 0.1 mg.
5. Precautions shall be taken to prevent expansion and overflow of the contents resulting from the heat of the hand when wiping the surface of the apparatus.

RESULT: Average specific gravity of given sample of cement =

COMMENTS

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MIX DESIGN

Concrete is the basic engineering material used in most of the civil engineering structures. Its popularity as basic building material in construction is because of, its economy of use, good durability and ease with which it can be manufactured at site. The ability to mould it into any shape and size, because of its plasticity in green stage and its subsequent hardening to achieve strength, is particularly useful.

Concrete like other engineering materials needs to be designed for properties like strength, durability, workability and cohesion. Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way.

With advent of high-rise buildings and pre-stressed concrete, use of higher grades of concrete is becoming more common. With advent of new generation admixtures, it is possible to achieve higher grades of concrete with high workability levels economically.

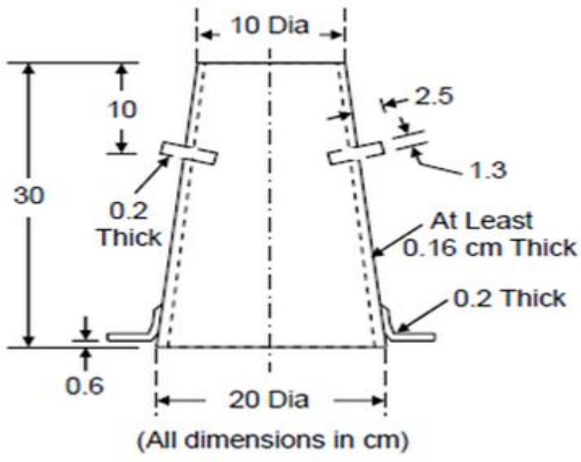
Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible

Concept of Mix Design

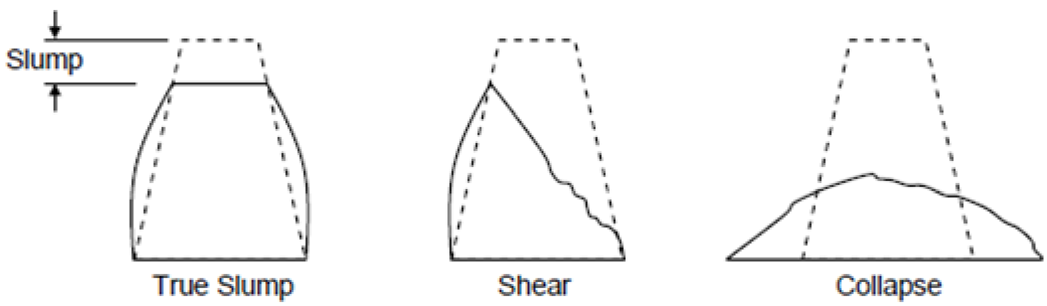
The relationships between aggregate and paste which are the two essential ingredients of concrete. Workability of the mass is provided by the lubricating effect of the paste and is influenced by the amount and dilution of paste. The strength of concrete is limited by the strength of paste, since mineral aggregates with rare exceptions, are far stronger than the paste compound. Essentially the permeability of concrete is governed by the quality and continuity of the paste, since little water flows through aggregate either under pressure or by capillarity

Since the properties of concrete are governed to a considerable extent by the quality of paste, it is helpful to consider more closely the structure of the paste. With the given materials, the four variable factors to be considered in connection with specifying a concrete mix are

- Water-Cement ratio
- Cement content or cement-aggregate ratio
- Gradation of the aggregates
- Consistency



Slump Cone



Different Types of Slump

OBSERVATIONS

Sl No	W/C ratio	Slump in mm
1	0.5	
2	0.6	
3	0.7	
4	0.8	

Exp No: Date:

WORKABILITY TESTS ON FRESH CONCRETE
SLUMP TEST

AIM: To determine the workability or consistency of concrete mix of given proportion by slump test.

APPARATUS: Iron pan to mix concrete, weighing machine, trowel slump, cone, scale and Tamping rod

The slump cone is a hollow frustum made of thin steel sheet with internal dimensions, as the top diameter 10 cms. The bottom diameter 20 cms, and height 30cms. It stands on a plane non-porous **s**urface. To facilitate vertical lifting from moulded concrete it is provided with a suitable guide attachment and suitable foot pieces and handles. The tamping rod is 16mm. dia. 60 cm. long and is bullet pointed at the lower end.

THEORY: Unsupported concrete, when it is fresh, will flow to the sides and a sinking in heightwill take place. This vertical settlement is called slump. Slump is a measure 0.5, 0.6, 0.7 and 0.8. For eachmix take 10 Kg. C.A., 5 Kg., FA and 2.5 Kg. Cement.

PROCEDURE

1. Mix the dry constituents thoroughly to get a uniform colour and then add water.
2. The internal surface of the mould is to be thoroughly cleaned and placed on a smooth, horizontal, rigid and nonabsorbent surface.
3. Place the mixed concrete in the cleaned slump cone in 4 layers each approximately 1/4 in height of the mould. Tamp each layer 25 times with tamping rod.
4. Remove the cone immediately, rising it slowly and carefully in the vertical direction.
5. As soon as the concrete settlement comes to a stop, measure the subsistence of the concrete in cms, which gives the slump.

Note: Slump test is adopted in the Laboratory or during the progress of the work in the field for determining consistency of concrete where nominal max., size of aggregates does not exceed 40 mm. Any slump specimen which collapses or shears off laterally gives incorrect results and at this juncture the test is repeated only true slump should be measured.

PRECAUTIONS:

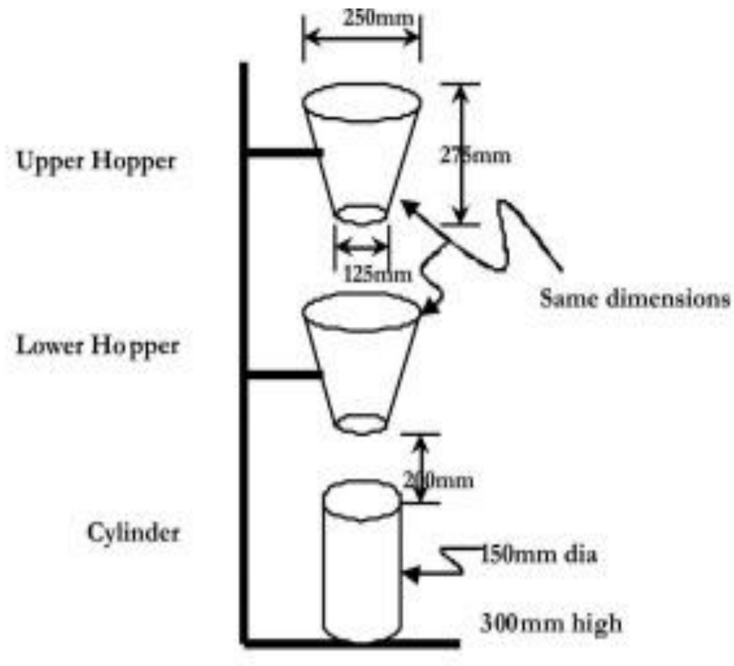
1. The strokes are to be uniformly applied through the entire area of the concrete section.
2. The cone should be removed very slowly by lifting it upwards without disturbing the concrete.
3. During filling the mould must be firmly pressed against the base.
4. Vibrations from nearly machinery might also increase subsidence; hence test should be made beyond the range of ground vibrations.

RESULT

COMMENTS: This test is not a true guide to workability. For example, a harsh coarse mix cannot be said to have same workability as one with a large portion of sand even though they have the same slump.

Recommended slumps of concrete mix of various works

S.No	Description of work	Recommended slump in cms
1	Road work	2.5 to 5.0
2	Ordinary beams to slabs|	5 to 10
3	Columns thin vertical section & retaining Walls etc	7.5 to 12.5
4	Mass concrete(Runway, |Pavements)	2.5 to 5



Compaction Factor Apparatus

OBSERVATIONS AND CALCULATIONS:

Weight of cylinder = W_1Kgs.

S.No	**W/c ration**	**Wt. With partially compaction W_2 (Kgs)**	**Wt. With fully compaction W_3 (Kgs)**	**Wt. With partially compacted concrete(W_2- W_3) (Kgs)**	**Wt. With fully compacted concrete(W_3- W_1) (Kgs)**	**Compaction factor (W_1- W_2)/ (W_3- W_1)**
1	0.5					
2	0.6					
3	0.7					
4	0.8					

Exp No: Date:

COMPACTION FACTOR TEST

AIM: To determine the consistency (workability) of freshly mixed concrete.

APPARATUS: Compaction factor apparatus, balance, tamping rod

THEORY: This test is adopted to determine workability of concrete where nominal size of aggregate does not exceed 40 mm. It is based on the definition, that workability is that property of concrete, which determines the amount of work required to produce full compaction. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction.

The compaction factor is defined as the ratio of the weight of partially compacted concrete to the weight of fully compacted concrete. It shall be stated to the nearest second decimal place.

PROCEDURE: Conduct test for W/c ratio 0.5, 0.6, 0.7, and 0.8, for each mix take 10 kg of coarse aggregate 5kg of fine aggregate and 2.5 Kg of cement.

1. Grease the inner surface of the hoppers and the cylinder.
2. Fasten the hopper doors.
3. Weigh the empty cylinder accurately (W_1. Kgs).
4. Fix the cylinder on the base with fly nuts and bolts
5. Mix coarse and fine aggregates and cement dry until the mixture is uniform in color and then with water until concrete appears to be homogeneous.
6. Fill the freshly mixed concrete in upper hopper gently with trowel without compacting.
7. Release the trap door of the upper hopper and allow the concrete of fall into the lower hopper bringing the concrete into standard compaction.
8. Immediately after the concrete comes to rest, open the trap door of the lower hopper and allow the concrete to fall into the cylinder, bringing the concrete into standard compaction.

9. Remove the excess concrete above the top of the cylinder by a trowel.
10. 10. Find the weight of cylinder i.e cylinder filled with partially compacted concrete (W_2kgs)
11. Refill the cylinder with same sample of concrete in approx. 4 layers, tamping each layerwith tamping for 25 times in order to obtain full compaction of concrete.
12. Level the mix and weigh the cylinder filled with fully compacted concrete (W_3 Kg)
13. Repeat the procedure for different for different a trowel.

PRECAUTIONS:

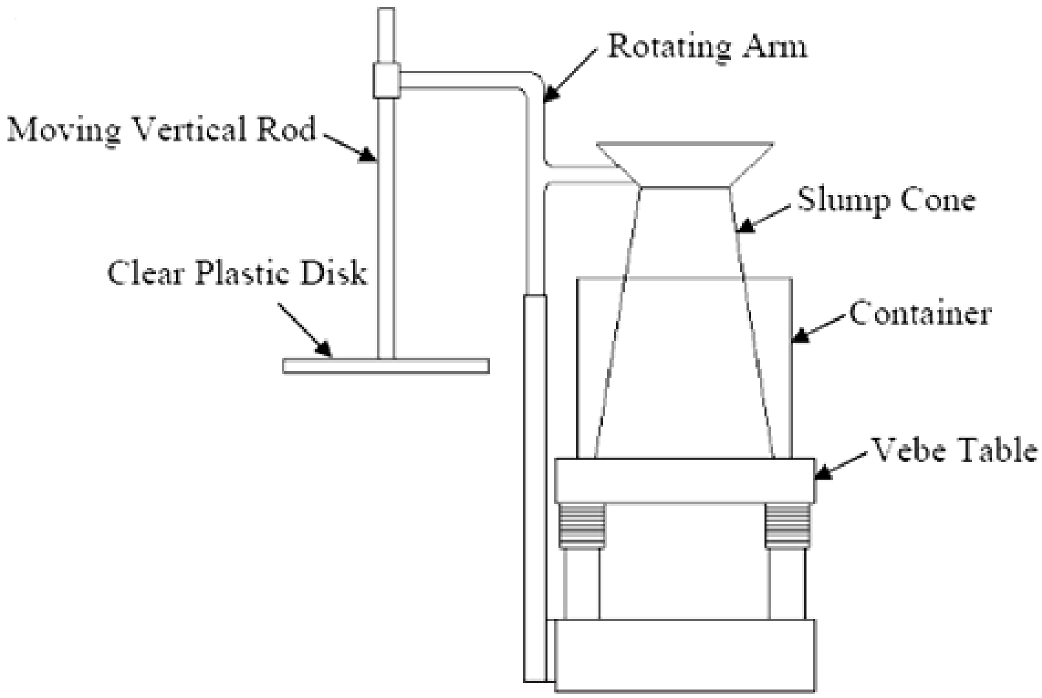
1. The top hopper must be filled gently.
2. The mix should not be pressed or compacted in the hopper.
3. If the concrete in the hopper does not fall through when the trap door is released, it should be freed by passing a metal rod. A single steady penetration will usually affect release.

COMMENTS: It is more sensitive, precise than slump test and is particularly useful to concrete mixes of low workability.

Suggested ranges of values of compaction factorsfor different placing conditions.

S.No	**Placing condition**	**Degree ofworkability**	**Values of workability**
1	Concreting shallow section with vibration	Very low	0.75 to 0.80
2	Concreting of lightly reinforced section with vibration	Low	0.8 to 0.85
3	Concreting of lightly reinforced section without vibration or heavily reinforced with vibration	Medium	0.85 to 0.92
4	Concreting of heavily reinforced section without vibration	High	0.92 to above

RESULT



Vebe Consistometer

OBSERVATION

Initial reading on the graduate rod A		
Final reading on the graduate rod B		
Slump B –A		
Time for complete remoulding in sec		

Exp No: Date:

VEE-BEE CONSISTOMETER

AIM: To measure the workability of concrete by vee-bee consistometer test

APPARATUS REQUIRED:Vee-Beeconsistometer test apparatus, iron rod, stop watc

THEORY The Veebeconsistometer (Bartos 1992; Scanlon 1994; Bartos, Sonebi, and Tamimi 2002) measures the remolding ability of concrete under vibration. The test results reflect the amount of energy required to remold a quantity of concrete under given vibration conditions. The Veebeconsistometer is applicable to concrete with slumps less than 5cm

PROCEDURE.

1. Placing the slump cone inside the sheet metal cylindrical pot of the consistometer.
2. The glass disc attached to the swivel arm is turned and placed on the top of the concrete pot.
3. The electrical vibrator is switched on and simultaneously a stop watch is started.
4. The vibration is continued till such a time as the conical shape of the concrete disappears and the concrete assumes cylindrical shape.
5. Immediately when the concrete fully assumes a cylindrical shape, the stop watch is switched off. The time required for the the shape of concrete to change from slump cone shape to cylindrical shape in seconds is known as vee bee degree.

Result: The consistency of the concrete is………sec.

OBSERVATIONS

Sl no	Max load in N	Area of specimen mm^2	Compressive strength N/mm^2
1			
2			
3			

CALCULATION: The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test, by the cross sectional area, calculated from the mean dimensions of section and shall be expressed to the nearest Kg/sq.cm. Average of three values shall be taken as the representative of the batch provided the individual variation is not more than + 15% of the average. Otherwise, repeat tests shall be made.

Exp No: Date:

TEST FOR COMPRESSIVE STRENGTH OF CONCRETE CUBES

AIM: Todetermination of the compressive strength of given concrete mixes.

APPARATUS: Testing Machine, Specimen mould, tamping rod

SPECIMEN: Cement concrete cubes of size 15cm, prepared from the given cement, fine aggregates & coarse aggregates, water.

THEORY & SIGNIFICANCE: Concrete is very strong in compression. It is assumed that whole of the compression will be taken up by the concrete while designing any RCC structure. The most important strength test for concrete is the compression test. This test is not only important from structural point of view but also other properties such as fatigue, impact, shrinkage, creep, deformation and thermal sensitivity bear some relationship with it.

PROCEDURE.

1. Calculate the material required for preparing the concrete of given proportions (1:2:4).
2. Mix them thoroughly in mechanical mixer until uniform color of concrete is obtained
3. Pour concrete in the oiled with a medium viscosity oil. Fill concrete is cube mouldsintwo layers each of approximately 75mm and ramming each layer with 35 blows evenlydistributed over the surface of layer.
4. Fill the moulds in 2 layers each of approximately 50mm deep and ramming each layer heavily.
5. Struck off concrete flush with the top of the moulds.
6. Immediately after being made, they should be covered with wet mats.
7. Specimens are removed from the moulds after 24hrs and cured in water 28 days
8. After 24hrs of casting, cylinder specimens are capped by neat cement paste 35 percent water content on capping apparatus. After 24 hours the specimens are immersed into water for final curing.
9. Compression tests of cube and cylinder specimens are made as soon as practicable afterremoval from curing pit. Test-specimen during the period of their removal from the curing pit and till testing, are kept moist by a wet blanket covering and tested in a moist

condition.

10. Place the specimen centrally on the location marks of the compression testing machine and load is applied continuously, uniformly and without shock.
11. Also note the type of failure and appearance cracks.

REPORTING OF RESULTS:

The following information shall be included in the report on each test specimen:

a) Identification mark

b) Date of test

c) Age of specimen

d) Curing conditions including date of manufacture of specimen in the field

e) Weight of specimen

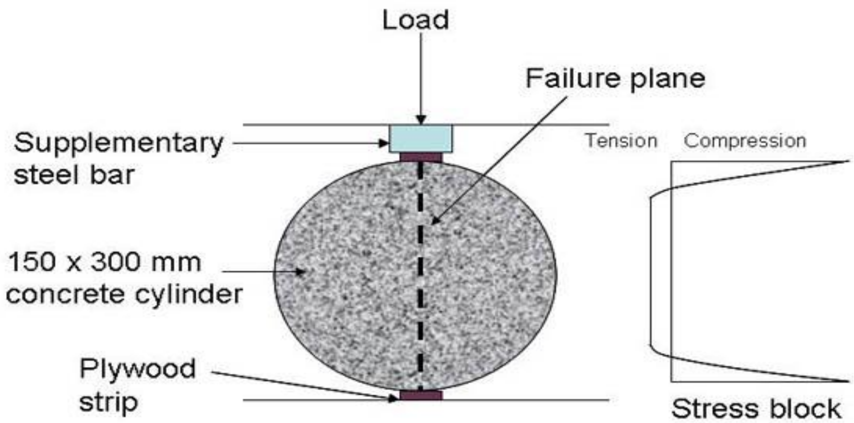
f) Dimensions of specimen

g) Compressive strength

h) Maximum load

RESULT: Compressive strength of Concrete --------------.N/mm^2

COMMENTS



Loading Arrangement for Determining Split Tensile Strength

OBSERVATION

Sl No	Dia of the specimen (mm)	Length of the specimen (mm)	Breaking load (N)	Split tensile strength (Mpa)

Calculations

Formula = $\frac{2P}{\pi d l}$

Where

P= Breaking load, d= dia of the specimen, l= length of the specimen

Exp No: Date:

SPLIT TENSILE STRENGTH OF CONCRETE

AIM: To determine the split tensile strength of concrete of given mix proportions.

