ADICHUNCHANAGIRI INSTITUTE OF TECHNOLOGY
(Affiliated to V.T.U., Accredited by NAAC & ISO 9001:2008)
Chikkamagaluru

Department of Civil Engineering

Concrete & Highway Materials Laboratory

18CVL58

B.E – Vth Semester

Laboratory Manual

Name: ____

USN: ____

Batch:_________________Section: __________________

A LABORATORY MANUAL

CONCRETE AND HIGHWAY MATERIALS LABORATORY

V th SEM CIVIL ENGINEERING

SUBJECT CODE 18CVL58

Head of the Department

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DEPARTMENT OF CIVIL ENGINEERING

ADICHUNCHANAGIRI INSTITUTE OF TECHNOLOGY

PEO's

PEO 1.Developing careers in government and private civil engineering organizations and other professionally related domains

PEO 2.Pursuing higher studies, and research to develop innovative solutions and technologies in civil engineering and other multi disciplinary areas

PEO 3. Improving professional and personal traits aligned to professional ethics and environmental compulsions

PEO 4. Professional leadership and Successful entrepreneurship

PSO's

PSO 1. Comprehend, analyze and design alternatives for execution of civil engineering facilities

PSO 2. Apply Standard Codes of Practices and schedule of rates for planning, design, quality control, estimating & costing of civil engineering projects.

PSO 3. Evaluate the buildings for resource conservation.

PROGRAM OUTCOMES (POS)

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent

responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PREFACE

This manual has been prepared to present the standard procedures & specifications involved in testing basic materials of civil engineering. Field inspection including sampling & laboratory testing of basic building materials like concrete & aggregates are key activities in the construction process.

This is not designed as field manual but is intended to be used in materials laboratory & other offices for guidance, reference & instruction. In the laboratory manual instructions for experiments to be performed are in conjunction with the course. The description for each experiment includes its objective, an equipment list, background material, and a recommended procedure.

The main objectives of these methods are

1. Measure a property that is of important for performance in service.
2. Make the test as simple & straight forward as possible.
3. Reduce to a reasonable minimum elapsed time necessary for completing the test.

The students will become familiar with the nature and properties of basic materials used for construction by conducting laboratory tests. The tests have been selected to illustrate the basic properties and methods of testing cement, Aggregates, Bitumen are outlined as per ASTM, AASHTO & Bureau of Indian Standards.

COURSE DETAILS

Course Name: Concrete and Highway Materials Laboratory

Course Code: 18CVL58

Course prerequisite: Basic Knowledge on Concrete Technology,
Geotechnical Engineering I &II, Transportation Engineering.

COURSE OBJECTIVES

1. To learn the procedure of testing concrete ingredients and properties of concrete as per standard code recommendations.

2. To learn the procedure of testing bituminous materials as per standard code recommendations.

3. To relate material characteristics to various application of construction.

4. Calculate material requirements for concrete and bituminous mixes as per codal provisions.

5. To learn the principals and procedures of testing Concrete and Highway materials and to get hands up experience by conducting the testes and evolving inferences.

COURSE OUTCOMES:

<u>During this course, students will develop expertise in</u>

1. Able to interpret the experimental results of concrete and highway materials based on laboratory tests.
2. Determine the quality and suitability of cement.
3. Design appropriate concrete mix Using Professional codes.
4. Determine strength and quality of concrete.
5. Evaluate the strength of structural elements using NDT techniques.
6. Test the soil for its suitability as sub grade soil for pavements.

Sl.No	Course Outcomes	PO's	Cognitive Level	Class Sessions
1	Determine the properties of cement by conducting basic test.	1,2,3,4,6	APPLY	7
2	Define the workability of fresh concrete and self compacting concrete by conducting tests.	1,2,3,4,6	APPLY	7.5
3	Estimate the strength of hardened concrete by conducting destructive and non destructive testing	1,2,3,4,6	APPLY	6.0
4	Determine the properties of soil by conducting CBR test.	1,2,3,4,6,10	APPLY	4.5
5	Examine the experimental strength of aggregate materials as per codal provisions.	1,2,3,4,6,9	APPLY	6.0
6	Illustrate the stability & properties of bituminous materials & mixes by conducting tests.	1,2,3,4,6,8	APPLY	9.0
TOTAL HOURS OF INSTRUCTION				40

LAB SAFETY DO'S AND DON'TS.

Conduct

a) Do not engage in practical jokes or boisterous (noisy) conduct in the laboratory.

b) Do not sit on laboratory benches.

c) Never run in the laboratory.

d) The use of Cell phones, personal audio or video equipment is prohibited in the laboratory.

e) The performance of unauthorized experiments is strictly forbidden.