APPARATUS: Compression testing machine weighing machine mixer, tamping rods

THEORY: The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure.

PROCEDURE:

1. Take mix proportion as 1:2:4 with water cement ratio of 0.6. Take 21kg of coarse aggregate, 10.5 kg of fine aggregate 5.25kg of cement and 3.l5 liters of water. Mix them thoroughly until uniform colour is obtained. This material will be sufficient for casting three cylinders of the size 150mm diameter X 300 mm length. In mixing by hand cement and fine aggregate be first mixed dry to uniform colour and then coarse aggregate is added and mixed until coarse aggregate is uniformly distributed throughout the batch. Now the water shall be added and the ingredients are mixed until resulting concrete is uniform in colour. Mix at least for two minutes.
2. Pour concrete in moulds oiled with medium viscosity oil. Fill the cylinder mould in four layers each of approximately 75 mm and ram each layer more than 35 times with evenly distributed strokes.
3. Remove the surplus concrete from the tope of the moulds with the help of the trowel.
4. Cover the moulds with wet mats and put the identification mark after about 3 to 4 hours.
5. Remove the specimens from the mould after 24 hours and immerse them in water for the final curing. The test is usually conducted at the age of 7-28 days. The time age shall be calculated from the time of addition of water to the dry ingredients.
6. Test at least three specimens for each age of test as follows

   (i) Draw diametrical lines on two ends of the specimen so that they are in the same

   axial plane.

I. Determine the diameter of specimen to the nearest 0.2 mm by averaging the diameters of the specimen lying in the plane of premarked lines measured near the ends and the middle of the specimen. The length of specimen also shall be taken be nearest 0.2 mm by averaging the two lengths measured in the plane containing pre marked lines.

II. Centre one of the plywood strips along the centre of the lower platen. Place the specimen on the plywood strip and align it so that the lines marked on the end of the specimen are vertical and centered over the plywood strip. The second plywood strip is placed length wise on the cylinder center on the lines marked on the ends of the cylinder.

III. The assembly is positioned to ensure that lines marked on the end of specimen are vertical and the projection of the plane passing through these two lines interest the centre of the platen.

Apply the load without shock and increase it continuously at the rate toproduce a split tensile stress of approximately1.4 to 2.1 N/mm2/min, until nogreater load can be sustained. Record the maximum load applied to specimen

Note the appearance of concrete and any unusual feature in the type of failure.

Compute the split tensile strength of the specimen to the nearest 0.25 N/mm2

PRECAUTIONS

The mould and base plate must be oiled lightly before use

The specimen should be made and cured as per IS 516-1959

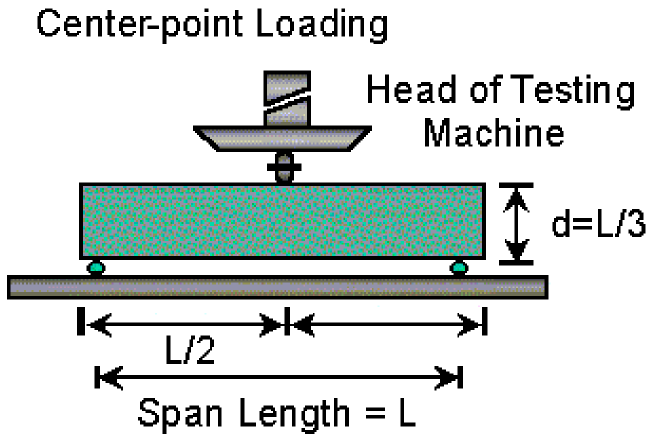
The specimen should be tested immediately on removal from the water

The specimen should be placed in testing machine centrally

Load should be applied without shock

RESULT

Sketch:



Flexural Testing on concrete

Result: The flexural strength of concrete is .... N/mm^2

IS Specification:

Conclusion:

Reference Code: -

IS 7246 – 1974 Recommendations for use of table vibrators consolidating concrete

IS 4031 - part 7 - 1988 Method of test for strength of concrete

IS 269: 1967 Specifications for ordinary and low Portland cement

IS: 650 – 1966 Specification for standard sand for testing of cement

Exp No: Date:

FLEXURAL STRENGTH TEST

Aim: To determine, the strength of concrete using flexural test

Apparatus: The following apparatus are required for the test.

1. Prism mould (15 cm x 15 cm x 70 cm)
2. Universal Testing Machine

Theory: Concrete is relatively strong in compression and weak in tension. In RCC concrete members, little dependence is placed on tensile strength of concrete since steel reinforcing bars are provided to resist all tensile forces. However, tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradient and many other reasons. Therefore, the knowledge of tensile strength of concrete is of importance.

Procedure:

1. Test specimens are stored in water at a temperature of 24^{o} C to 30^{o} C for 48 hours before testing. They are tested immediately on removal from the water whilst they are still wet condition.
2. The dimension of each specimen should be noted before testing.
3. The bearing surface of the supporting and loading rollers is wiped and clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers.
4. The specimen is then placed in the machine in such manner that the load is applied to the upper most surface as cast in the mould
5. The axis of specimen is carefully aligned with the axis of the loading device. No packing is used between the bearing surfaces of the specimen and rollers.
6. The load is applied without shock and increasing continuously at a rate of the specimen. The rate of loading is 4kN/min for the 15cm specimen and 18 kN /min for the 10cm specimen.
7. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded

NON-DESTRUCTIVE TEST

Introduction

Non-destructive testing (NDT) methods are techniques used to obtain information about the properties or internal condition of an object without damaging the object. Non-destructive testing is a descriptive term used for the examination of materials and components in such way that allows materials to be examined without changing or destroying their usefulness

The greatest disadvantage of the conventional methods of testing concrete lies in the fact that in-situ strength of the concrete can not be obtained without damaging the actual structure. Also the test specimens are destroyed, once the test is performed and subsequent testing of the same specimens is not possible. The variability of constituents of the mix to be controlled, but they can not take into account the differences of compaction and actual curing conditions between the test specimens and the corresponding concrete in a structure. It is these differences, which are difficult to assess by conventional strength tests, Also, conventional method of testing is not sufficient to predict the performance of the structures under adverse conditions e.g. exposure to liquid, gas, and chemicals radiation, explosion, fire, extreme cold or hot weather, marine and chemical environment. All such severe exposure conditions may induce deterioration in concrete and impair the integrity, strength and stability of the structure. Thus, conventional strength test does not give idea about the durability and performance of the actual concrete in the structure.

NDT methods are extremely valuable in assessing the condition of structures, such as bridges, buildings, elevated service reservoirs and highways etc. The principal objectives of the non-destructive testing of concrete in situ is to assess one or more of the following properties of structural concrete as below

- In situ strength properties
- Durability
- Density
- Moisture content
- Elastic properties
- Extent of visible cracks

- Thickness of structural members having only one face exposed
- Position and condition of steel reinforcement
- Concrete cover over the reinforcement.
- Reliable assessment of the integrity or detection of defects of concrete members even when they are accessible only from a single surface.

The Non Destructive Testing is being fast, easy to use at site and relatively less expensive can be used for

- To test actual structure instead of representative cube samples.
- To test any number of points and at any location.
- Quality control and quality assurance management tool
- To assess the structure for various distressed conditions
- Damage assessment due to fire, chemical attack, impact, age etc.
- To detect cracks, voids, fractures, honeycombs and week locations
- To monitor progressive changes in properties of concrete & reinforcement.
- To assess overall stability of the structure
- Monitoring repairs and rehabilitation systems
- Scanning for reinforcement location, stress locations.

NDT TECHNIQUES

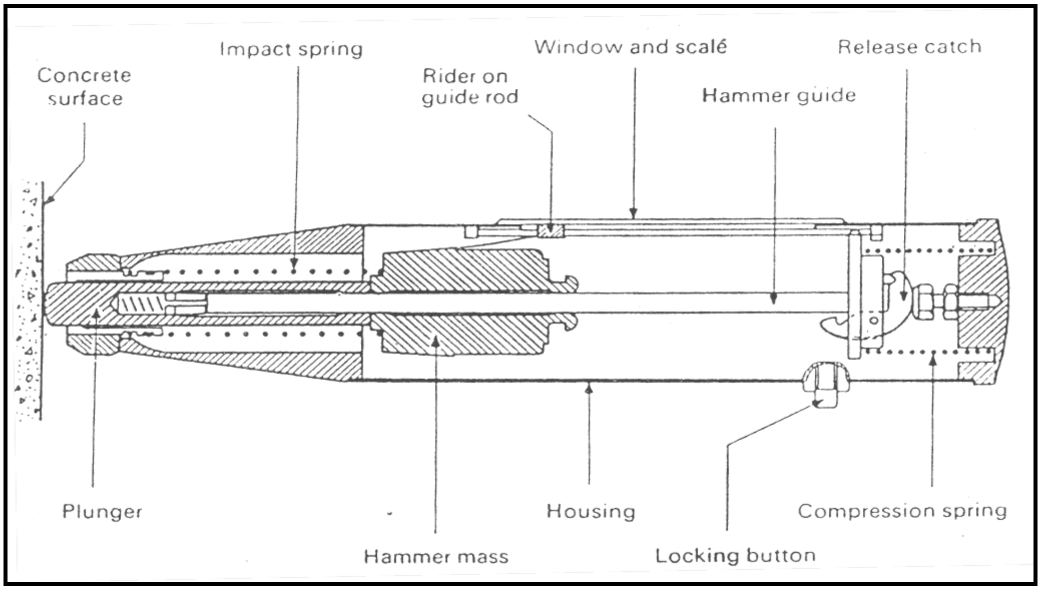
The various Non destructive / partial destructive tests are as below

Group - I A: Non Destructive Tests for Concrete

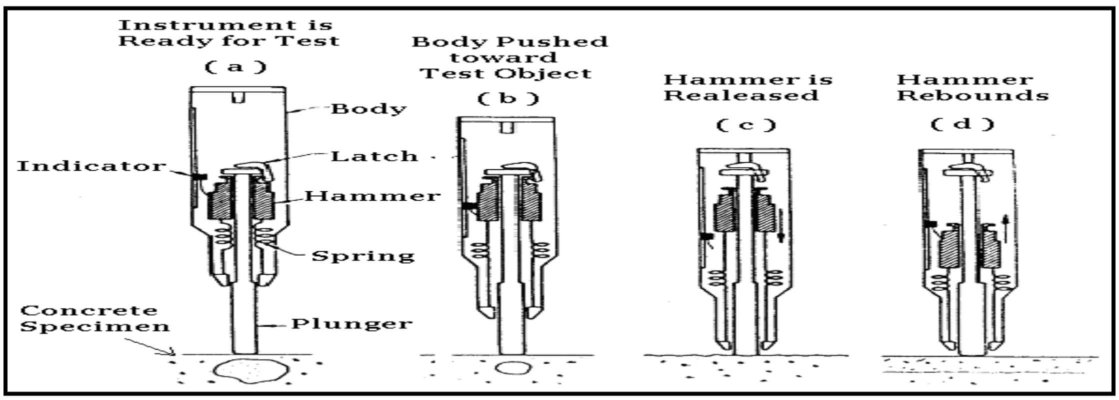
- Surface Hardness Tests – Rebound Hammer Test
- Ultrasonic Pulse Velocity Test

Group - I B: Partially Destructive Tests for Concrete

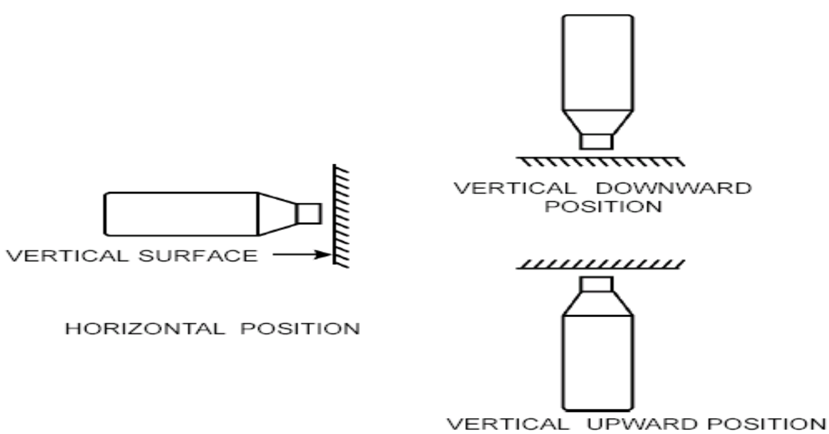
- Penetration Resistance Test (Windsor Probe)
- Pull-out Test
- Pull-off Test
- Break-off Test
- Core Cutting



Basic Features of Rebound Hammer



Schematic Cross Section of Rebound Hammer & Principle of Operation



Various positions of Rebound Hammer

Exp No: Date:

SCHMIDT'S REBOUND HAMMER TEST

AIM: Assessing the compressive strength of concrete with the help of suitable co-relations between rebound index and compressive strength

APPARATUS: Rebound Hammer

Principle of test: The test is based on the principle that the rebound of an elastic mass depends on the hardness of the surface upon which it impinges. When the plunger of the rebound hammer pressed against the surface of the concrete, the spring controlled mass rebounds and the extent of such rebound depend upon the surface hardness of concrete. The surface hardness and therefore the rebound is taken to be relation to the compressive strength of concrete. The rebound is read off along a graduated scale and is designated as the rebound number or rebound index.

Working of rebound hammer: A schematic cut way view of Schmidt rebound hammer is shown in figure. The hammer weight about 1.8 kg., is suitable for use both in a laboratory and in the field. When the plunger of rebound hammer is pressed against the surface of concrete, a spring controlled mass rebounds and the extent of such rebound depends upon the surface hardness of concrete.

The rebound distance is measured on a graduated scale and is designated as rebound number. Basically, the rebound distance depends on the value of kinetic energy in the hammer, prior to impact with the shoulder of the plunger and how much of that energy is absorbed during impact. The energy absorbed by the concrete depends on the stress-strain relationship of concrete. Thus, a low strength low stiffness concrete will absorb more energy than high strength concrete and will give a lower rebound number.

Method of testing (operation)

1. To prepare the instrument for a test, release the plunger from its locked position by pushing the plunger against the concrete and slowly moving the body away from the concrete. This causes the plunger to extend from the body and the latch engages the hammer mass to the plunger rod.

2. Hold the plunger perpendicular to the concrete surface and slowly push the body towards the test object. (The surface must be smooth, clean and dry and should preferably be formed, but if trowelled surfaced are unavoidable, they should be rubbed smooth with the carborundum stone usually provided with the equipment. Loose material can be ground off, but areas which are rough from poor compaction, grout loss, spalling or tooling must be avoided, since the results will be unreliable).

3. As the body is pushed, the main spring connecting the hammer mass to the body is stretched. When the body is pushed to the limit, the latch is automatically released and the energy stored in the spring propels the hammer mass towards the plunger tip. The mass impacts the shoulder of the plunger rod and rebounds.

4. During rebound, the slide indicator travels with the hammer mass and records the rebound distance. A button on the side of the body is pushed to lock the plunger in the retracted position and the rebound number is read from the scale.

   The test can be conducted horizontally, vertically upward or downward or at any intermediate angle. Due to different effects of gravity on the rebound as the test angle is changed, the rebound number will be different for the same concrete. This will require separate calibration or correction charts, given by the manufacturer of the hammer.

Factors affecting rebound number

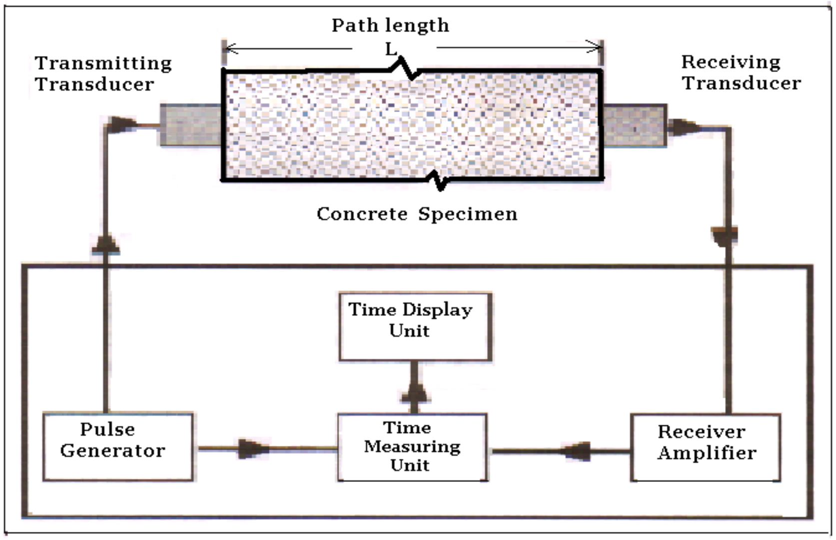
The results of Schmidt rebound hammer are significantly influenced by the following factors

(a) Smoothness of Test Surface
(b) Size, Shape and Rigidity of the Specimen
(c) Age of Test Specimen
(d) Moisture Condition
(e) Type of Coarse Aggregate
(f) Type of Cement
(g) Type of Mould
(h) Surface Carbonation

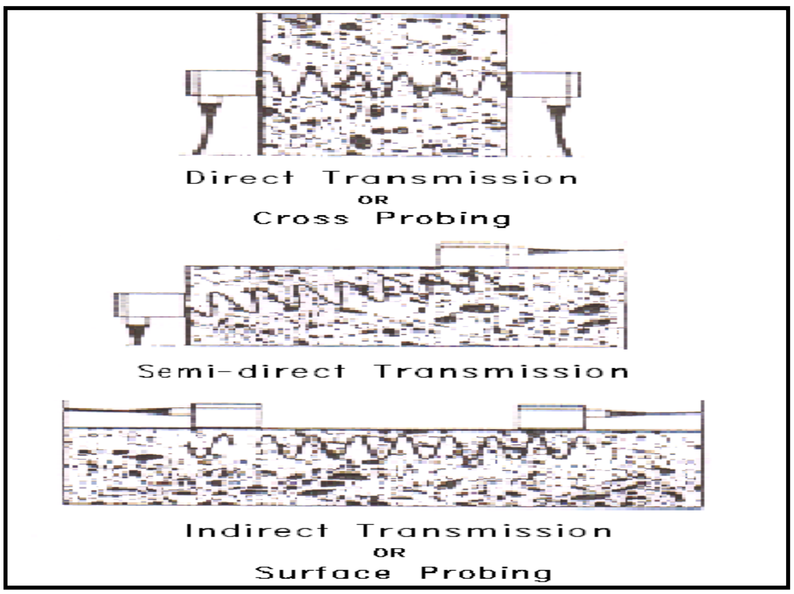
Influence of these factors has different magnitudes. Hammer orientation will also influence the measured values, although correction factors can be used to allow for this effect.

Precautions to be taken while using rebound hammer: The following precautionary measuresare taken while using the rebound hammer which may give rise to minimize error

- The surface on which the hammer strikes should be smooth and uniform. Moulded faces in such cases may be preferred over the Trowelled faces.
- The test hammer should not be used within about 20 mm from the edge of the specimen.
- Rebound hammer should not be used over the same points more than once.
- The rebound test must be conducted closely placed to test points; on at least 10 to 12 locations while taking the average extremely high and low values of the index number should be neglected.



Schematic Diagram of Ultrasonic Pulse Velocity Method



Different Methods of Propagating Ultrasonic Pulses through Concrete

Table: Velocity Criteria For Concrete Quality Grading As per Table 2 of IS 13311 (Part1): 1992

Sr. No.	Pulse Velocity by Cross Probing (km/sec)	Concrete Quality Grading
1.	Above 4.5	Excellent
2.	3.5 to 4.5	Good
3.	3.0 to 3.5	Medium
4.	Below 3.0	Doubtful

Exp No: Date:

NON-DESTRUCTIVE TESTING OF CONCRETE BY ULTRASONIC PULSE VELOCITY METHOD

AIM: The main objects of the ultrasonic pulse velocity method are to establish

- The Homogeneity of the Concrete
- The Quality of the Concrete in Relation to the Specified Standard Requirements.

APPARATUS: Electrical pulse generator,Transducer - one pair,Amplifier andElectronic timing device.

Principle: This is one of the most commonly used method in which the ultrasonic pulses generated by electro-acoustical transducer are transmitted through the concrete. In solids, the particles can oscillate along the direction of sound propagation as longitudinal waves or the oscillations can be perpendicular to the direction of sound waves as transverse waves. When the pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. This transducers convert electrical signals into mechanical vibrations (transmit mode) and mechanical vibration into electrical signals (receive mode). The travel time is measured with an accuracy of +/- 0.1 microseconds.

The velocity and strength of concrete are directly related. The common factor is the density of concrete; a change in the density results in a change in a pulse velocity, likewise for a same mix with change in density, the strength of concrete changes. Thus lowering of the density caused by increase in water-cement ratio decreases both the compressive strength of concrete as well as the velocity of a pulse transmitted through it.

Pulse Velocity method is a convenient technique for investigating structural concrete. The underlying principle of assessing the quality of concrete is that comparative higher velocities are obtained when the quality of concrete in terms of density, homogeneity and uniformity is good. In case poorer quality of concrete, lower velocities are obtained. If there is a crack, void or flaw inside the concrete which comes in the way of transmission of the pulses, the pulse strength is attenuated and it passes around the discontinuity, thereby making path length longer. Consequently, lower velocities are obtained.

Transducer

Any suitable type of transducer operating within the frequency Lange of 20 kHz to 150 kHz as in following Table may be used. Piezoelectric and magneto-strictive types of transducers may be used, the latter being more suitable for the lower part of the frequency range.

Natural Frequency of Transducers for Different Path Lengths

Path Length, mm	Natural Frequency Minimum Transverse of Transducer, kHz	Dimensions of Members, mm
Upto 500	150	25
500-700	>60	70
700-1500	>40	150
Above 1500	> 20	300

There are three possible ways of measuring pulse velocity through concrete:

a. **Direct Transmission (Opposite faces) through Concrete**: In this method transducers are held on opposite face of the concrete specimen under test as shown in fig. The method is most commonly used and is to be preferred to the other two methods because this results in maximum sensitivity and provides a well defined path length.

b. **Semi-direct Transmission (Adjacent faces) through Concrete:**Sometimes one of the face of the concrete specimen under test is not accessible, in that case we have to apply semi-direct method as shown in fig. In this method, the sensitivity will be smaller than cross probing and the path length is not clearly defined.

c. **Indirect Transmission (Surface or Same face Probing) through Concrete:**This method of pulse transmission is used when only one face of concrete is accessible. Surface probing is the least satisfactory of the three methods because the pulse velocity measurements indicate the quality of concrete only near the surface and do not give information about deeper layers of concrete. The weaker concrete that may be below a strong surface can not be detected. Also in this method path length is less well defined. Surface probing in general gives lower pulse velocity than in the case of cross probing and depending on number of parameters.

Determination of pulse velocity:

A pulse of longitudinal vibration is produced by an electro-acoustical transducer, which is held in contact with one surface of the concrete member under test. After traversing a known path length (L) in the concrete, the pulse of vibration is converted into an electrical signal by a second electro-acoustical transducer and electronic timing circuit enable the transit time (T) of the pulse to be measured. The pulse velocity (V) is given by

V = L / T

Where,

V = Pulse velocity

L = Path length

T = Time taken by the pulse to traverse the path length

Interpretation of Results:

The ultrasonic pulse velocity of concrete can be related to its density and modulus of elasticity. It depends upon the materials and mix proportions used in making concrete as well as the method of placing ,compacting and curing of concrete. If the concrete is not compacted thoroughly and having segregation, cracks or flaws, the pulse velocity will be lower as compare to good concrete, although the same materials and mix proportions are used. The quality of concrete in terms of uniformity can be assessed using the guidelines as per Table 2 of IS 13311 (Part1): 1992:

Results:

SELF COMPACTING CONCRETE

Self compacting concrete is concrete that is able to flow under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without segregation, whilst maintaining homogeneity.

Application Area

Self compacting concrete may be used in precast applications or for concrete placed on site. It can be manufactured in a site batching plant or in a ready mix concrete plant and delivered to site by truck. It can then be placed either by pumping or pouring into horizontal or vertical structures. In designing the mix, the size and the form of the structure, the dimension and density of reinforcement and cover should be taken in consideration.

Characteristics of Fresh Self Compacting Concrete

The level of fluidity of self compacting concrete is governed chiefly by the dosing and type of superplasticizer. Due to the high fluidity of self compacting concrete, the risk of segregation and blocking is very high. Preventing segregation is therefore an important feature of the control regime. The tendency to segregation can be reduced by the use of a sufficient amount of fines (e 0.125 mm), or using a Viscosity Modifying Admixture (VMA).

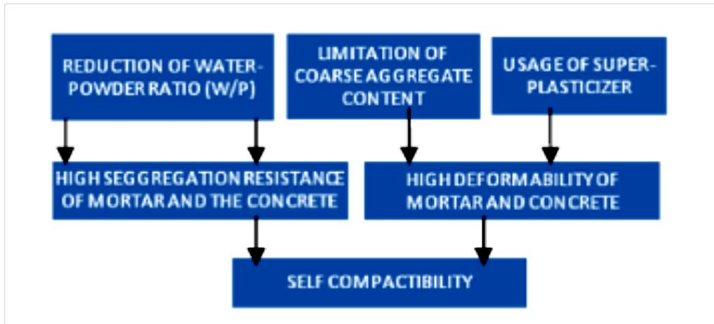
Features of fresh self compacting concrete

a) Slump about 600 mm

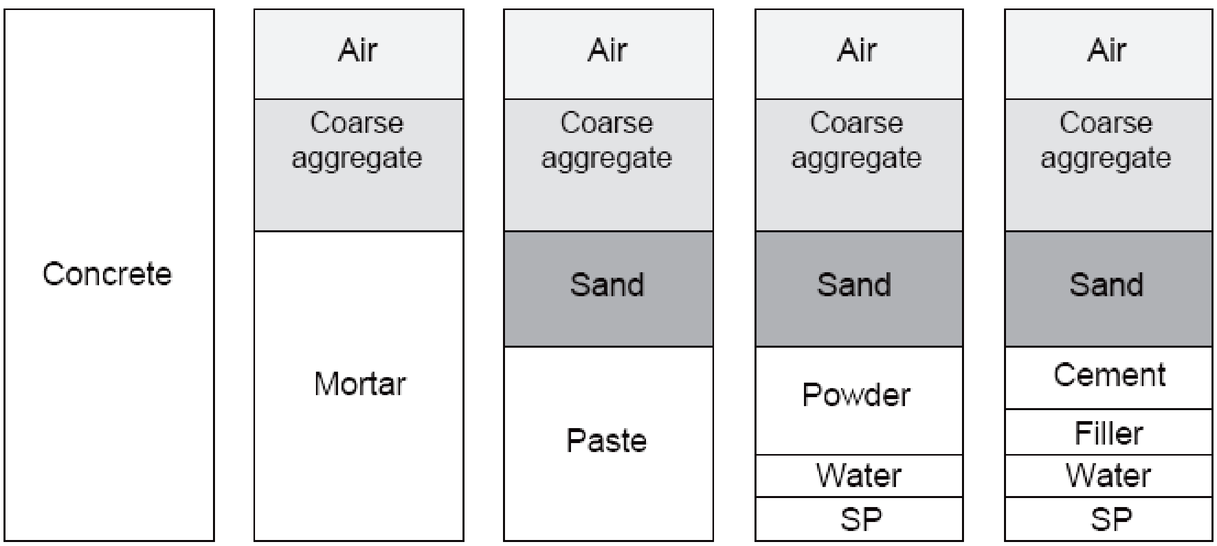
b) Use of Viscosity Modifying Admixture

c) Segregation resistance

For performing various experiments such as Slump-Test, V-funnel Test, L-Box Test and Compressive and tensile Strength Test for self compacting concrete. Lets take a Mix proportion of M-30 Grade. The ingredients for self-compacting concrete are similar to conventional concrete. It consists of cement, coarse and fine aggregates, water, mineral and chemical admixtures. Similar to conventional concrete, SCC can also be affected by the physical characteristics of materials and mixture proportioning. A rational mix design method for self compacting concrete using a variety of materials is necessary. The coarse and fine aggregate contents are fixed so that self-compact ability can be achieved easily by adjusting water-powder ratio, super plasticizer dosage. Moulds without any need for vibration and compaction during the pouring process. It can be used in pre-cast applications or for concrete placed on site. SCC results in durable concrete structures, and saves labour and consolidation noise.

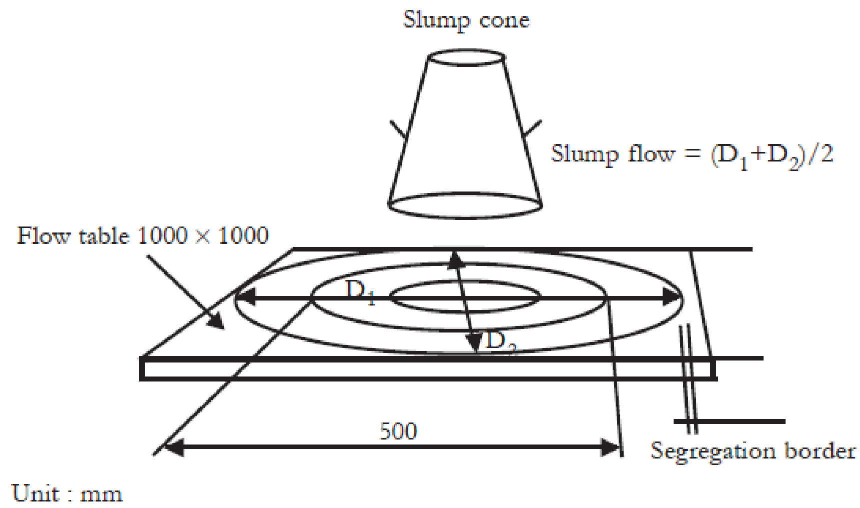


Basic principles for production of self-compacting concrete



Schematic Composition of SCC

At the stage before solidification, self-compacting concrete is required to have three qualities: high-flowabilityresistance against segregation and possibility, i.e, ability that is necessary to pass the space between reinforcing bars. Other additional properties, such as, washout resistance and finishability, may be significant and specified for individual projects/applications. Therefore, it is important to test whether the concrete is selfcompactable or not and also to evaluate deformability or viscosity for estimating proper mix proportioning if the concrete does not have sufficient selfcompactability. The existing procedures for self-compacting characteristics are those, which measure height differences at different points under free flow and also resistance against blocking.



Slump flow test

$$\textbf{Flow \%} = \frac{Diameter\ of\ flow\ (cm) - 25}{25} \times 100$$

Percent of Flow	**0 – 20 %**	**20 – 60 %**	**60 – 100 %**	**100 – 120 %**	**120 – 150 %**
Consistency	Dry	Stiff	Plastic	Wet	Sloppy

Exp No: Date:

Flow Test

Aim:

The flow table test or flow test is a method to determine the consistence of fresh concrete.

Equipment:

- Flow table with a grip and a hinge, 70 cm x 70 cm.
- Abrams cone, open at the top and at the bottom - 30 cm high, 17 cm top diameter, 25 cm base diameter
- Water bucket and broom for wetting the flow table.
- Tamping rod, 60 cm height
- Scale for measurement

Principle:

This test is giving us the ability of concrete to flow under the gravitational force when poured and compacted within the cone and suddenly lifted up

The basic equipment used is the same as for theconventional Slump test. The test method differs from the conventional one in the way that the concrete sampleplaced into the mould has no reinforcement rod and when theslump cone is removed the sample collapses. The diameter of the spread of the sample is measured, ie, a horizontal distanceis measured as against the vertical slump measured in theconventional test. While measuring the diameter of the spread, the time that the sample takes to reach a diameter of 500 mm(T50) is also sometimes measured. The Slump Flow test cangive an indication about the filling ability of SCC and anexperienced operator can also detect an extreme susceptibilityof the mix to segregation.

Procedure:

1. The flow table is wetted.
2. The cone is placed on the flow table and filled with fresh concrete in two layers, each layer 25 times tamp with tamping rod.
3. The cone is lifted, allowing the concrete to flow.
4. The flow table is then lifted up several centimeters and then dropped, causing the concrete flow a little bit further.
5. After this the diameter of the concrete is measured in a 6 different direction and take the average.

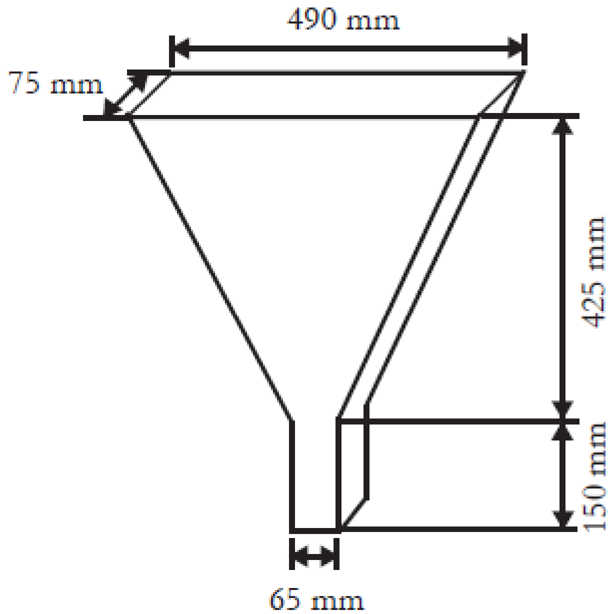


Fig. V-funnel

Exp No: Date:

V-Funnel Test

Aim: This test gives account of the filling capacity (flowability).

Equipment:

1. V-funnel, as shown in Figure 7, made of steel, with a flat, horizontal top and placed on vertical supports, and with a momentary releasable, watertight opening gate
2. Stopwatch with the accuracy of 0.1 secondfor recording the flow time
3. Straightedge for leveling the concrete
4. Buckets with a capacity of 12-14 litres for taking concrete sample
5. Moist sponge or towel for wetting the inner surface of the V-funnel

Principle:

The V-funnel test was developed in Japan and used by Ozawa, et al. The equipment consists of a V-shaped funnel. The funnel is filled with concrete and the time taken by it to flow through the apparatus measured. This test gives account of the filling capacity (flowability). The inverted cone shape shows any possibility of the concrete to block is reflected in the result.

Though the test is designed to measure flow ability, 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.