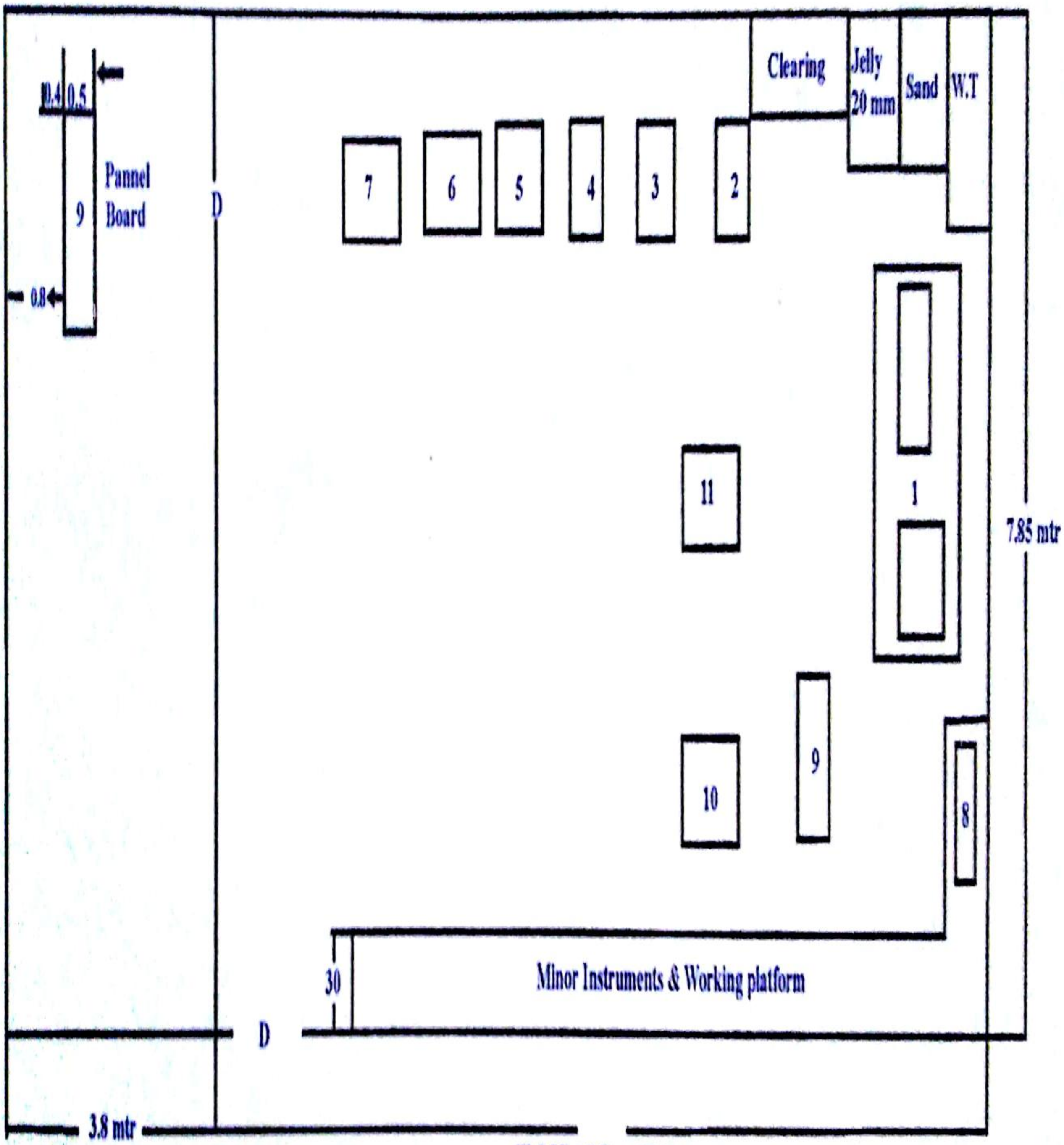
General Procedure

1. Never leave experiments while in progress.
2. Do not remove any equipment or chemicals from the laboratory.
3. Coats, bags, and other personal items must be stored in designated areas, not on the bench tops or in the aisle ways.
4. Always perform the experiments or work precisely as directed by the teacher.
5. Keep your workstation neat and clean.

Apparel in the Laboratory

1. Low waist jeans, pants, short shirts are NOT acceptable and NOT permitted at anytime.
2. Wear a full-length, long-sleeved laboratory coat or chemical-resistant apron.
3. Wear shoes that adequately cover the whole foot; low-heeled shoes with non-slip soles are preferable.
4. Do not wear sandals, open-toed shoes, open-backed shoes, or high-heeled shoes in the laboratory.
5. Avoid wearing shirts exposing the torso, shorts; long pants that completely cover the legs are preferable.
6. Secure loose clothing (especially loose long sleeves, neck ties, or scarves).
7. Remove jewelry (especially dangling jewelry).
8. "Baggy" pants or sloppy dress will NOT be permitted at anytime.
9. Clothing that is provocative or contains obscene messages or messages that are contrary to the mission of the college will not be permitted.
10. Secure Long hair - Long hair can accidentally fall into flames or chemicals. Many hair sprays, gels, mousses, etc. are flammable! Think about this! Loose, long hair can also block your vision, which can lead to accidents.
11. Clothing which has advertising is NOT acceptable.
12. Make-up and jeweler are NOT appropriate

LAY OUT OF CONCRETE AND HIGH WAY MATERIALS TESTING LABORATORY



FLOOR AREA = 155.00 sq mtr

1) Compression Testing Machine 200 Tonne Capacity
2) Combaction Factor Tester
3) Impact Testing Machine
4) Vibrating Machine
5) Sieve Shaker
6) Dorrys abrasion Testing Machine
7) Vee-bee Consistometer
8) Ductility Testing Machine
9) Marshall Stability Apparatus
10) Flexural Test Apparatus
11) Cement Autoclave

CONTENTS

Page No.

PART A CONCRETE LAB

CONTENTS

PART B: HIGHWAY MATERIALS LAB

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's apparatus conforming to IS: 5513-1976
- Weighing Balance
- Gauging Trowel
- Stop Watch.

REFERENCE CODE:

- IS: 4031 (Pat 4) – 1988 methods of physical test for hydraulic cement
- IS: 5513-1996 for specification for Vicat's apparatus.