Procedure

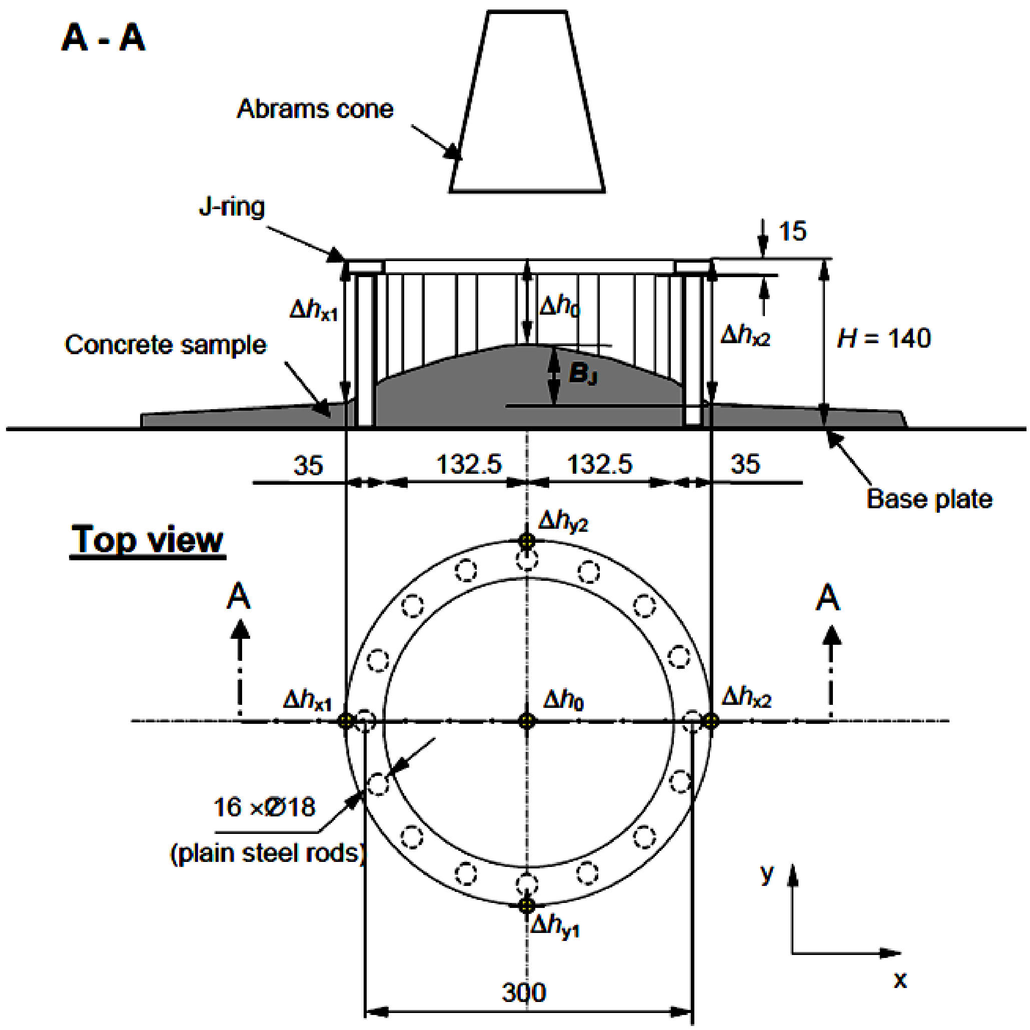
1. Place the cleaned V-funnel vertically on a stable and flat ground, with the top opening horizontally positioned
2. Wet the interior of the funnel with the moist sponge or towel and remove the surplus of water, e.g. through the opening. The inner side of the funnel should be 'just wet'.
3. Close the gate and place a bucket under it in order to retain the concrete to be passed
4. Fill the funnel completely with a representative sample of SCC without applying any compaction or rodding
5. Remove any surplus of concrete from the top of the funnel using the straightedge.

Open the gate after a waiting period of (10 ± 2) seconds. Start the stopwatch at the same moment the gate opens.

6. Look inside the funnel and stop the time at the moment when clear space is visible through the opening of the funnel. The stopwatch reading is recorded as the V-funnel flow time, noted as *t*V
7. Do not touch or move the V-funnel until it is empty.

Interpretation of result:

This test measures the ease of flow of concrete, shorter flow time indicates greater flow ability. For SCC a flow time of 10 seconds is considered appropriate. The inverted cone shape restricts the flow, and prolonged flow times may give some indication of the susceptibility of the mix to blocking. After 5 minutes of settling, segregation of concrete will show a less continuous flow with an increase in flow time.



J-Ring Test Apparatus

Exp No: Date:

J-Ring Test

Aim: The J-ring test aims at investigating both the filling ability and the passing ability of SCC.

Apparatus:J-ring, Straight rod for aligning the reference line in the measurement, with a length of about 400 mm and at least one flat side having the flexure less than 1 mm.

Procedure

1. Place the cleaned base plate in a stable and level position
2. Fill the bucket with 6~7 litres of representative fresh SCC and let the sample stand still for about 1 minute (± 10 seconds).
3. Under the 1 minute waiting period pre-wet the inner surface of the cone and the test urface of the base plate using the moist sponge or towel, and place the cone in the centre on the 200 mm circle of the base plate and put the weight ring on the top of the cone to keep it in place. (If a heavy cone is used, or the cone is kept in position by hand no weight ring is needed).
4. Place the J-ring on the base plate around the cone
5. Fill the cone with the sample from the bucket without any external compacting action such as rodding or vibrating. The surplus concrete above the top of the cone should be struck off, and any concrete remaining on the base plate should be removed
6. Check and make sure that the test surface is neither too wet nor too dry. No dry area on the base plate is allowed and any surplus of the water should be removed – the moisture state of the plate shall be 'just wet'.
7. After a short rest (no more than 30 seconds for cleaning and checking the moist state of the test surface), lift the cone perpendicular to the base plate in a single movement, in such a manner that the concrete is allowed to flow out freely without obstruction from the cone, and start the stopwatch the moment the cone loose the contact with the base plate

Precisions of the J-ring flow spread and flow time $T50_J$

J-ring flow spread S_J [mm]	**< 600**	**600 ~ 750**	**> 750**
Repeatability r [mm]	59	46	25
Reproducibility R [mm]	67	46	31
J-ring flow time $T50_J$ [sec]	**≤ 3.5**	**3.5 ~ 6**	**> 6**
Repeatability r [sec]	0.70	1.23	4.34
Reproducibility R [sec]	0.90	1.32	4.34
J-ring blocking step B_J [mm]	**≤ 20**		**> 20**
Repeatability r [mm]	4.6		7.8
Reproducibility R [mm]	4.9		7.8

8. Stop the stopwatch when the front of the concrete first touches the circle of diameter 500 mm. The stopwatch reading is recorded as the T50J value. The test is completed when the concrete flow has ceased.
9. lay the straight rod with the flat side on the top side of the J-ring and measure the relative height differences between the lower edge of the straight rod and the concrete surface at the central position (Δ*h*0) and at the four positions outside the J-ring, two (Δ*h*x1, Δ*h*x2) in the *x*-direction and the other two (Δ*h*y1, Δ*h*y2) in the *y*-direction (perpendicular to *x*)
10. Measure the largest diameter of the flow spread, d_{max}, and the one perpendicular to it, d_{perp}, using the ruler (reading to nearest 5 mm). Care should be taken to prevent the ruler from bending

Expression Of Results

The J-ring flow spread S_J is the average of diameters d_{max} and d_{perp}, S_J is expressed in mm to the nearest 5 mm

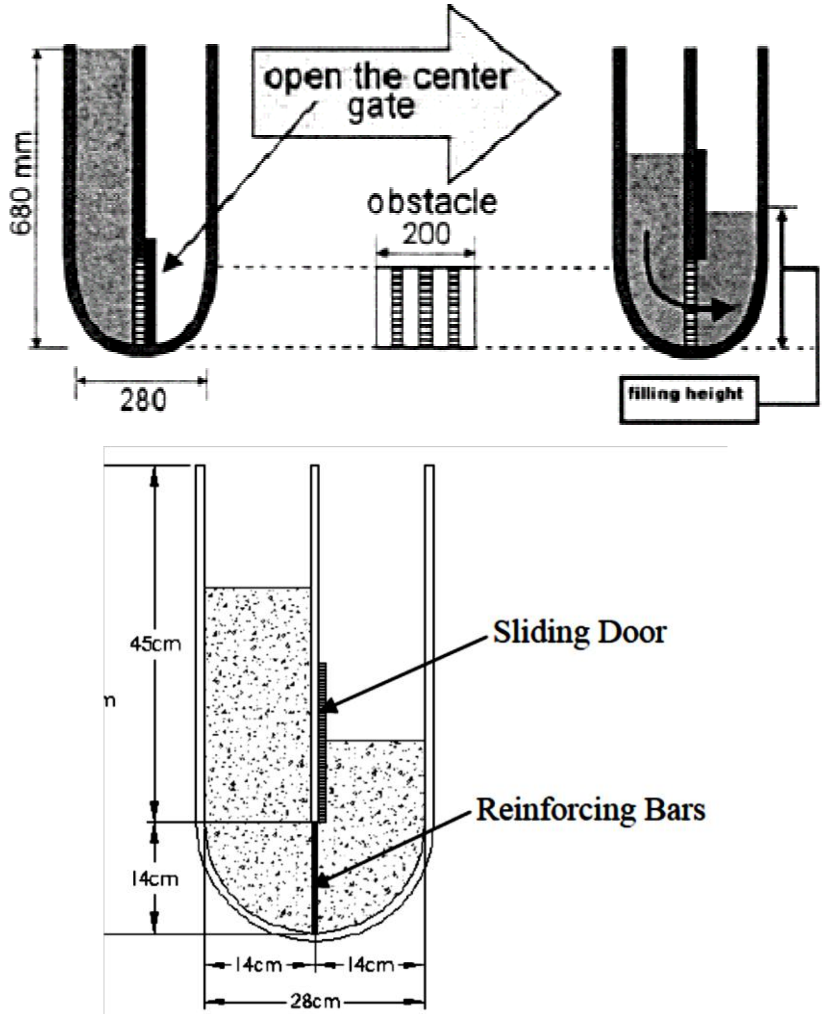
$$S_J = \frac{d_{max} + d_{perp}}{2}$$

Expression Of Results

The J-ring flow time T50J is the period between the moment the cone leaves the base plate and SCC first touches the circle of diameter 500 mm. T50J is expressed in seconds to the nearest 1/10 seconds

The J-ring blocking step *BJ* is calculated using equation and expressed in mm to the nearest 1 mm.

$$B_J = \frac{\Delta H_{x1} + \Delta H_{x2} + \Delta H_{y1} + \Delta H_{y1}}{4} - \Delta H_0$$



U-Box Test Apparatus

Exp No: Date:

U box test

Aim: The test is used to measure the filing ability of self compacting concrete

Apparatus: U box of a stiff non absorbing material**,** Scoop.Trowel, Stopwatch

The test is used to measure the filing ability of self compacting concrete. The apparatus consists of a vessel that is divided by a middle wall into two compartments; an opening with a sliding gate is fitted between the two sections. Reinforcing bar with nominal diameter of 134 mm are installed at the gate with centre to centre spacing of 50 mm. this create a clear spacing of 35 mm between bars. The left hand section is filled with about 20 liter of concrete then the gate is lifted and the concrete flows upwards into the other section. The height of the concrete in both sections is measured.

Procedure:

1. About 20 liter of concrete is needed to perform the test, sampled normally.

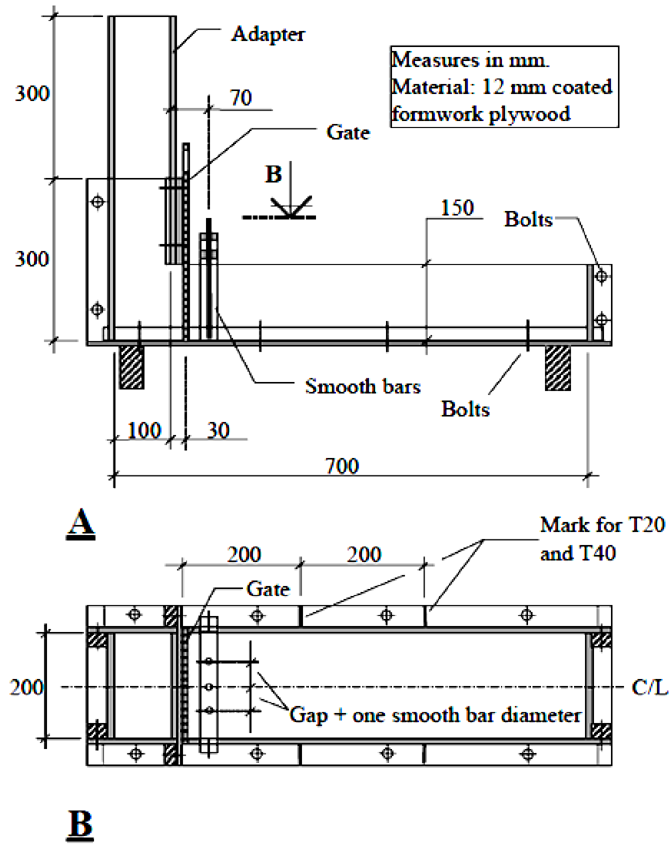
2. Set the apparatus level on firm ground, ensure that the sliding gate can open freely and then close it. Moisten the inside surface of the apparatus, remove any surplus water, fill the vertical section of the apparatus with the concrete sample.

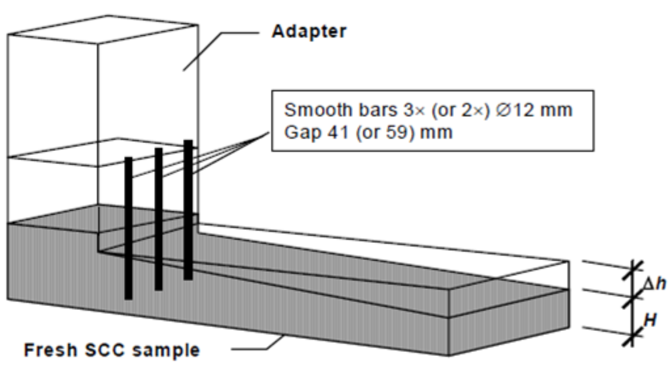
3. Leave it stand for 1 minute. Lift the sliding gate and allow the concrete to flow out into the other compartment. After the concrete has come to rest, measure the height of the concrete in the compartment that has been filled, in two places and calculate the mean (H_1).

4. Measure also the height in the other equipment (H_2). Calculate H_1-H_2, the filling height. The whole test has to be performed within 5 minutes.

Interpretation of the result:

If the concrete flows as freely as water, at rest it will be horizontal, so H_1-H_2=0. Therefore the nearest this test value, the ‘filling height’, is to zero, the better the flow and passing ability of the concrete.





Precisions of the L-box passing or blocking ratio

Passing ratio P_L	**1**	**0.9**	**0.8**	**0.7**	**< 0.65**
Blocking ratio B_L	**0**	**0.1**	**0.2**	**0.3**	**> 0.35**
Repeatability r	0.01	0.06	0.10	0.15	0.18
Reproducibility R	0.03	0.07	0.11	0.16	0.18

Exp No: Date:

L-Box Test

Aim: The method aims at investigating the passing ability of SCC.

Apparatus

- Two types of gates can be used, one with 3 smooth bars and one with 2 smooth bars. The gaps are 41 and 59 mm, respectively
- Suitable tool for ensuring that the box is level i.e. a spirit level
- Suitable buckets for taking concrete sample

Principle

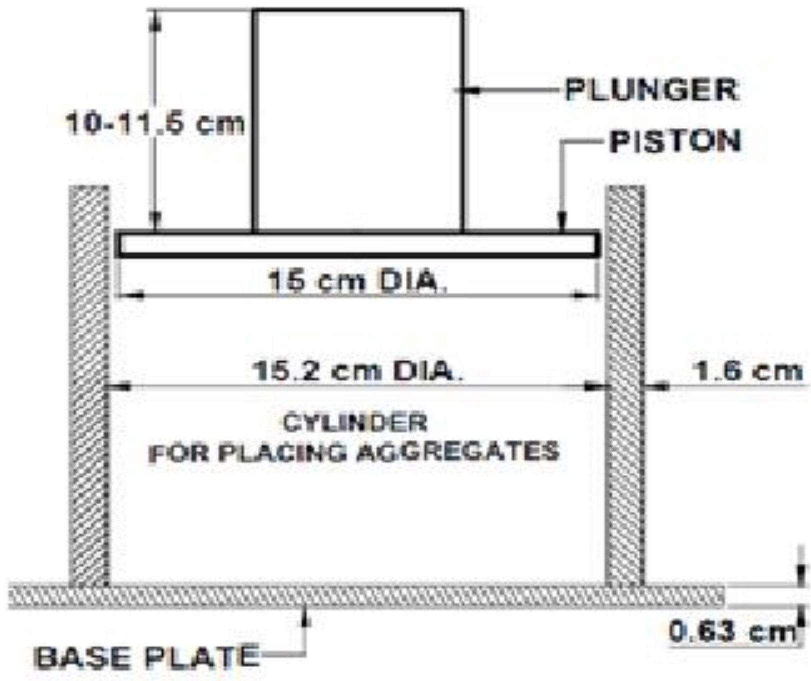
It measures the reached height of fresh SCC after passing through the specified gaps of steel bars and flowing within a defined flow distance. With this reached height, the passing or blocking behavior of SCC can be estimated.

Procedure

1. Place the L-box in a stable and level position
2. Fill the vertical part of the L-box, with the extra adapter mounted, with 12.7 liters of representative fresh SCC
3. Let the concrete rest in the vertical part for one minute (± 10 seconds). During this time the concrete will display whether it is stable or not (segregation).
4. Lift the sliding gate and let the concrete flow out of the vertical part into the horizontal part of the L-box.
5. When the concrete has stopped moving, measure the average distance, noted as Δh, between the top edge of the box and the concrete that reached the end of the box, at three positions, one at the centre and two at each side.

Expression of Results

The passing ratio PL or blocking ratio BL is calculated using equation and expressed in dimensionless to the nearest 0.01



Aggregate Crushing Test Apparatus

OBSERVATION

	Sample I	Sample II
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve= W_2gm		
Aggregate crushing = $(W_2/W_1)*100$ Value (per cent)		

Exp No: Date:

AGGREGATE CRUSHING VALUE TEST

AIM: To determine the aggregate crushing value of coarse aggregates.

APPARATUS: The apparatus of the aggregate crushing value test as per IS: 2386 (Part IV) – 1963consists of:

1. A 15cm diameter open ended steel cylinder with plunger and base plate, of the general form and dimensions as shown in Fig
2. A straight metal tamping rod of circular cross-section 16mm diameter and 45 to 60 cm long, rounded at one end.
3. A balance of capacity 3k, readable and accurate up to 1 g.
4. IS Sieves of sizes 12.5,10 and 2.36 mm
5. A compression testing machine capable of applying load up to 40tonnes. At uniform rate of 4tonnes. /minute
6. Cylindrical measure having internal dia. of 11.5cm. & height 18 cm. For measuring the sample.

THEORY: The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. Crushing value is a measure of the strength of the aggregate. The aggregates should therefore have minimum crushing value.

PROCEDURE: The test sample: It consists of aggregates sized 12.5 mm - 10.0 mm(minimum 3kg). The aggregates should be dried by heating at 100^0-110^0 C for a period of 4 hours and cooled.

1. Sieve the material through 12.5 mm and 10.0 mm IS sieve. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.
2. The cylinder of the test shall be put in position on the base-plate and the test sample added in thirds, each third being subjected to 25 strokes with the tamping rod.
3. The surface of the aggregate shall be carefully leveled.

4. The plunger is inserted so that it rests horizontally on this surface, care being taken to ensure that the plunger does not jam in the cylinder
5. The apparatus, with the test sample and plunger in position, shall then be placed between the plates of the testing machine.
6. The load is applied at a uniform rate as possible so that the total load is reached in 10 minutes. The total load shall be 40 tones.
7. The load shall be released and the whole of the material is removed from the cylinder and sieved on 2.36mm IS Sieve.
8. The fraction passing the sieve shall be weighed and recorded.

PRECAUTIONS

1. The plunger should be placed centrally & rest directly on the aggregates .Care should be taken that it does not touch the walls of the cylinder so as to ensure that the entire load ids transferred onto the aggregates.

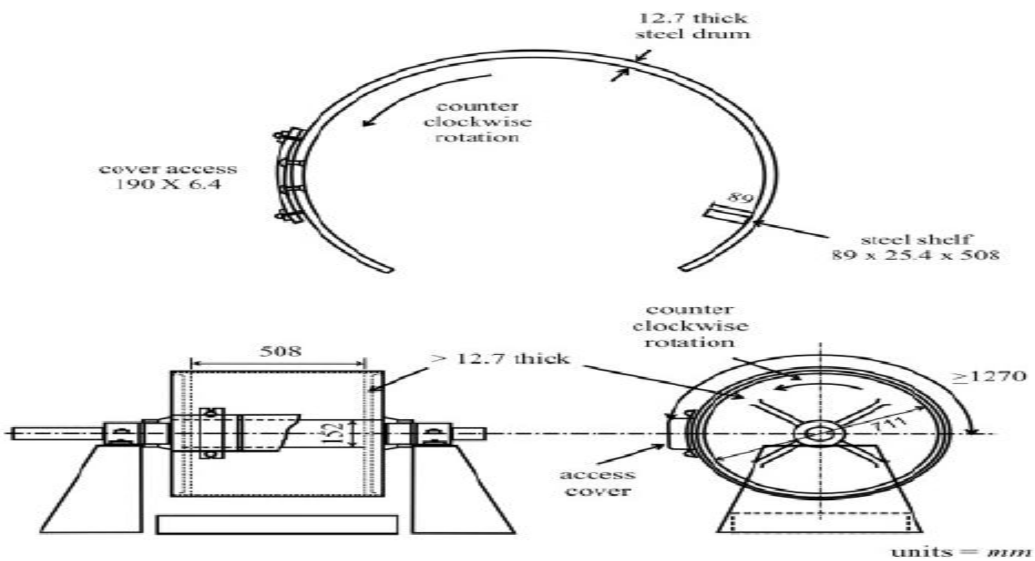
2. In the operation of sieving the aggregates through 2.36mm sieve & weighing care should be taken to avoid loss of fines. The sum of weights of fractions retained & passing the sieve should not differ from the originals weights of the specimen by more than 1gm.
3. The tamping should be done properly by gently dropping the tamping rod and not by hammering action Also the tamping should be uniform over the surface.

REPORTING OF RESULTS

The mean of the two results shall be reported to the nearest whole number as the ‘aggregate crushing value’ of the size of the material tested.

RESULT

Meanaggregate Crushing test value =



LOS ANGELES ABRASION TESTING MACHIN

OBSERVATIONS

	Sample I	**Sample II**
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 1.7 mm sieve= W_2gm		
Aggregate abrasion value = $(W_2/W_1)*100$ Value (per cent)		

Exp No: Date:

ABRASION TEST

AIM: To determine Los Angeles abrasion valueof coarse aggregates.

APPARATUS: The apparatus as per IS: 2386 (Part IV) – 1963 consists of:

a) Los Angeles Machine: It consists of a hollow steel cylinder, closed at both the ends with an internal diameter of 700 mm and length 500 mm and capable of rotating about its horizontal axis. A removable steel shaft projecting radially 88 mm into cylinder and extending full length (i.e. 500 mm) is mounted firmly on the interior of cylinder. The shelf is placed at a distance 1250 mm minimum from the opening in the direction of rotation.
b) Abrasive charge: Cast iron or steel balls, approximately 48 mm in diameter and each weighing between 390 to 445 g; 6 to 12 balls are required.
c) Sieve: The 1.70 mm IS sieve
d) Balance of capacity 5 kg or 10 kg
e) Drying oven
f) Miscellaneous like tray etc

THEORY: The abrasion value of the aggregates is determined in order to determine their resistance against wearing. In this the aggregate sample is mixed with abrasive charge consisting of six standard balls & rotated in closed inclined cylinders for specific number of revolutions. The abrasion value is then expressed as the percentage of abraded material with reference to the original weight of the test sample.

PROCEDURE: Test Sample: It consists of clean aggregates dried in oven at 105^0- 110^0C and are coarser than 1.70 mm sieve size. The sample should conform to any of the grading shown in table.

TABLE 1 GRADING OF TEST SAMPLE

Sieve size (square hole)		Weight in g of Test Sample for Grade						
Passing mm	Retained on mm	A	B	C	D	E	F	G
80	63	-	-	-	-	2500*	-	-
63	50	-	-	-	-	2500*	-	-
50	40	-	-	-	-	5000*	5000*	-
40	25	1250	-	-	-	-	5000*	5000*
25	20	1250	-	-	-	-	-	5000*
20	12.5	1250	2500	-	-	-	-	-
12.5	10	1250	2500	-	-	-	-	-
10	6.3	-	-	2500	-	-	-	-
6.3	4.75	-	-	2500	-	-	-	-
4.75	2.36	-	-		5000	-	-	-

*Tolerance of ±12 percent permitted.

1. Select the grading to be used in the test. It should be chosen such that it conforms to the grading to be used in construction, to the maximum extent possible.
2. Take 5 kg of sample for grading A, B, C or D and 10 kg for grading E, F and G.
3. Choose the abrasive charge as per Table 2.

TABLE 2 SELECTION OF ABRASIVE CHARGES

Grading	No. of Steel balls	Weight of charge, g
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 25
D	6	2500 ± 25
E	12	5000 ± 25
F	12	5000 ± 25

1. The test sample and the abrasive charge shall be placed in the Los Angles abrasion testing machine.
2. The machine is rotated at a speed of 20 to 33 rev/min for grading A, B,C and D, the machine shall be rotated for 500 revolutions; for grading E, F and G, it shall be rotated for 1000 revolutions
3. The material is discharged from the machine after the completion of the test and is sieved through 1.7 mm IS sieve.
4. The weight of the aggregate passing through 1.7mm sieve is taken and recorde

REPORTING OF RESULTS The difference between the original weight and the final weight of the test sample shall beexpressed as a percentage of the original weight of the test sample. This value is reported asthe percentage wear.

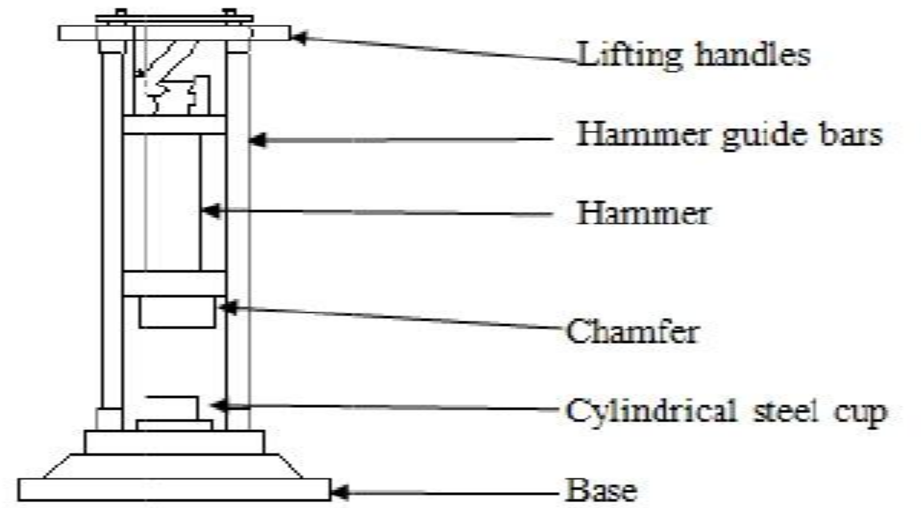
TABLE 3. MAXIMUM L A ABRASION VALUES OF AGGREGATES IN DIFFERENT TYPES OF PAVEMENT LAYERS

Sl no.	Types of pavement layer	Maximum Los Angeles Abrasion value (%)
1	Water bound macadam ,sub-base course	60
2	i) WBM base course with bituminous surfacing ii) Bituminous macadam base course iii) Built-up spray grout base course	50
3	i) WBM surfacing course ii) Bituminous macadam binder course iii) Bituminous penetration macadam iv) Built-up spray grout binder course	40
4	i) Bituminous carpet surface course ii) Bituminous surface dressing, single or two coats iii) Bituminous surface dressing, using pre-coated aggregates	35
5	i) Bituminous concrete surface course ii) Cement concrete pavement surface course	30

RESULT: Mean Los Angeles Abrasion value =

STANDARD RESULTS: The suitability of aggregate is adjudged, dependent upon its proposed used in the pavement layers. The table below shows the specified limits of present aggregate crushing value, for different types of road construction.

Sl.no.	Type of Road construction	Aggregate crushing value not more than
1.	Flexible Pavements a) Soiling b) Water –Bound- Macadam c) Bituminous macadam d) Bituminous surface- dressing or thin premix carpet Dense- mix carpet	 50 40 40 30
2.	Rigid Pavements a) Other than wearing course b) Surface wearing course	 45 30



AGGREEGATE IMPPACT TESTING MACCHINE

	Sample I	Sample II
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve= W_2gm		
Aggregate impact = $(W_2/W_1)*100$ Value (per cent)		

Exp No: Date:

AGGREGATE IMPACT TEST

AIM: To determine the impact value of the road aggregates

APPARATUS: The apparatus consists of an impact testing machine, a cylindrical measure tamping rod, IS sieve balance and oven.

a) ***Impact testing machine:*** The machine consists of a metal base with a plane lower surface supported well on a firm floor, without rocking. A detachable cylindrical steel cup of internal diameter 10.2 cm and depth 5 cm is rigidly fastened centrally to the base plate. A metal hammer of weight between 13.5 and 14.0 kg having the lower end cylindrical in shape 10 cm in diameter and 5 cm long, with 2 mm chamber at the lower edge is capable of sliding freely between vertical guides, and fall concentric over the cup. There is an arrangement for raising the hammer and allowing it to fall freely between vertical guides from a height of 38 cm on the test sample in the cup, the height of fall being adjustable upto 0.5 cm. A key is provided for supporting the hammer while fastening or removing the cup.

(b) Measure: A cylindrical metal measure having internal diameter 7.5 cm and depth cm for measuring aggregates.

(c) Tamping rod: A straight metal tampingrod of circular cross section, 1 cm in diameter and 23 cm long, rounded at one end.

(d) Sieve: IS sieve of sizes 12.5 mm, 10 mm and 2.36 mm for sieving the aggregates

(e) Balance: A balance of capacity Dot less than 500 g to weigh accurate upto 0.1 g.

(f)Oven: A thermostatically controlled drying oven capable of maintaining constant temperature between 100°C and 110°C.

PROCEDURE:

The test sample: It consists of aggregates sized 12.5 mm - 10.0 mm. The aggregate should be dried by heating at 10000-1100C for a period of 4 hours and cooled.

1. Sieve the material through 12.5 mm and 10.0 mm IS sieve the aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.
2. Pour the aggregates to fill about 1/3rdd depth of measuring cylinder.
3. Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.
4. Add two more layers in similar manner, so that cylinder is full.
5. Strike off the surplus aggregates.
6. Determine the net weight of the aggregates to the nearest gram (W1).
7. Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.
8. Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.
9. Raise the hammer until its lower face is 380 mm above the surface of the aggregate sample in the cup and allow it to fall freely on the aggregate sample. Give 15 such blows at an interval of not less than one second between successive falls.
10. Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm ($W_{2)}$. Also weigh the fraction retained in the sieve.
11. Note down the observations in the Performa and compute the aggregate impact value. The mean of two observations, rounded to nearest whole number is reported as the Aggregate Impact Value.

PRECAUTIONS:

1. Place the plunger centrally so that it falls directly on the aggregate sample and does not touch the walls of the cylinder in order to ensure that the entire load is transmitted on to the aggregates.
2. In the operation of sieving the aggregates through 2.36 mm sieve the sum of weights of fractions retained and passing the sieve should not differ from the original weight of the specimen by more than 1 gm.
3. The tamping is to be done properly by gently dropping the tamping rod and not by hammering action. Also the tampering should be uniform over the surface of the aggregate taking care that the tamping rod does not frequently strike against the walls of the mould.

REPORTING OF RESULTS

The mean of the two results shall be reported to the nearest whole number as the aggregate impact value of the tested material.

Aggregate impact value is used to classify the stones in respect of their toughness property as indicated below in Table 1

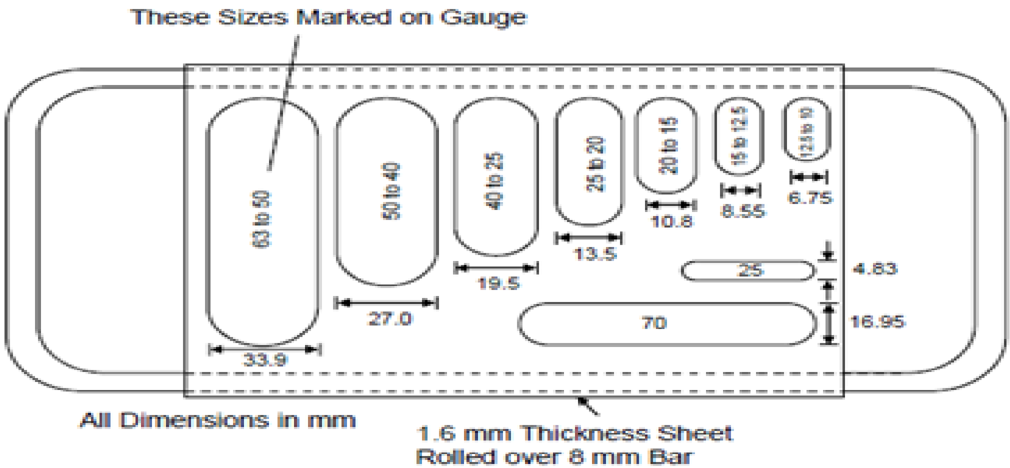
Table 1: Classification of aggregate based on aggregate impact value

Aggregate impact value (%)	Quality of aggregate
< 10	Exceptionally strong
10 – 20	Strong
20 – 30	Satisfactory for road surfacing
>35	Weak for road surfacing

Table 2: Maximum allowable impact values of aggregate in different types of Pavement material/ layers

Sl.No	Types of pavement material /layer	Aggregate impact value (%)
1	Water bound macadam, sub-base course	50
2	Cement concrete, base course	45
3	i) WBM base coarse with bitumen surfacing ii) Built-up spray grout, base course	40
4	Bituminous macadam, base course	35
5	i) WBM, surfacing course ii) Built-up spray grout, surfacing course iii) Bituminous penetration macadam iv) Bituminous surface dressing v) Bituminous macadam, binder course vi) Bituminous carpet vii) Bituminous/Asphaltic concrete viii) Cement concrete, surface course	30

RESULT =



Thickness Gauge

CALUCULATIONS

Flakiness index= $100 * \frac{w}{W} \%$

Where, ***w*** is the weights of material passing the various thickness gauges and **W** is the total weights of aggregate passing and retained on the specified sieves.

SIZE OF AGGREGATE (mm)		THICKNESS	LENGTH
Passing through IS sieve	Retained on IS sieve	THICKNESS GAUGE(mm)	LENGTH GAUGE(mm)
63	50	33.90	-
50	40	27.00	81.0
40	31.5	19.50	58.5
31.5	25	16.95	-
25	20	13.50	40.5
20	16	10.80	32.4
16	12.5	8.55	25.6
12.5	10	6.75	20.2
10	6.3	4.89	14.7

Dimensions of Thickness and Length gauge

*This dimension is equal to 0.6 times the mean sieve size.

This dimension is equal to 1.8 times the mean sieve size.

Exp No: Date:

SHAPE TEST

A. FLAKINESS INDEX

AIM: This method of test lays down the procedure for determining the flakiness index of the coarse aggregate.

APPARATUS The apparatus shall consist of the following:

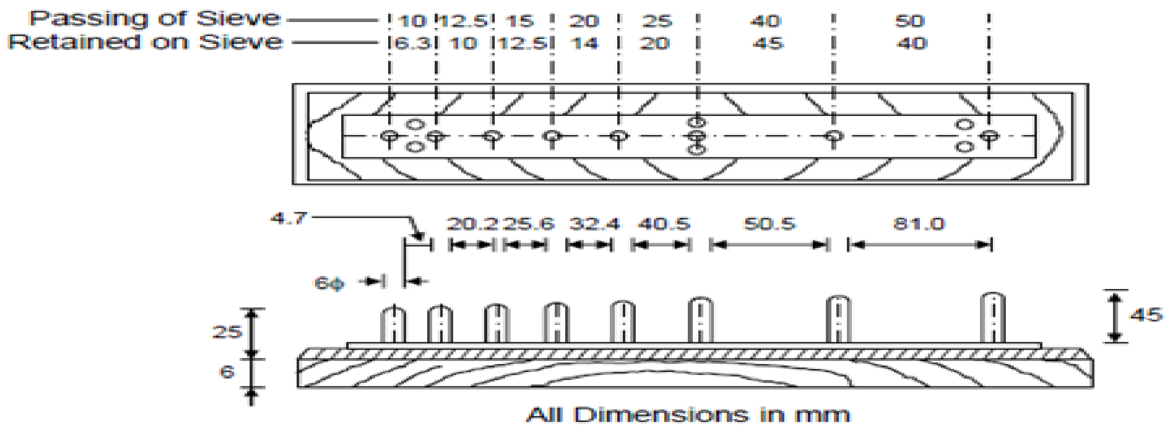
1) A balance – The balance shall be of sufficient capacity and sensitivity and shall have an accuracy of 0.1 percent of the weight of the test sample
2) Metal Gauge – The metal gauge shall be of the pattern as shown in Fig
3) Sieves – The sieves of sizes as shown in Table

PRINCIPLE The flakiness index of an aggregate is the percentage by weight of particles in it whose leastdimension (thickness) is less than three-fifths of their mean dimension. The test is notapplicable to sizes smaller than 6.3mm.