THEORY:

The standard consistency of a cement paste is defined as that consistency which will permit the vicat plunger to penetrate to a depth of 33 to 35 mm from the top of the vicat mould. (From top of the specimen).

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.

PROCEDURE:

1. Prepare a paste of weighed quantity of cement (400 grams) with a weighed quantity of potable or distilled water, starting with 26% water of 400g 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 until commencing 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. Repetition of the experiment fresh cement is to be taken.

OBSERVATION AND CALCULATION:

1. Type of cement…………………….
2. Brand of cement…………………..
3. Time of Test……………………….
4. Room Temperature…………………

Tabular Column:-

Trail No.	Weight of cement (gms)	Percentage by water of dry Cement (%)	Amount of water added (ml)	Penetration (mm)
1				
2				
3				
4				
5				
6				
7				
8				

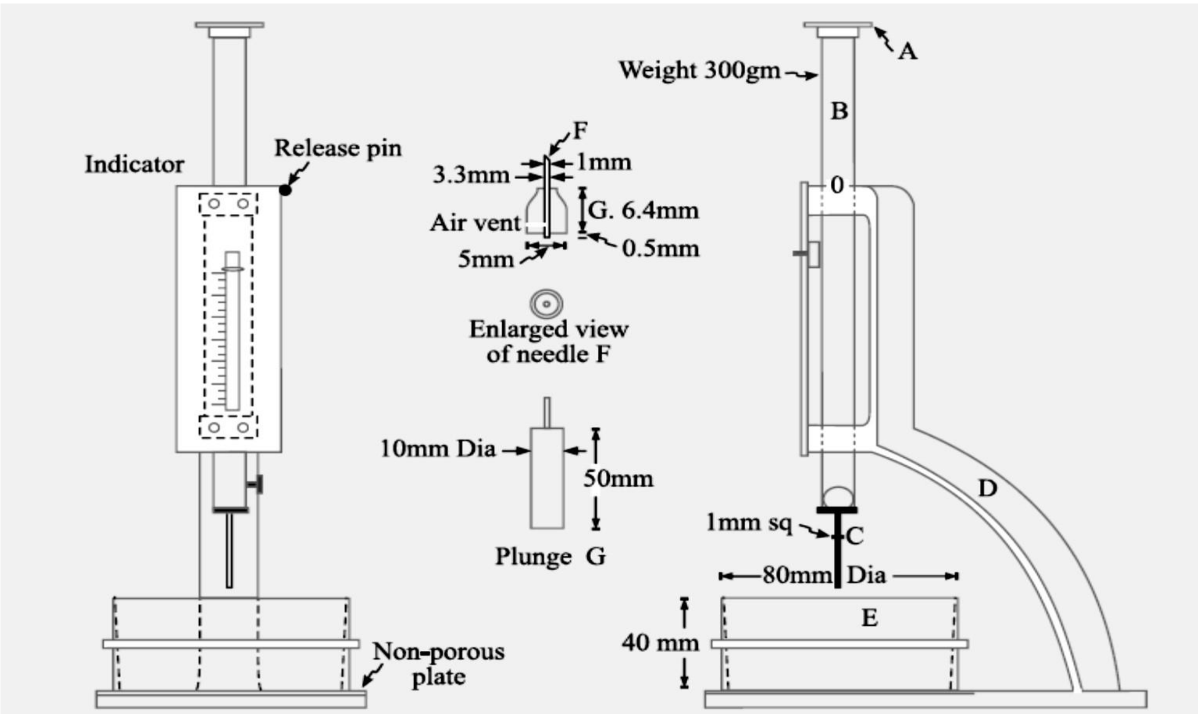


Fig: - Vicat Apparatus

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

CONCLUSION: The percentage of water which allows the plunger to penetrate only to a depth of 33to 35 mm from top is known as the percentage of water required to produce a cement paste of standard consistency .So_______% of water required to produce a cement paste of standard consistency.

Exp. No: - **Date:-**

DETERMINATION OF SETTING TIME OF STANDARD CEMENT PASTE

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

APPARATUS:

- Vicat apparatus conforming to IS : 5513-1976
- Weighing Balance
- Glass plate
- Gauging Trowel
- Stop Watch

REFERENCE CODE:

- IS: 4031 (Pat 4) – 1988 methods of physical test for hydraulic cement
- IS: 5513-1996 for specification for Vicat's apparatus.
- IS: 269-2015 for cement

THEORY:

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 definite pressure.

PROCEDURE:

1. Preparation of Test Block: - Prepare a neat 400 gms cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency. Potable or distilled water shall be used in preparing the paste.
2. Start a stop-watch at the instant when water is added to the cement. Fill the Vicat mould with a cement paste gauged as above and the mould resting on a nonporous plate. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould.
3. Immediately after moulding, place the test block in the moist closet or moist room and allow it to remain there except when determinations of time of setting are being made.
4. Determination of Initial Setting Time: - Place the test block confined in the mould and resting on the non-porous plate, under the rod bearing the needle lower the needle gently until it comes in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block
5. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block beyond 5.0 ± 0.5 mm measured from the bottom of the mould shall be the initial setting time

6. Determination of Final Setting Time: - Replace the needle of the Vicat apparatus by the needle with an annular attachment.
7. 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.
8. The period elapsing 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.