PROCEDURE

1. A quantity of aggregate shall be taken sufficient to provide the minimum number of200 pieces of any fraction to be tested.
2. The sample shall be sieved with sieves specified in Table
3. Then each fraction shall be gauged in turn for thickness on a metal gauge of the pattern shown in Fig 4 or in bulk on sieves having elongated slots. The width of the slot used in the gauge or sieve shall be of the dimensions specified in column 3 of Table for the appropriate size of material.
4. The total amount of aggregate passing the gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

RESULT=



Length Gauge

CALUCULATIONS

Elongation index= $100 * \frac{x}{W}\%$

Where,***x***is the weight of materials retained on specified gauges and **W** is the total weights of aggregate passing and retained on the specified sieves.

B. ELONGATION INDEX

AIM: This method of test lays down the procedure for determining the elongation index of the coarse aggregate.

APPARATUS

a) The apparatus shall consist of the following:
b) A balance – The balance shall be of sufficient capacity and sensitivity and shall have an accuracy of 0.1 percent of the weight of the test sample
c) Metal Gauge – The metal gauge shall be of the pattern as shown in Fig
d) Sieves – The sieves of sizes as shown in Table

THEORY The elongation index of an aggregate is the percentage by weight of particles in it whose greatest dimension (thickness) is greater than one and four-fifths of their mean dimension. The test is not applicable to sizes smaller than 6.3mm.

PROCEDURE

1. A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
2. The sample shall be sieved with sieves specified in Table
3. Each fraction shall be gauged in turn for length on a metal gauge of the pattern shown in Fig. The gauge length used shall be of the dimensions specified in column 4 of Table for the appropriate size of material.
4. The total amount of aggregate retained by the length gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample

RESULT

C.ANGULARITY NUMBER

Aim - This method of test lays down the procedure for determining the angularity number of coarse aggregate.

Apparatus - The apparatus shall consist of the following:

1**. Metal Cylinder**-A metal cylinder closed at one end and of about 3 litres capacity, the diameter and height of which shall be approximately equal, for example 15 cm and 15 cm. The cylinder shall be made from metal of thickness not less than 3 mm and shall be of sufficient rigidity to retain. its shape under rough usage.
2.Tamping Rod - A straight metal tamping rod of circular crosssection of 16 mm diameter and 60 cm long, rounded at one end.
3.Balance -Balance or scale of capacity 10 kg readable to one gram.
4. Scoop - A metal scoop approximately 20 x 12 x 5 cm, that is, about 1-litre heaped capacity.

Preparation of the Test Sample - The amo.unt of aggregate available shall be sufficient to provide, after separation on the appropriate pair of sieves, at least 10 kg of the predominant size, as determined by the sieve analysis on the 20-mm, 16-mm, 12*5-inm; lo-mm, 6.3-mm and 4.75~mm IS Sieves.

The test sample shall consist of aggregate retained between the appropriate pair of IS Sieves (square mesh) from the following sets:

20-mm and 16-mm
16-mm and 12.5-mm
12.5-mm and 10-mm
10-mm and 6.3-mm
6.3-mm and 4.75-mm

1. The aggregate is compacted in three layers, each layer being given 100 blows using the standard tamping rod at a rate of 2 blows/second by lifting the rod 5 cm above the surface of the aggregate and then allowing it to fall freely.

2. The blows are uniformly distributed over the surface of the aggregate.

3. After compacting the third layer, the cylinder is filled to overflowing and excess material is removed off with temping rod as a straight edge.

4. The aggregate with cylinder is then weighed. Three separate determinations are made and mean weight of the aggregate in the cylinder is calculated.

Results - The angularity number shall be expressed to the nearest whole number.________

CALCULATION

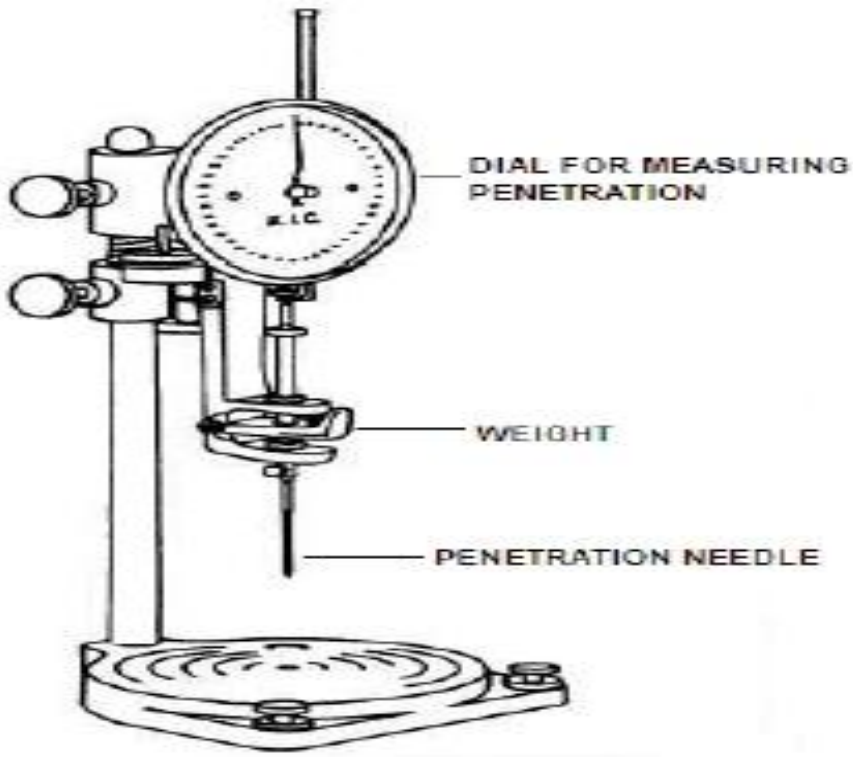
$$Angularity\ Number = 67 - \frac{100\,W}{CG_s}$$

WHERE,

W = mean weight of the aggregate filling cylinder.

C = weight of water required to completely fill the cylinder (i.e. volume of cylinder)

GS = specific gravity of the aggregate



Penetrometer

OBSERVATIONS & CALCULATIONS:

SL. No.	Particulars	Test 1	Test 2	Test 3
1.	Penetrometer Dial reading a) Initial			
	b) Final			
2.	Penetration Value			
	Mean Penetration Value =			

Exp No: Date:

PENETRATION TEST

AIM: To determine the consistency of bituminous material

APPARATUS:

a) **Container A** flat bottomed cylindrical metallic dish 55 mm in diameter and 35 mm in depth is required. If the penetration is of the order of 225 or more deeper dish of 70 mm diameter and 45 mm depth is required.
b) **Needle**: A straight, highly polished, cylindrical hard steel rod, as per standard dimensions
c) **Water bath**-A water bath maintained at 25 ± 0.1^{0}Ccontaining about 10ltrs. Of water. The sample being immersed to a depth not less of than 100mm from the top & supported on a performed shell not less than from the bottom of the bath.
d) **Transfer dish or tray**: It should provide support to the container and should not rockthe container. It should be of such capacity as to completely immerse the containerduring the test.
e) **Penetration apparatus**: It should be such that it will allow the needle to penetrate without much friction and is accurately calibrated to give results in one tenth of a millimeter
f) **Thermometer**: Range 0- 440 C and readable up to 0.20C
g) **Time measuring device**: With an accuracy ± 0.1 sec

THEORY

Penetration value is a measurement of hardness or consistency of bituminous material. It is the vertical distance traversed or penetrated by the point of a standard needle in to the bituminous material under specific conditions of load, time, and temperature. This distance is measured in one tenth of a millimeter. This test is used for evaluating consistency of bitumen. It is not regarded as suitable for use in connection with the testing of road tar because of the high surface tension exhibited by these materials and the fact that they contain relatively large amount of free carbon.

STANDARDS

The Indian Standards Institution has classified paving bitumen available in this country into the following six categories depending on the penetration values. Grades designated ‘A’ (such as A 35) are from Assam Petroleum and those designated ‘S’ (such as S 35) are from other sources.

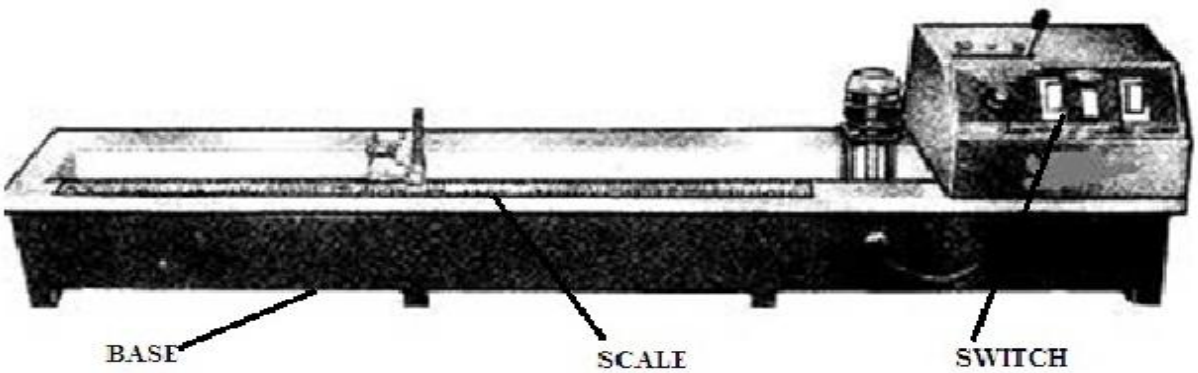
Bitumen Grade	A25	A 35 & S 35	A 45 & S 45	A 65 & S 65	A 90 & S 90	A 200 & S 200
Penetration Value	20 to 30	30 to 40	40 to 50	60 to 70	80 to 100	175 to 225

PROCEDURE:

1. Preparation of test specimen- Soften the material to a pouring consistency at a temperature not more than 60^0C for tars and 90^0C for bitumen's above the approximate softening point and stir it thoroughly until it is homogeneous and is free from air bubbles and water. Pour the melt into the container to a depth at least 10mm in excess of the excepted penetration. Protect the sample from dust and allow it to cool in an atmosphere at a temp. Between 15^0C to 30^0C for an hour. Then place it along with the transfer dish in the water bath at 25^0C ±0.1^0C & aloe it remain for one to one and half hour. The test is carried out at 25^0C ±0.1^0C unless otherwise stated.
2. Fill the transfer dish water from the water bath to depth sufficient to cover the container completely. Place the sample in it and put it upon the sand of the penetration apparatus.
3. Clean the needle with benzene, dry it load with the weight, the total moving load required is 100±0.25gms. Including the weight of the needle, carrier, and superimposed weights.
4. Adjust the needle with to make contact with surface if the sample. This may be done by placing the needle point in contact with its image reflected by the surface of the bituminous material.
5. Make the pointer of the dial to read zero or note the initial dial reading.
6. Release the needle for exactly 5 sec.
7. Adjust the penetration machine to measure the distance penetrated.
8. Make at least 3 readings at points on the surface of the sample not less than 10mm apart and not less than 10mm from the side of the dish, after each test return the sample and transfer dish to the water bath & wash the needle. Clean with benzene& dry it in case of material of penetration greater then 225,3 determinations on each of the 2 identical test specimens using a separate needle for each determine should be made, leaving the needle in the sample on completion of each determinations to avoid disturbance of the specimen.

RESULT

Briquette Mould



Ductility Testing Machine

OBSERVATIONS AND CALCULATION:

Sl.no	Particulars	Briquette mould no.		
		1	2	3
1	Initial reading = a =			
2	Final reading = b =			
3	Ductility in cms = b =			

Exp No: Date:

DUCTILITY TEST

AIM: To measure the ductility of a given sample of bitumen.

APPARATUS

a) **Briquette mould:** It is made up of brass with the shape as shown in fig. The ends b &b are known as clips and the parts a & a as sides of the mould, the dimensions of the mould shall be such that when properly assembled it will form a briquette specimen having the following dimensions.
   a. Total length 75.0±0.5mm
   b. Distance between clips 30.0±0.3mm
   c. Width at mouth of clip 20.0±0.2mm
   d. Width at min. cross section
   e. (Half way between clips) 10.0±0.1mm
   f. Thickness through h out 10.0±0.1mm

b) **Water bath:** The water bath must have a thermostat maintained with in ±0.1^{0}C of the specified test temperature it should contain 10ltrs. Of water. The specimen is to be immersed up to a depth of not less than 100mm being supported on a perforated shelf of about 50mm from the bottom of the bath.

c) **Testing machine:** For pulling a briquette of bituminous material apart, any apparatus may be used which is so constructed that the specimen will be continuously immersed in water while the two clips of pulled apart horizontally at a uniform specific a speed. It also must have suitable arrangements for stirring water to attain uniform temperature.

THEORY

The ductility test gives a measure of adhesive property of bitumen and its ability to stretch. In a flexible pavement design, it is necessary that binder should form a thin ductile film around the aggregates so that the physical interlocking of the aggregates is improved. Binder material having insufficient ductility gets cracked when subjected to repeat traffic loads and it provides pervious pavement surface. Ductility of a bituminous material is measured by the distance in centimeters to which it will elongate before braking when two ends of standard briquette specimen of the material are pulled apart at a specified speed and at a specified temperature.

The suitability of bitumen is judged, depending upon its type and proposed use. Bitumen with low ductility value may get cracked especially in cold water. ISI has specified following values of min. ductility for various grades of bitumen as follows.

Source of paving bitumen and penetration grade	Minimum ductility value in cms.
Assam petroleum A 25	5
A 35	10
A 45	12
A65, A90 & A200	15
Bitumen from sources other than Assam petroleum	
S35	50
S45,S65,S90	75

COMMENTS

PROCEDURE

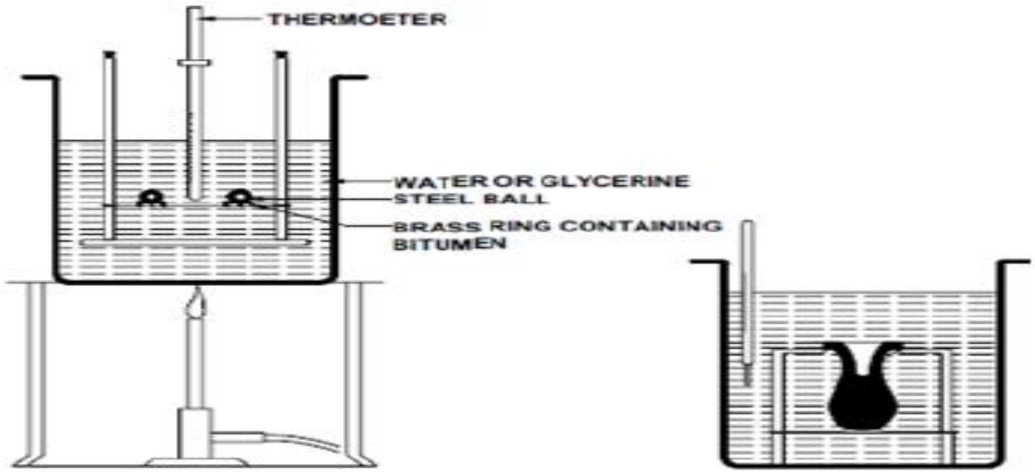
Preparation of test specimen: The test specimen is prepared by melting the bituminous material by a temperature 75^{0}C to 100^{0}C approximate. Above the softening point until it becomes thoroughly fluid. The mould is assembled on a brass plate & its interiors as well as brass plate should be coated with on equal mixture of glycerine&dextine to prevent sticking the fluid materials is then poured in a thin stream, back& forth from end to end mould until it is more than full. It is closed to room temp. For 30-40min. and then placed in the water bath for 30mins. After which the excess is cutoff by means of hot spatula so that the mould shall be just full & level.

a) Remove the side pieces and brass plate
b) Keep the briquette mould in the testing machine and hook the clips carefully with out causing any initial strain.
c) Adjust the pointer to read zero or initial reading of the pointer to be noted.
d) Start the machine & pull two clips horizontally at a speed of50mm/min.
e) Note the distance at which the bitumen thread of specimen breaks.

PRECAUTIONS:

1. The plate assembly upon which the mould is placed shall be perfectly flat & level so that the bottom surface of the mould touches it throughout.
2. In filling the mould, care should be taken not to disarrange the parts & thus distort the briquette & to see that no air pockets shall be with in the molded sample.
3. If the bituminous material comes in contact with water surface or rests on the bottom of the water bath the test should not be considered as normal. In that case, the specific gravity of water is adjusted by adding either methyl alcohol or sodium chloride so that the bituminous material doesn’t comes to the surface or touch the bottom at any time during the test.

RESULT



Assembly of Apparatus For Determination of Softening Point (Ring & Ball)

OBSERVATION & CALCULATIONS:

Liquid Used In the Bath

	Ball 1	Ball 2
Temperature when the ball touches bottom (^{0}C)		
Average		

Exp No: Date:

SOFTENING POINT TEST

AIM: To determine the softening point of given bituminous material

APPARATUS Ring and Ball apparatus, Water bath with stirrer, Thermometer, Glycerin,etc. Steel balls each of 9.5mm and weight of 2.5±0.08gm.

THEORY: The softening point of bitumen or tar is the temperature at which the substance attains a particular degree of softening. As per IS:334-1982, it is the temperature (in o C) at which a standard ball passes through a sample of bitumen in a mould and falls through a height of 2.5 cm, when heated under water or glycerin at specified conditions of test. The binder should have sufficient fluidity before its applications in road uses. The determination of softening point helps to know the temperature up to which a bituminous binder should be heated for various road use applications. Softening point is determined by ring and ball apparatus.