OBSERVATION:

1. Type of cement =…………………….
2. Brand of cement =…………………..
3. Weight of given sample of cement is =…………… ….gms
4. The normal consistency of a given sample of cement is =…………………. %
5. Volume of water addend for preparation of test block=…………………ml

Tabular Column:-

Sl.No.	Setting Time (min)	Penetration (mm)
1		
2		
3		
4		
5		
6		
7		
8		

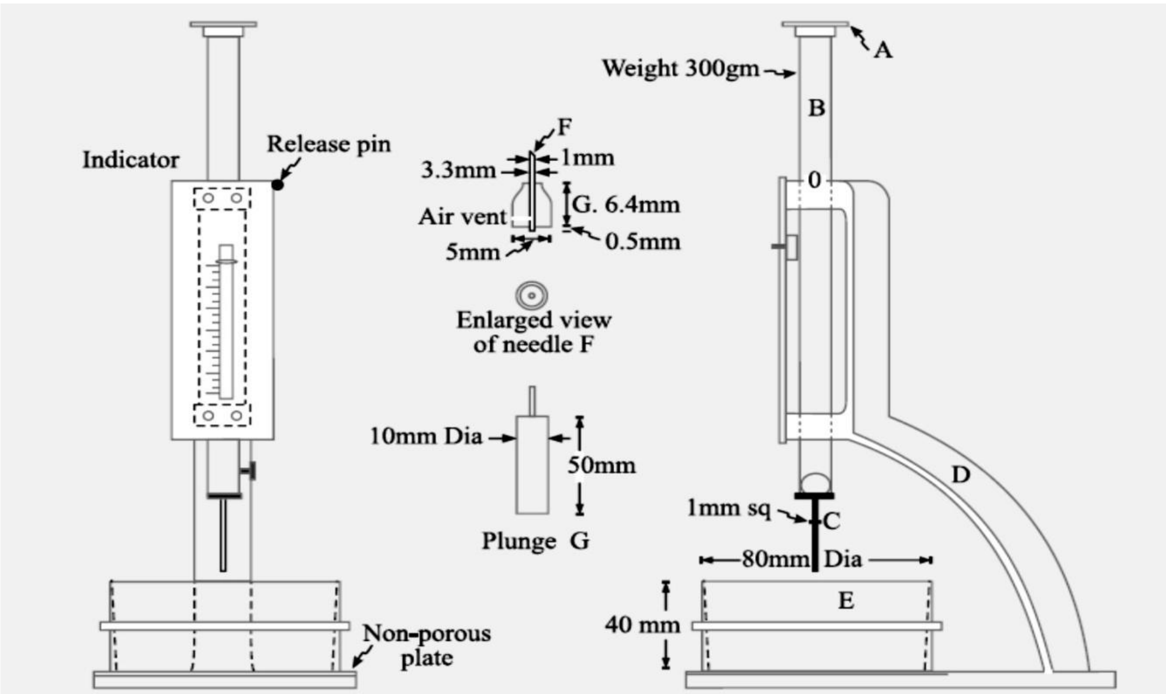


Fig. : Vicat Apparatus

RESULT:

1. The initial setting time of the cement sample is found to be.............minutes
2. The final setting time of the cement sample is found to be …........... minutes

CONCLUSION: As per IS 269: 2015 the initial setting time should be more than 30min And final setting time should be less than 600min. So the values are within the permissible limit so this cement may be used for concrete work.

Table 1: Recommended Value

Type/Name Of Cement	Referenced Indian Stanadard	Initial Setting Time, mints (min.)	Final Setting Time, mints (max.)
OPC(33)	IS:269	30	600
OPC(43)	IS:8112	30	600
OPC(53)	IS:12269	30	600
SRC	IS:12330	30	600
PPC	IS:1489,P1	30	600
RHPC	IS:8041	30	600
PSC	IS:455	30	600
High alumina	IS:6452	30	600
Super sulphated	IS:6909	30	600
Low heat	IS:12600	60	600
Masonry cement	IS:3466	90	1440
IRS-T-40	Railway	60	600

Exp. No: - **Date:-**

COMPRESSIVE STRENGTH TEST OF HYDRULIC CEMENT

AIM: To determine the compressive strength of standard cement mortar cubes

THEORY: 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 cm2) composed of one part of cement and three parts of standard stand should satisfy IS code specifications.

REFERENCE: IS: 4031 (Part 6) – 1988., IS 269-2015.

APPARATUS:

- Vibration Machine
- Poking Rod
- Cube Mould size conforming to IS : 10080-1982
- Weighing Balance
- Trowel
- Stop Watch
- Graduated Glass Cylinders

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 cm2) composed of one part of cement and three parts of standard stand should satisfy IS code specifications.

PROCEDURE:

1. **Preparation of test specimens: -** Clean appliances shall be used for mixing and the temperature of water and that of the test room at the time when the above operations are being performed shall be 27 ± 2°C.distilled water shall be used in preparing the cubes.
2. The material for each cube shall be mixed separately and the quantity of cement, standard sand and water shall be as follows: Cement 200 g and Standard Sand 600 g

1. Water (P/4+3) percent of combined mass of cement and sand, where P is the percentage of water required to produce a paste of standard consistency.
2. Place on a nonporous plate, a mixture of cement and standard sand. Mix it dry with a trowel for one Minute and then with water until the mixture is of uniform colour. The quantity of water to be used shall be as specified in step 2. The time of mixing shall in any event be not less than 3 min and should the time taken to obtain a uniform colour exceed 4 min, the mixture shall be rejected and the operation repeated with a fresh quantity of cement, sand and water.
3. **Moulding Specimens: -** In assembling the moulds ready for use, treat the interior faces

of the mould with a thin coating of mould oil.

4. Place the assembled mould on the table of the vibration machine and hold it firmly in position by means of a suitable clamp. Attach a hopper of suitable size and shape securely at the top of the mould to facilitate filling and this hopper shall not be removed until the completion of the vibration period.
5. Immediately after mixing the mortar in accordance with step 1 & 2, place the mortar in the cube mould and prod with the rod. Place the mortar in the hopper of the cube mould and prod again as specified for the first layer and then compact the mortar by vibration.
6. The period of vibration shall be two minutes at the specified speed of 12 000 ± 400 vibration per minute.
7. At the end of vibration, remove the mould together with the base plate from the machine and finish the top surface of the cube in the mould by smoothing the surface with the blade of a trowel.
8. **Curing Specimens:-** keep the filled moulds in moist closet or moist room for 24 ± 1 hour after completion of vibration. At the end of that period, remove them from the moulds and immediately submerge in clean fresh water and keep there until taken out just prior to breaking.
9. The water in which the cubes are submerged shall be renewed every 7 days and shall be maintained at a temperature of 27 ± 2°C. After they have been taken out and until they are broken, the cubes shall not be allowed to become dry.
10. Test three cubes for compressive strength for each period of curing mentioned under the relevant Specifications (i.e. 3 days, 7 days, 28 days)
11. The cubes shall be tested on their sides without any packing between the cube and the steel plattens of the testing machine. One of the plattens shall be carried on a base and shall be self-adjusting, and the load shall be steadily and uniformly applied, starting from zero at a rate of 35 N/mm^2/min.

OBSETRVATION:

- Type of cement=...........................
- Brand of cement=........................
- Date of casting=.............................

Tabular Column:-

Sl.No	Age of Cube	Dimensions Of the specimen (mm)			Weight of Cube (gms)	C/S - area (mm^2)	Crushing Load (N)	Average Compressive strength (MPa)
		L mm	B mm	H mm				
1								
2								
3								
4								

$$\text{Compressive Strength} = \frac{\text{Crushing load}}{\text{Cross section area}}$$

Fig.: Universal Testing Machine

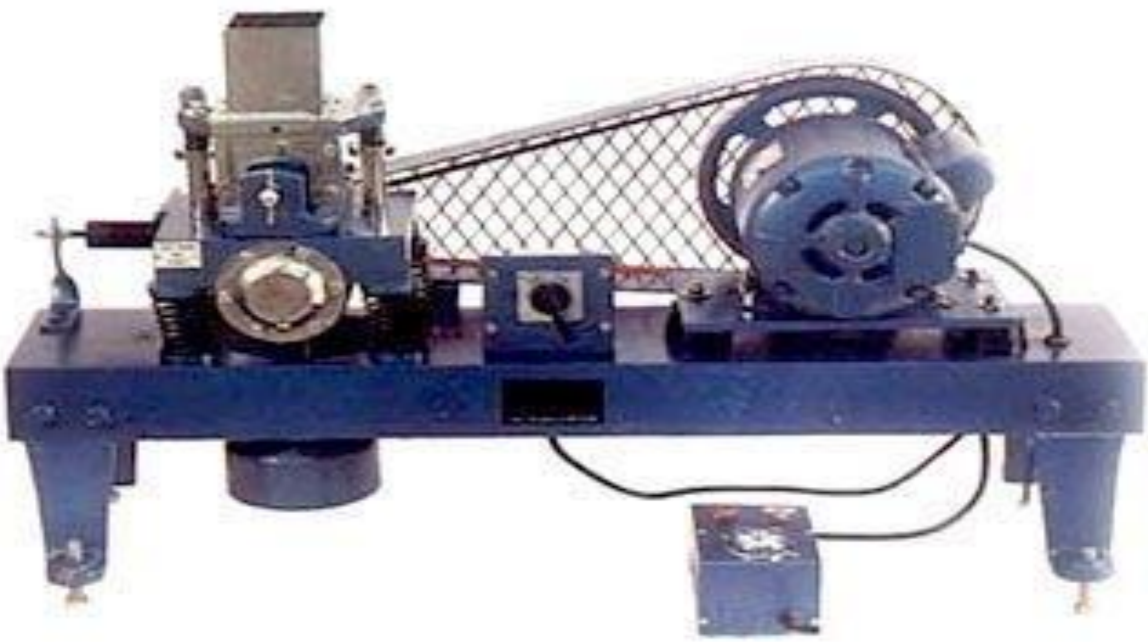


Fig.: Vibrator

RESULT: The average compressive strength of the given cement

1) 3 days ………………………. N/mm^2
2) 7 days……………………….. N/mm^2
3) 28 days……………………… N/mm^2

Table 2: Standard Specifications

Cement Type	Compressive Strength (Mpa)			
	1 Day	**3 Days**	**7 Days**	**28 Days**
OPC(33)	—	16	22	33
OPC(43)	—	23	33	43
OPC(53)	—	27	27	53
SRC	—	10	16	33
PPC	—	16	22	33
RHPC	16	27	—	—
PSC		16	22	33
High alumina	30	35	—	—
Super sulphated	—	15	22	30
Low heat	—	10	16	35
Masonry	—	—	2.5	5.0
IRS-T-40	—	—	37.5	—

Exp. No: - **Date:-**

SPECIFIC GRAVITY OF CEMENT

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

APPARATUS:

- Weighing balance
- specific gravity bottle (50ml capacity)
- kerosene
- funnel

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 (W1).
2. Fill the specific gravity bottle with cement sample at least half of the bottle and weigh with stopper (W2).
3. Fill the specific gravity bottle containing the cement, with kerosene (free of water) placing the stopper and weigh it (W3) ,While doing this do not allow any air bubbles to remain in the specific gravity bottle.
4. After weighing the bottle, the bottle shall be cleaned and dried again.
5. Then fill it with fresh kerosene and weigh it with stopper (W4).
6. Remove the kerosene from the bottle and fill it with full of water and weigh it with stopper (W5).