PROCEDURE

Preparation of test sample: Heat the material to a temperature between 75^0c to 100^0c above its softening point. Stir until it is completely fluid & free from air bubbles and water if necessary filter it throws IS sieve 30. Place the rings, previously heated to a temperature approximating to that of the molten material, on a metal plate which has been smeared with a mixture in air, level the material in the ring by removing the excess with a warmed sharp knife.

1. Assemble the apparatus with rings, thermometer& ball guides in position.
2. Fill the bath distilled water to a height of 50mm above the upper surface o the rings.
3. Apply each to the bath & stir the liquid so the temperature rises at a uniform rate of
    a. 5+0. 5^0c/minute.
4. As the temperature increases the bituminous material softness & the balls sinks through the ring, carrying a portion of the material with it.
5. Note down the temperature when any of the steel with bituminous coating touches the bottom plate.

6. Record the temperature when the second ball also touches the bottom plate.
7. The average of the two readings to the nearest 0.5^0c is reported as the softening point.

Note: Use Glycerin in place of water if the softening point is excepted to be above 80^0c & the starting temperature of the test is 35^0c

PRECAUTIONS:

1. Distilled water should be used as the heating medium.
2. During the conduct of test the apparatus should not be subjected to vibrations.
3. The bulb of the thermometer should be at about the same level as the rings.

STANDARD RESULTS: Softening point indicates the temperature at which binders possess the viscosity. Bituminous materials do not have a definite melting point; rather the change of state form solid to liquid is gradually & over a wide range of temperature. Softening point as particular significance for materials that are to be used as joint & crack fillers. Higher softening point ensures that they will not flow during service. In general, the higher the softening point the lesser the susceptibility. Bitumen with higher softening point may be prepared in warmer places. The result obtained shall not differ from the mean by more than the following.

Softening point(^{0}c)	Repeatability (^{0}c)	Reproducibility(^{0}c)
40-60	1.0	5.5
61-80	1.5	5.5
81-100	2.0	5.5
101-120	2.5	5.5
121-140	3.0	5.5

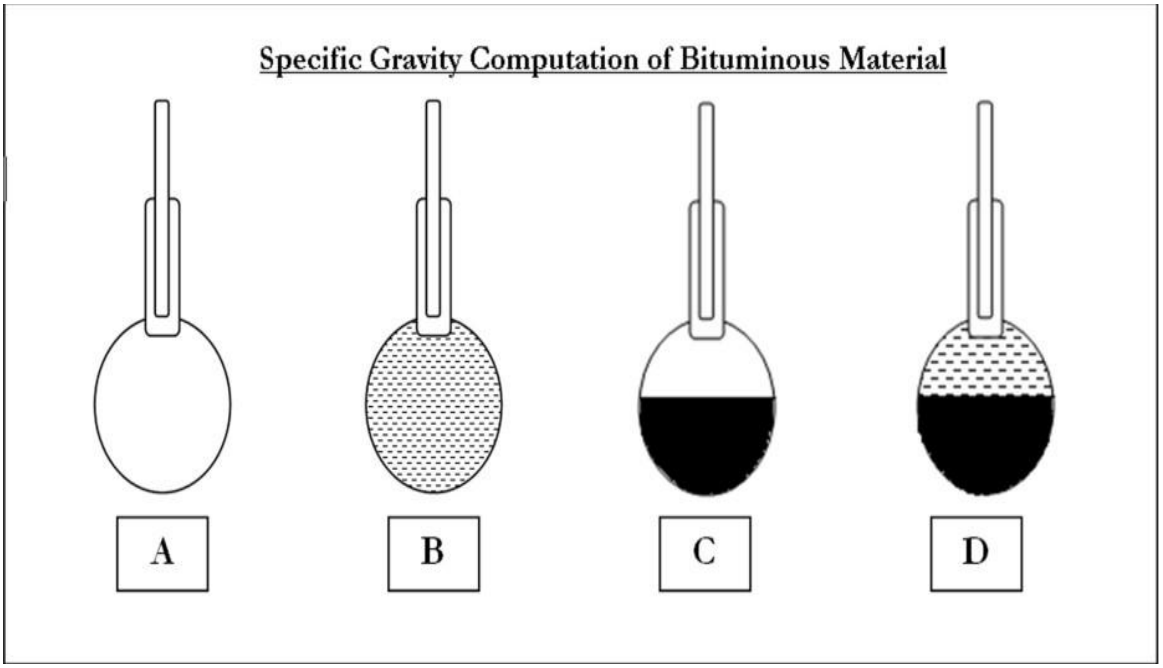
RESULT

The ranges of softening point specified by the Indian Standards Institution for various grades of bitumen are given below.

Bitumen Grades	Softening point, °C
*A25&A35	55 to 70
*S35	50 to 65
A45,S45&A65	45 to 60
S65	40 to 55
A90&590	35 to 50
A 200 & S 200	30 to 45

* A denotes bitumen from Assam Petroleum, and ‘S’ denotes bitumen from sources other than from Assam Petroleum. Also see Table under ‘Application of penetration test.

COMMENTS



CALCULATION

The specific gravity of the bituminous material is calculated as follows:

(i) Pyknometer method

Specific gravity= $\dfrac{\text{weight of bituminous material}}{\text{Weight of equal volume of wate at } 27^{\circ}\text{C}} = \dfrac{(c-a)}{(b-a)-(d-c)}$

a = weight of specific gravity bottle
b = weight of the specific gravity bottle filled with distilled water
c = weight of the specific gravity bottle about half filled with bituminous material.
d = weight of the specific gravity bottle about half filled with the material and the rest with distilled water.

Exp No: Date:

SPECIFIC GRAVITY TEST

AIM: To determine the specific gravity of given sample of water.

APPARATUS: There are two methods (i) Pyknometer method (ii) Balance method. For pyknometer method, the apparatus are specific gravity bottle of 50 ml capacity, ordinary capillary type with 6 mm diameter neck or wide mouthed capillary type bottle with 25 nm diameter neck can be used. For balance method an analytical balance equipped with a pan straddle is used.

PROCEDURE:

The specific gravity bottle is cleaned, dried arid weighed along with the stopper. It is filled with fresh distilled water, stopper placed and the same is kept in water container for at least half an hour at temperature 27°c ± 0.1°C. The bottle is then removed and cleaned from outside. The specific gravity bottle containing, distilled water is now weighed.

The bituminous material is heated to a pouring temperature and is poured in the above empty bottle taking all the precautions that it is dean and dry before filling sample materials. The material is filled upto the half taking care to prevent entry of air bubbles. To permit an escape of air bubbles, the sample bottle is allowed to stand for half an hour at suitable temperature cooled to 27°C and then weighed. The remaining space in the specific gravity bottle is filled with distilled water at 27°C, stopper placed and is, placed in water container at 27°C. The bottle containing bituminous material and containing water is removed, cleaned from outside and is again weighed.

STANDARDS

The Indian Standard institution specifies that the minimum specific gravity values of paving bitumen at 27°C shall be 0.99 for grades A 25, A 35, A 45, A 65, S 35, S 45, and S 65, 0.98 for A 0 and S 90 and 0.97 for A 200 and S 200. (For classification of bitumen, see Table under Experiment No. 17, ‘Applications of penetration test).

RESULT

OBSERVATIONS & CALCULATIONS:

Sl.no.	Particulars	Test 1	Test2
1.	Test temperature		
2.	Time taken to follow50cc of the binder		
3.	Viscosity in Sec.		

Exp No: Date:

VISCOSITY TEST

AIM:To determine the viscosity of given bituminous material.

APPARATUS: A orifice viscometer (one of 4.0mm diameter used to test cut back grades 0 and 1 and 10mm orifice to test all other grades), water bath, stirrer and thermometer.

THEORY: Viscosity of a fluid is the property by virtue of which it offers resistance to flow. Higher the viscosity, the slower will be the movement of the liquid. The viscosity affects the ability of the binder to spread, move into, & fill up the voids between aggregates. It also place on important. Role in coating of aggregates. Highly viscous binder may not fill up the voids completely there by resulting in poor density of the mix. At lower viscosity the binder does not hold the aggregates together but just acts as lubricant the viscosity of bituminous binders falls very rapidly as the temperature rises since binders exhibit viscosity over a wider range, it is necessary to use different methods for the determination of viscosity for binder in the liquid state (Road tars & cutback bituminous),the viscosity is determined as the time in sec. by 50cc of the material to flow from a cup through specified orifice under standard conditions to test & at specified temperature. Equipment like sliding plate micro viscometer, & brook field viscometer are however in used for defining the viscous characteristics of the bitumen of all grades irrespective of testing temperature.

PROCEDURE:

1. Adjust the tar viscometer so that the top of the tar cup is leveled select the test temp. From table1. Heat the water in the water bath to the temp. Specified for the test & maintain it with in ±0.1^{0}c of the specified temp. Throughout the duration of test. Rotate the stirrer gently at frequent intervals or continuously.
2. Clean the Tar cup, orifice of the viscometer with a suitable solvent and dry thoroughly.

3. Warm and stir the material under examination to 20^0c above the temp. Specified for test & cool while continuing the stirring.
4. When the temp. Falls slightly above the specified temp, pour the tar in to the cup until the leveling peg ion the valve rods is just immersed when the latter is vertical.
5. Pour in to the graduated receiver 20ml; of mineral oil or one %by weight, solution of soft soap & place it under with orifice of the cup.
6. Place the other thermometer in the tar & stir until the temp. is with in $\pm 0.1^0$c of the specified temp. When this temp. Has been reached .suspended the thermometer coaxially with the cup & with its bulb approximately at the geometric center of the tar.
7. Hallow the assembled apparatus to stand for 5 min. during which period the thermometer reading should remain within 0.05^0c of the specified temp. Remove the temp. & quickly remove any excess tar so that the final level is on the central line on the leveling peg when the valve is in vertical position.
8. Lift the valve & suspend it on valve support
9. Start the stop watch when the reading in the cylinder is 25ml & stop when it is 75ml, note the time in sec.
10. Report the viscosity as the time taken in sec. by 50 ml. of tar to flow out at the temp. Specified for the test.

PRECAUTIONS:

a. The tar cup should be cleaned thoroughly with non- corroding solvents such as light tar oils free from phenols.
b. The orifice seize should be tested at frequent intervals with a gauge having a appropriate diameters.

REAULT

MARSHALLA STABILITY APPARATUS

Exp No: Date:

BITUMINOUS MIS DESIGN BY MARSHALL METHOD

AIM: To determine optimum binder content of given bituminous mix by Marshall Method ofmix design.

APPARATUS: Mould assembly, sample extractor, compaction pedestal and hammer, breaking head,loading machine flow meter, thermometers water bath and oven

THEORY

In this method, the resistance to plastic deformations of cylindrical specimen of bituminous mixture is measured when the same is added at the periphery at 5 cm per minute. This test procedure is used in designing and evaluating bituminous paving mixes. The test procedure is extensively used in routine test programs for the paving jobs. There are two major features of the Marshall method of designing mixes namely, (i) density-voids analysis (ii) stability-now tests. The Marshall stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature at 60°C. The flow value is the deformation the Marshall test specimen undergoes during the loading upto the maximum load, in 0.25 mm units. In this test an attempt is made to obtain optimum binder content for the type of aggregate mix and traffic intensity

PROCEDURE:

1. The coarse aggregates, fine aggregates and mineral filler material should be proportioned and mixed in such a way that final mix after blending has the graduation within the specified range.
2. Approximately 1200 grams of aggregates and filler are taken and heated to a temperature of 175$_o$C to 195$_O$ C.
3. The compaction mould assembly and rammer are cleaned and kept pre- heated to a temperature of 100$_o$C to 145$_o$C. The bitumen is heated to temperature of 121$_o$C to 138$_o$C and the required quantity of first trial percentage o f bitumen is added to the heated aggregate and thoroughly mixed using a mechanical mixer or by hand mixing with

trowel.

4. Then the mix is heated and a temperature of 150_o to 160_oC is maintained and then the mix is transferred into the pre-heated mould and compacted by giving seventy five blows on each side.
5. The specific gravity values of different aggregates, filler and bitumen used are determined first. The theoretical specific gravity of the mix is determined.
6. Soon after the compacted bituminous mix specimens have cooled to room temperature, the weight, average thickness and diameter of the specimen are noted. The specimens are weighted in air and then in water.
7. The bulk density value of the specimen if calculated from weight and volume
8. Then the specimen to be tested is kept immersed under water in a thermostatically controlled water bath maintained at $60^0 \pm 1^0$C for 30 to 40 minutes.
9. The specimens are taken out one, placed in the marshal test and the marshal stability value and flow are noted.
10. The corrected Marshall Stability value of each specimen is determined by applying the appropriate correction factor, if the average height of the specimen is not exactly 63.5mm.
11. Five graphs are plotted with values of bitumen content against the values of density, Marshall Stability, voids in total mix, flow value, voids filled by bitumen.
12. Let the bitumen contents corresponding to maximum density be B_1, corresponding tomaximum stability be B_2 and that corresponding to the specified voids content (at 4.0%)be B_3. Then the optimum bitumen content for mix design is given by: $B_o = (B_1+B_2+B_3)/3$

RESULT: The optimum binder content of the given mix is…….

OBSERVATIONS AND CALCULATIONS:

Total mass of soil taken for analysis = M = ______ gram.

IS Sieve	Practical Size D mm	Mass Retained M^1, (g)	Corrected mass retained M.(g).	Percentage retained	Cumulative Percentage retained	Percentage Finer (N)

Specimen Calculations:

Corrected Mass Retained = $M = M^1 \times \frac{M}{\sum M^1}$

Exp No: Date

Wet sieve Analysis

AIM: To determine the grain size distribution of the given soil by hydrometer

IS CODE: IS: 2720 (Part-4)-1985

THEORY: Soil gradation (sieve analysis) is the distribution of particle sizes expressed as a percent of the total dry weight. The percentage of sand, silt and clay in the inorganic fraction of soil is measured in this procedure. The method is based on Stoke's law governing the rate of sedimentation of particles suspended in water.

APPARATUS REQUIRED:

Glass cylinders of 1000-ml capacity, Thermometer, Hydrometer, Electric mixer with dispersing cup, Balance sensitive to ± 0.01g, Stop watch & Beaker, Dispersing solution-4% (Dissolve 5 g of sodium hexa-metaphosphate in de-ionized water of 125 ml)

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. 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 200gm of oven dried soil sample and soaked with water.
2. If de-flocculation is required, 2% calgon solution is used instead of water.
3. The sample is stirred and left for soaking period of at least 1 hour.
4. The slurry is then sieved through 4.75 mm sieve and washed with a jet of water.
5. The material retained on the sieve is the gravel fraction, which should be dried in oven and weighed.
6. The material passing through 4.75 mm sieve is sieved through 75 micron sieve.
7. The material is washed until the water filtered becomes clear.
8. The soil passed through 75 micron sieve is collected and dried in oven.
9. Take 40 gm of the oven dry soil sample after removing soluble salts and organic matter if any.

10. It is then mixed with 4% solution of dispersing agent in water to get a known amount of suspension by volume and stirred well.

11. This suspension should be made 24 hrs before testing.

12. After 24 hours, the suspension is again mixed using Electric mixer with dispersing cup and

13. Following stirring with mixer, the suspension which is made up to 1000 ml in the measuring cylinder is turned end to end for even distribution of particles before the time't' begins to be measured.

14. The hydrometer readings are recorded at regular intervals as indicated in the data sheet. From the data obtained the particle size distribution curve is plotted in the semi-logarithmic graph sheet along with the dry sieve analysis results.

CORRECTIONS (INDIVIDUAL):

Meniscus Correction (Cm): Since the suspension is opaque, the readings will be taken at the top of the meniscus while the actual should be from the bottom of the meniscus. It is constant for a hydrometer (Always positive).

Temperature Correction (Ct): If the temperature is less than 27˚C, the correction is negative and vice-versa. Temperature should be measured from starting till end of the tests at regular intervals and are averaged. Then it is compared with the standard temperature (27˚C).

Dispersion Agent Correction (Cd): Addition of calgon always increases the specific gravity of the specimen. Hence, this correction is always negative

OBSERVATION AND RECORDING

For Dynamic Compaction

- Optimum water content (%)
- Weight of mould + compacted specimen g
- Weight of empty mould g Weight of compacted specimen g
- Volume of specimen
- Bulk density g/cc
- Dry density g/cc

For static compaction

- Dry density g/cc
- Moulding water content %
- Wet weight of the compacted soil,(W)g
- Period of soaking 96 hrs. (4days).

For penetration Test

- Calibration factor of the proving ring 1 Div. = 1.176 kg
- Surcharge weight used (kg) 2.0 kg per 6 cm construction
- Water content after penetration test %
- Least count of penetration dial 1 Div. = 0.01 mm

Exp No: Date:

CALIFORNIA BEARING RATIO TEST

AIM: To determine the California bearing ratio by conducting a load penetration test in the laboratory.

APPARATUS:

1.Cylindricalmould with inside dia 150 mm and height 175 mm, provided with a detachable extension collar 50 mm height and a detachable perforated base plate 10 mm thick.

2.Spacer disc 148 mm in dia and 47.7 mm in height along with handle.

3Metal rammers. Weight 2.6 kg with a drop of 310 mm (or) weight 4.89 kg a drop 450 mm.

4.Weights. One annular metal weight and several slotted weights weighing 2.5 kg each, 147 mm in dia, with a central hole 53 mm in diameter.

5.Loading machine. With a capacity of atleast 5000 kg and equipped with a movable head or base that travels at an uniform rate of 1.25 mm/min. Complete with load indicating device.

6.Metal penetration piston 50 mm dia and minimum of 100 mm in length.

7.Two dial gauges reading to 0.01 mm.

8.Sieves. 4.75 mm and 20 mm I.S. Sieves.

9.Miscellaneous apparatus, such as a mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers.

DEFINITION OF C.B.R. It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.

C.B.R. = Test load/Standard load * 100

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

Penetration of plunger (mm)	Standard load (kg)
2.5	1370
5.0	2055
7.5	2630
10.0	3180
12.5	3600

The test may be performed on undisturbed specimens and on remoulded specimens which may be compacted either statically or dynamically.

PREPARATION OF TEST SPECIMEN Undisturbed specimen Attach the cutting edge to the mould and push it gently into the ground. Remove the soil from the outside of the mould which is pushed in . When the mould is full of soil, remove it from weighing the soil with the mould or by any field method near the spot.

Determine the density

Remoulded specimen Prepare the remoulded specimen at Proctors maximum dry density or any other density at which C.B.R> is required. Maintain the specimen at optimum moisture content or the field moisture as required. The material used should pass 20 mm I.S. sieve but it should be retained on 4.75 mm I.S. sieve. Prepare the specimen either by dynamic compaction or by static compaction.

Dynamic Compaction Take about 4.5 to 5.5 kg of soil and mix thoroughly with the required water.

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

Compact the mix soil in the mould using either light compaction or heavy compaction. For light compaction, compact the soil in 3 equal layers, each layer being given 55 blows by the 2.6 kg rammer. For heavy compaction compact the soil in 5 layers, 56 blows to each layer by the 4.89 kg rammer.

Remove the collar and trim off soil.

Turn the mould upside down and remove the base plate and the displacer disc.

Weigh the mould with compacted soil and determine the bulk density and dry density.

Put filter paper on the top of the compacted soil (collar side) and clamp the perforated base plate on to it.

Static compaction

Calculate the weight of the wet soil at the required water content to give the desired density when occupying the standard specimen volume in the mould from the expression.

W =desired dry density * (1+w) V

Where W = Weight of the wet soil

w = desired water content

V = volume of the specimen in the mould = 2250 cm3 (as per the mould available in laboratory)

Take the weight W (calculated as above) of the mix soil and place it in the mould.

Place a filter paper and the displacer disc on the top of soil.

Keep the mould assembly in static loading frame and compact by pressing the displacer disc till the level of disc reaches the top of the mould.

Keep the load for some time and then release the load.

Remove the displacer disc. The test may be conducted for both soaked as well as unsoaked conditions.

If the sample is to be soaked, in both cases of compaction, put a filter paper on the top of the soil and place the adjustable stem and perforated plate on the top of filter paper.

Put annular weights to produce a surcharge equal to weight of base material and pavement expected in actual construction. Each 2.5 kg weight is equivalent to 7 cm construction. A minimum of two weights should be put.

Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Remove the mould from tank. Note the consolidation of the specimen.

Procedure for Penetration Test Place the mould assembly with the surcharge weights on the penetration test machine. Seat the penetration piston at the center of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the piston on the sample is established. Set the stress and strain dial gauge to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.

Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10 and 12.5 mm. Note the maximum load and corresponding penetration if it occurs for a penetration less than 12.5 mm. Detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 3 cm layer and determine the moisture content.

Penetration Dial	**Load Dial**	**Corrected Load**

Interpretation and recording

C.B.R. of specimen at 2.5 mm penetration

C.B.R. of specimen at 5.0 mm penetration

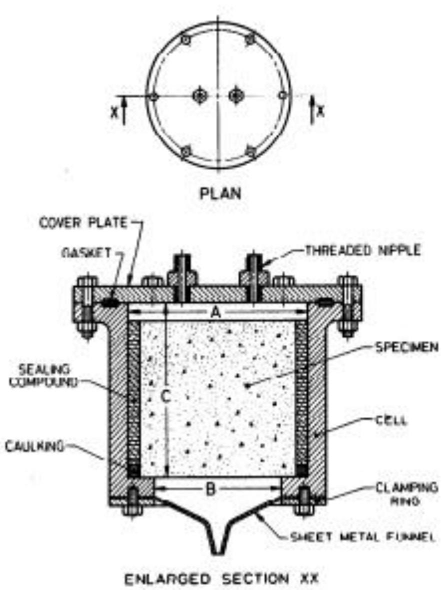
Exp No: Date

PERMEABILITY OF CONCRETE

Objective

Permeability of cement mortar or concrete is of particular significance in structures which are intended to retain water or which come into contact with water. Besides functional considerations, permeability is also intimately related to the durability of concrete, specially its resistance, against progressive deterioration under exposure to severe climate, and leaching due to prolonged seepage of water, particularly when it contains aggressive gases or minerals in solution. The determination of the permeability characteristics of mortar and concrete, therefore, assumes considerable importance. The test consists in subjecting the mortar or concrete specimen of known dimensions, contained in a specially designed cell, to a known hydrostatic pressure from one side, measuring the quantity of water percolating through it during a given interval of time and computing the coefficient of permeability. The test permits measurement of the water entering the specimen as well as that leaving it.

Apparatus Required



Specimen Dia mm	Dimension of Cell, mm		
	A	B	C
100 150 200	115 170 330	80 120 280	110 160 320

Fig. 1 Typical Details of Permeability Cell

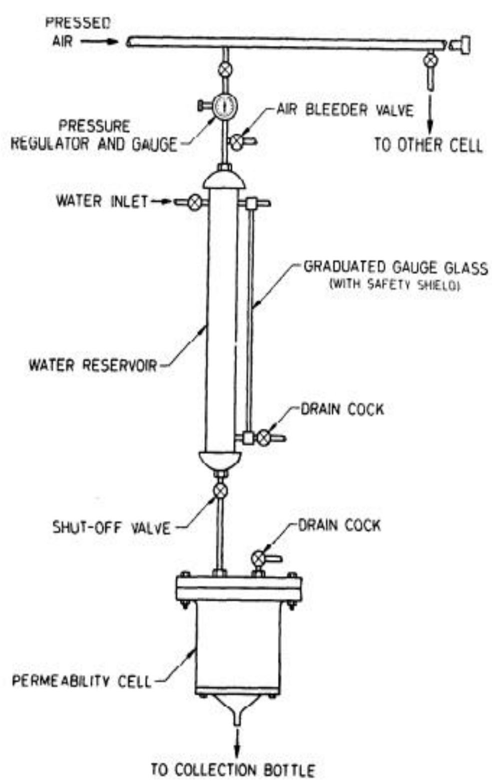


Fig. 2 Permeability Test Set-up (Schematic)

Fig. 1: Concrete Permeability Apparatus The permeability cell shall consist of a metal cylinder with a ledge at the bottom for retaining the specimen, a flange at the top, a removable cover plate and a sheet metal funnel which can be securely bolted to the cell. A rubber or neoprene O-ring or other suitable gasket, seated in matching grooves, shall be used between the cell and the covet plate to render the joint water-tight.

Fig. 2: Water Reservoir in Permeability Apparatus A suitable reservoir may consist of a length of metal pipe, 50 to 100 mm in diameter and about 500 mm long. The reservoir shall be fitted with a graduated side arm gauge-glass, and the necessary fittings and valves for admitting water and compressed air and for draining, bleeding and connection to the permeability cell.

Procedure

Preparation of Test Specimen

1. Specimens shall be cylindrical in shape with height equal to the diameter. The standard size of specimen shall have diameter (and height) of 150 mm. In the case of specimens containing aggregates whose nominal size does not exceed 20 mm, the diameter (and the height) of the specimen may be reduced to 100 mm. In the case of specimens containing aggregates whose nominal size exceeds 40 mm, the diameter (and the height) of the specimen should not be less than about four times the nominal size of the aggregate.
2. The mortar or concrete mix shall be cast in split moulds of the required size, with a removable collar of about half the height set on the top. The material shall be compacted either by hand rodding or vibration, as proposed to be done during construction. The collar shall then be removed and the mould shall be struck off level with a straight-edge using a sawing motion without further trovelling or finishing, which might raise the fines to the surface. The specimen shall be cured for 28 days unless otherwise specified by the engineer-in-charge.

Pressure Head

1. The standard test pressure head to be applied to the water in the reservoir should be 10 kg/cm2. This may, however, be reduced up to 5 kg/cm2 in the case of relatively more permeable specimens where steady state of flow is obtained in a reasonable time, and may be increased up to 15 kg/cm2 for relatively less permeable specimens and where sealing could be ensured to be fully elfective.
2. With the reservoir drain-cock and the shut-off valve between the reservoir and the cell closed, and with the air bleeder valve open, the reservoir shall be filled with water. The reservoir drain-

cock shall then be opened to flush out any air and closed again. The reservoir shall be refilled to a point above the zero mark of the gauge-glass scale; the bleeder valve shall be closed and the desired air pressure applied. The drain-cock shall be carefully opened to bring the water to the zero mark and quickly closed. Water shall then be drawn off and caught in 250 ml increments in a graduated jar and the level in the gauge-glass read on the scale. The calibration constant for the reservoir shall be expressed in millilitres per division of the scale.

Sealing of Test Specimen

1. The specimen shall be surface-dried and the dimensions measured to the nearest 0.5 mm. It shall then be centred in the cell, with the lower end resting on the ledge. The annular space between the specimen and the cell shall be tightly caulked to a depth of about 10 mm using a cotton or hemp cord soaked in a suitable molten sealing compound. The rest of the space shall be carefully filled with the molten sealing compound, level with the top of the specimen. Any drop in the level due to cooling shall be made up, using a heated rod to remelt the solidified compound before pouring fresh material over it. A mixture of bees-wax and rosin, applied smoking hot, forms an effective seal. The proper proportions are best chosen by trial. Other suitable materials are stearine pitch, marine glue, and various asphaltic compounds.

Testing the Seal

1. It is essential that the seal is watertight. This may be checked very conveniently by bolting on the top cover plate, inverting the cell and applying an air pressure of 1 to 2 kg/cm2 from below. A little water poured on the exposed face of the specimen is used to detect any leaks through the seal, which would show up as bubbles along the ledge. In case of leaks the specimen shall be taken out and resealed.

Assembling the Apparatus

1. After a satisfactory seal has been obtained, the funnel shall be secured in position and the cell assembly connected to the water reservoir. With the air bleeder valve, the valve between the reservoir and the cell, and the drain-cock in the cell open, de-aired water shall be allowed to enter the reservoir. When water issues freely through the drain-cock, it shall be closed and the water reservoir filled. The reservoir water inlet and air bleeder valves shall then be closed.

Running the Test

1. With the system completely filled with water, the desired test pressure shall be applied to the water reservoir and the initial reading of the gauge-glass recorded. At the same time a clean collection bottle shall be weighed and placed in position to collect the water percolating through the specimen. The quantity of percolate and the gauge-glass readings shall be recorded at periodic intervals. In the beginning, the rate of water intake is larger than the rate of outflow. As the steady state of flow is approached, the two rates tend to become equal and the outflow reaches a maximum and stabilizes. With further passage of time, both the inflow and outflow generally register a gradual drop. Permeability test shall be continued for about 100 hours after the steady state of flow has been reached and the outflow shall be considered as average of all the outflows measured during this period of 100 hours.

2. Test shall preferably be carried out at a temperature of 27°C +/- 2°C. In case arrangements are not available for maintaining the above temperature, a record shall be maintained of the actual temperature. An approximate correction may be made on the basis that each 5°C increase of temperature above the standard temperature, results in 10 percent increase in the coefficient of permeability and vice versa.

. Calculation

The Coefficient of Permeability shall be calculated as follows: $K = Q / (A*T*H/L)$

where, K= Coefficient of permeability (cm/sec), Q= quantity of water in millimeters percolating over the entire period of test after the steady state has been reached, A= area of the specimen face in cm2, T= time in seconds over which Q is measured, and H/L= ratio of the pressure head to thickness of specimen, both expressed in the same units.

Precautions

1. The seal around the specimen shall be effective. Leakage through it can give rise to entirely misleading results. Obtaining a good seal is a matter of experience and only a general guidance can be provided.

2. It is important that the air content of the water entering the specimen should not exceed about 0.2 percent. Excessive amounts of dissolved air can result in air locks in the specimen and apparent reduction in permeability. Periodical samples shall be drawn from the cell drain-cock and the dissolved air determined. The system shall be drained and replenished with fresh de-aired water, as soon as the air content exceeds the above limit.

3. The flow should be permitted to attain the steady state before the coefficient of permeability is calculated. Examination of the inflow and outflow rate data or suitable graphs of the same may be used to determine the establishment of the steady strata.
4. The observation of outflow from the specimen is liable to be influenced by evaporation of the percolate during collection. The collection bottle may be housed in a humid chamber, or alternatively, blank observations on a similar bottle containing water should be made and the necessary correction for evaporation loss applied. The inflow measurement provides an additional check.
5. It is very important that the specimen surface is carefully prepared by sand blasting or chiselling, as even a thin highly -impervious skin can result in considerable underestimation of the permeability.

VIVA QUESTIONS

1) What is normal consistency of cement paste?

2) What is purpose of making this determination?

3) How is the standard or normal consistency expressed?

4) What is range of values most for Portland cement

5) What is meaning of Consistency in concrete?
6) What is slump of concrete?
7) What is the significance of shear slump?
8) What is segregation?
9) What is the difference is between fully compacted and partially compacted concrete?
10) What is the significance of compacted concrete?
11) Define density of concrete & how it affects the strength of concrete?
12) Describe the factors affecting the choice of the method of test.
13. What are the advantages and disadvantages of Vee-Bee method of test over the other? Methods
14. How does strength correlate with other properties of hardened concrete?
15. What are the requirements for curing the specimens?
16. What do you mean by elongation index of an aggregate?
17. What do you infer from elongation index?
18. How the elongation index of the sample helps in deciding the design of a highway?
19. What do you mean by flakiness index of an aggregate?
20. What do you infer from flakiness index?
21. How the flakiness index of the sample helps in deciding the design of a highway?
22. How is the crushing strength test carried out on cylindrical stone specimen? Why is the test not carried out commonly?

23. Explain aggregate crushing value. How would you express?

24. Briefly explain the aggregate crushing value test procedure.

25. What is the specified standard size' of aggregates? How is the aggregate crushing value of non standard size aggregate evaluated?

26. Aggregate crushing value of material A is 40 and that of B is 25. Which one is better and why?

27. What are the applications of aggregate crushing test?

28. What are the recommended maximum values of aggregate crushing value for the aggregates to be used in base and surface courses of cement concrete?

29. What are the uses and applications of the aggregate crushing test?

30. Why Los Angeles abrasion test is considered superior to other tests to find the hardness of aggregates?

31. How is Los Angeles abrasion value expressed?

32. The abrasion value found from Los Angeles test for aggregates A and B are 35 and 15 respectively. Which aggregate is harder? Why? For what types of constructions are these suitable?

33. Briefly explain the Los Angeles abrasion test procedure.

34. What are the desirable limits of Los Angeles Abrasion values specified for different types of pavement surfacing?

35. What are the advantages of Aggregate Impact test over Page Impact test?

36. Briefly mention the procedure of aggregate impact test?

37. How is aggregate impact expressed?

38. What are the desirable limits of aggregate impact value specified for different types of pavement surfaces?

39. Aggregate impact value material A is 20 and that of B is 45. Which one is better for surface course? Why?

40. What do you understand by dry and wet impact value?
41. How is penetration value of bitumen expressed?
42. What are the standard load, time and temperature specified for penetration test.
43. Briefly outline the penetration test procedure.
44. What do you understand by 80/ 100 bitumen?
45. What are the effects of: (i) higher test temperature (ii) higher pouring temperature (iii) Exposed bitumen, on penetration test results.
46. Explain ductility of Bitumen and its significance.
47. How is ductility value expressed?
48. Outline the ductility test procedure.
49. What is the minimum area of cross section of the ductility specimen?
50. What are the precautions to be taken while finding the ductility value?
51. What are the factors affecting the ductility test results?
52. What is softening point?
53. What does softening point of bituminous materials indicate?
54. What are the applications of ring and ball test results?
55. Explain the two methods of finding specific gravity of bituminous materials.
56. What precautions should be taken while finding the specific gravity?
57. What are the applications of specific gravity and results?
58. Explain the term viscosity.
59. What are the different methods in determining the viscous characteristics of bituminous materials?

60. What is absolute unit for viscosity?
61. What are the uses of viscosity test?
62. Write a note on float test.
63. What are the precautions to be taken during viscosity test using orifice viscometer?
64. Define flash and fire points.
65. Briefly outline the flash point test procedure.
66. What is the significance of flash point test. Differentiate between flash point and fire point.
67. Why do we need to design bituminous mix?
68. What are the essential properties of bituminous mixes?
69. What is the significance of flow value in Marshall test?
70. Why is the sample in Marshall test placed on its periphery while loading?
71. What is the measure taken if a mix results in excessive voids?
72. What is filler?
73. What are different types of fillers?
74. Does Portland cement, if used in bituminous mix, improve strength?
75. Briefly out line Marshall Stability test procedure?
76. How is bituminous mixed designed based on Marshall design approach?

Reference codes

Sl No	Experiments	Codes	Code book Page No
1	Normal Consistency Of Cement	(IS: 4031 - 1988 - 4),	1-2
2	Initial And Final Setting Times Of Cement	(IS: 4031- 1988 -5)	1-2
3	Specific Gravity Of Cement	(IS: 4031-1988)	
4	Soundness Of Cement	(IS 4031-1988 Part 3)	2-4
5	Compressive Strength Of Cement	(IS 269-1989, IS 8112-1989, IS 12269 -1987, IS 4031-1988 (Part6)	1-3
6	Slump Test	(IS 1199-1959)	8-12
7	Compaction Factor Test	(IS 1199-1959)	13-16
8	Vee-Bee Consistometer	(IS 1199-1959)	17-20
9	Test For Compressive Strength Of Concrete Cubes	(IS: 516 – 1959)	10-11
10	Split Tensile Strength Of Concrete	(IS: 5816 – 1999)	1-4
11	Aggregate Crushing Value Test	(IS 2386- part IV)	4-7
12	Aggregate Impact Test	(IS 2386- part IV)	10-16
13	Abrasion Test	(IS 2386- part IV)	17-19
14	Shape Test	(IS 2386- part I)	11-17
15	Softening Point Test	(IS1205-1978)	33-38
16	Viscosity Test	(IS1206-1978)	39-44
17	Ductility Test	(IS1207-1978)	71-74
18	Flash & Fire Point Test	(IS 1209-1978)	75-84
19	Specific Gravity of Bitumen	(IS 1202-1978)	19-24
20	Penetration Test	(IS1203-1978)	25-28
21	Permeability of concrete	(IS 3085:1965)	125-129