OBSERVATIONS:

Tabular Column:-

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 Cement			
Average Specific gravity of Cement			

$$\text{Specific gravity of Cement} = \frac{(W2 - W1)*(W4 - W1)}{((W4 - W1)-(W3-W2))*(W5 - W1)}$$

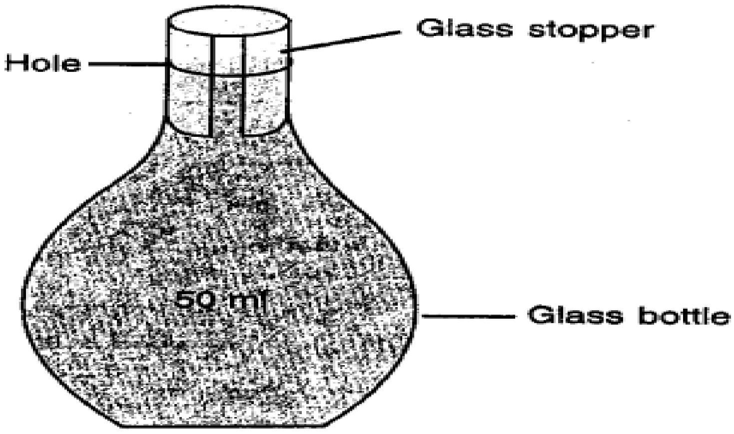


Fig.: Specific Gravity Bottle

CALCULATION:

RESULTS: Specific gravity of given Cement =---------------------------------------

CONCLUSION: The specific gravity of OPC should be between 2.6 to 3.15 the given sample of cement specific gravity within the above limits so it is suitable for use

Exp. No: - **Date:-**

FINENESS TEST OF CEMENT BY SIEVE ANALYSIS

AIM: To determine the fineness of the cement of the given sample by sieve analysis.

APPARATUS:

- IS: 90µ test sieve
- bottom pan
- weighing balance,
- brush

REFERENCE CODE: IS 4031 (PART1): 1988, IS460 (PART1): 1985.

THEORY: The degree of fineness of cement is a measure of the mean size of the grains. The finer cement has quicker action with water and gains early strength without change in the ultimate strength. Finer cement is susceptible to shrinkage and cracking.

PROCEDURE:

1. Accurately weigh 100 gms of cement sample and place it over the test sieve. Gently breakdown the air set lumps if any with fingers.
2. Hold the sieve with pan in both hands and sieve with gentle wrist motion, in circular and vertical motion for a period of 10 to 15 minutes without any spilling of cement.
3. Place the cover on the sieve and remove the pan. Now tap the other side of the sieve with the handle of brush and clean the outer side of the sieve.
4. Empty the pan and fix it below the sieve and continue sieving as mentioned in the steps 2 and 3. Totally sieve for 15 minutes and weigh the residue (Left over the sieve).

OBSERVATIONS AND CALCULATION:

1. Type of cement =............................
2. Brand of cement=....................................
3. Room temperature=............................

Tabular Column:-

SL No	Details	Trial 1	Trial 2	Trail 3
1	Weight of cement taken= W_1 gms			
2	Weight of cement retained after sieving = W_2 gms			
3	Fineness (W2/W1)×100 in %			
4	Average Fineness in %			

CALCULATION

$$\text{Percentage weight of Residue} = \frac{\text{Weight of sample left on the sieve x100}}{\text{Total weight of sample}}$$

RESULT: Fineness of the given sample is=……………………………………%

CONCLUSION: For ordinary cement fineness is less than 10% and rapid hardening cement fineness is less than 5%.so it is better for use.

Exp. No: - **Date:-**

AIR PERMEABILITY TEST FOR FINENESS OF CEMENT (IS-4031-PART-2)

AIM: To determine the specific surface area of cement.

APPARATUS: Blaine's variable air permeability apparatus, weight box, balance, stopwatch, mercury & crucible.

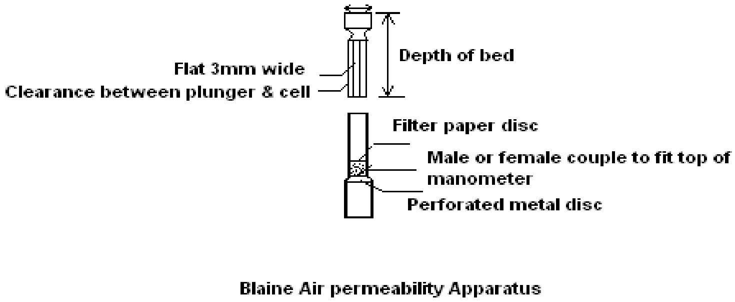


Fig: - Blaine Air permeability Apparatuses

PROCEDURE:

1. 1.Determine the bulk volume of the compacted bed of cement, V

   $V = (Wa - Wb)/\rho$

   Wa = Mass of the mercury required to fill the permeability cell.

   Wb = Mass of the mercury to fill the portion of the cell not occupied by the bed of the cement formed by 2.8 grams of standard cement sample.

   P = Density of the mercury at the temperature of test.
2. Determine the mass of the sample, W required to produce a bed having porosity e= 0.500
3. W = 3.15 v (1-e)
4. Evacuate the air until the fluid moves above the upper line without pulling it over the top of the side outlet. Close the valve & note the time Ts taken by the manometer liquid to fall from second mark.
5. Place the perforated disc in the permeability cell, and then add a filter paper, followed by the sample & another filter paper. Compress the specimen with plunger; remove the plunger & the couple the permeability cell with the manometer.
6. Evacuate the air until the fluid moves above the upper line without puling it over the top of side tube. Close the valve of manometer & note down the time T it takes for the fluid to drop from second mark to the third mark on the manometer when the air is allowed to permeate through the compacted bed of cement obtained in step 04. Note the air temperature.

Calculate the specific surface area S,

S = Ss √ T / √ Ts

Ss = Specific surface of standard cement in cm2 /gm

OBSERVATIONS:

Tabular Column:-

1	Mass of sample	W gm	
2	Air temp	Deg C	
3	Time for liquid to fall through the middle interval	Sec	
4	First run	Sec	
5	Second run	Sec	
6	Third run	Sec	
7	Average Time	Sec	
8	Specific Surface	Cm2/	

RESULT: Fineness of the given sample is=……………………………Kg/Cm^2

CONCLUSION:

Significance of fineness of cement: Hydration rate is function of fineness so setting time, shrinkage, heat of hydration & permeability are all influenced by fineness. Increasing the fineness substantially increase the rate of hydration thereby shortening the setting time speeding up the strength of concrete.

Exp:- **Date:-**

DESIGN OF CONCRETE MIX AS PER IS-10262 -2019

Aim: To study the proportioning of given mix ingredients

Requirements of concrete mix design

The requirements which form the basis of selection and proportioning of mix ingredients are

1) The minimum compressive strength required from structural consideration
2) The adequate workability necessary for full compaction with the compacting equipment available.
3) Maximum water-cement ratio and/or maximum cement content to give adequate durability for the particular site conditions
4) Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

Types of Mixes

i. Nominal Mixes

In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement-aggregate ratio which ensures adequate strength are termed nominal mixes.

ii. Standard mixes

The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes.

iii. Designed Mixes

In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down.

Mix Design procedures are as follows as per IS 10262-2019

Step 1: TARGET STRENGTH FOR MIX PROPORTIONING

Step 2: SELECTION OF WATER CEMENT RATIO

Step-3: ESTIMATION OF AIR CONTENT

Step 4: SELECTION OF WATER CONTENT

Step 5: CALCULATION OF CEMENT CONTENT

Step 6: PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

Step 7: MIX CALCULATIONS

Step 8: MIX PROPORTIONS FOR TRIAL NUMBER

Step 9: CASTING OF CONCRETE CUBES FOR 7 AND 28 DAYS

Problem 1:

A-1 STIPULATIONS FOR PROPORTIONING

a) Grade designation: M40
b) Type of cement: PPC conforming to IS 1489 (Part 1)
c) Maximum nominal size of aggregate: 20 mm
d) Minimum cement content and maximum water-cement ratio to be adopted and/or : Severe (for reinforced concrete) Exposure conditions as per Table 3 and Table 5 of IS 456
e) Workability: 75 mm (slump)
f) Method of concrete placing: Chute (Non pumpable)
g) Degree of site control: Good
h) Type of aggregate: Crushed angular aggregate
j) Maximum cement content not including fly ash: 450 kg/m3
k) Chemical admixture type: Superplasticizer - normal

A-2 TEST DATA FOR MATERIALS

a) Cement used: PPC conforming to IS 1489 (Part 1)
b) Specific gravity of cement: 2.88
c) Chemical admixture: Superplasticizer conforming to IS 9103
d) Specific gravity of 1) Coarse aggregate [at saturated surface dry : 2.74 (SSD) Condtion]
2) Fine aggregate [at saturated surface dry : 2.65 (SSD) Condtion],
3) Chemical admixture : 1.145
e) Water absorption 1) Coarse aggregate: 0.5 percent 2) Fine aggregate: 1.0 percent
f) Moisture content of aggregate [As per IS 2386 (Part 3)]
1) Coarse aggregate : Nil
2) Fine aggregate : Nil
g) Sieve analysis: 1) Coarse aggregate:

1) Coarse aggregate :

IS Sieve Sizes mm	*Analysis of Coarse Aggregate Fraction*		*Percentage of Different Fractions*			*Remarks*
	I (20-10 mm)	II (10 - 4.75 mm)	I 60 percent	II 40 percent	Conforming 100 percent	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
20	100	100	60	40	100	
10	0	71.20	0	28.5	28.5	Conforming to Table 7 of IS 383
4.75		9.40		3.7	3.7	
2.36		0				

2) Fine aggregate : Conforming to grading Zone II of Table 9 of IS 383

Solution:-

A-3 TARGET STRENGTH FOR MIX PROPORTIONING

f'ck = f ck+1.65 S or f'ck = f ck + X whichever is higher.

where f'ck = target average compressive strength at 28 days,

f ck = characteristic compressive strength at 28 days,

S = standard deviation, and X = factor based on grade of concrete.

From Table 2IS 10262-2019, standard deviation, S = 5 N/mm^2.

From Table 1, X = 6.5. Therefore, target strength using both equations, that is,

a) f'ck = f ck+1.65 S = 40+1.65 × 5 = 48.25 N/mm^2

b) f'ck = f ck + 6.5 = 40 + 6.5 = 46.5 N/mm^2 The higher value is to be adopted. Therefore, target strength will be 48.25 N/mm^2 as 48.25 N/mm^2 > 46.5 N/mm^2.

A-4 APPROXIMATE AIR CONTENT

From Table 3, the approximate amount of entrapped air to be expected in normal (non-air-entrained) concrete is 1.0 percent for 20 mm nominal maximum size of aggregate.

A-5 SELECTION OF WATER-CEMENT RATIO

From Fig. 1, the free water-cement ratio required for the target strength of 48.25 N/mm2 is 0.36 for OPC 43 grade curve. (For PPC, the strength corresponding to OPC 43 grade curve is assumed for the trial). This is lower than the maximum value of 0.45 prescribed for 'severe' exposure for reinforced concrete as per Table 5 of IS 456. 0.36< 0.45, hence O.K.

A-6 SELECTION OF WATER CONTENT

From Table 4, water content = 186 kg (for 50 mm slump) for 20 mm aggregate.

Estimated water content for $75\text{ mm slump} = 186 + \frac{3}{100}$ = **191.58 kg**

As super plasticizer is used, the water content may be reduced. Based on trial data, the water content reduction of 23 percent is considered while using superplasticizer at the rate 1.0 percent by weight of cement. Hence the water content = 191.58 × 0.77 = 147.52 kg ≈ 148 kg

A-7 CALCULATION OF CEMENT CONTENT

Water-cement ratio = 0.36 Cement content = (148 /0.36) = 411.11 kg/m^3 ≈ 412 kg/m^3

From Table 5 of IS 456, minimum cement content for 'severe' exposure condition = 320 kg/m^3 **412 kg/m3> 320 kg/m^3, hence, O.K.**

A-8 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGETE CONTENT

From Table 5, the proportionate volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.50 = 0.62.

In the present case water-cement ratio is 0.36. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.14, the proportion of volume of coarse, aggregate is increased by (at the rate of 0.028 ± 0.01 for every ± 0.05 change in water cement ratio). Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of

$$0.36 = 0.62 + 0.028 = 0.648.$$

Volume of fine aggregate content = 1 – 0.648 = 0.352

A-9 MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows:

a) Total volume = 1 m^3

b) Volume of entrapped air in wet concrete = 0.01 m^3

c) Volume of cement = $\frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$

$$= \frac{412}{2.88} \times \frac{1}{1000} = 0.143 \text{ m}^3$$

d) Volume of water = $\frac{\text{Mass of Water}}{\text{Specific gravity of Water}} \times \frac{1}{1000}$

$$= \frac{148}{1} \times \frac{1}{1000} = 0.148 \text{ m}^3$$

e) Volume of chemical admixture (superplasticizer) (@ 1.0 percent by mass of cementitious material)

$$= \frac{\text{Mass of chemical admixture}}{\text{Specific gravity of admixture}} \times \frac{1}{1000}$$

$$= \frac{4.12}{1.145} \times \frac{1}{1000} = 0.0036 \text{ m}^3$$

g) Volume of all in aggregate

= [(a-b)-(c+d+e)] = [(1-0.01) – (0.143 + 0.148 + 0.0 036)]

= 0.695 m^3

h) Mass of coarse aggregate

= g × Volume of coarse aggregate × Specific gravity of coarse aggregate × 1 000

= 0.695 × 0.648 × 2.74 × 1 000

= 1233.98 kg ≈ 1234 kg

j) Mass of fine aggregate

= g × volume of fine aggregate × Specific gravity of fine aggregate × 1 000

= 0.695 × 0.352 × 2.65 × 1 000

= 648.29 kg ≈ 648 kg

A-10 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement = 412 kg/m3 Water = 148 kg/m^3

Fine aggregate (SSD) = 648 kg/m^3

Coarse aggregate (SSD) = 1 234 kg/m^3

Chemical admixture = 4.12 kg/m^3,

Free water-cement ratio = 0.36

NOTE — Aggregates shall be used in saturated surface dry condition. If otherwise, when computing the requirement of mixing water, allowance shall be made for the free (surface) moisture contributed by the fine and coarse aggregates. On the other hand, if the aggregates are dry, the amount of mixing water shall be increased by an amount equal to the moisture likely to be absorbed by the aggregates. Necessary adjustments are also required to be made in mass of aggregates. The surface water and percentage water absorption of aggregates shall be determined according to IS 2386.

A-11 ADJUSTMENT ON WATER, FINE AGGREGATE AND COARSE AGGREGATE

(If the coarse and fine aggregate is in dry condition)

a) Fine Aggregate (Dry) $= \frac{\text{Mass of fine aggregate in SSD condition}}{1 + \text{Water absorption}/100}$

$= \frac{648}{1 + 1/100}$

= 641.58 kg/m^3 ≈ 642 kg/m^3

b) Coarse Aggregate (Dry) $= \frac{\text{Mass of Coarse aggregate in SSD condition}}{1 + \text{Water absorption}/100}$

$= \frac{1234}{1 + 0.50/100}$

= 1227.86 kg/m3 ≈ 1228 kg/m^3

The extra water to be added for absorption by coarse and fine aggregate,

1) For coarse aggregate = Mass of coarse aggregate in SSD condition – mass of coarse aggregate in dry condition = 1 234 – 1 228 = 6 kg

2) For fine aggregate = Mass of fine aggregate in SSD condition – mass of fine aggregate in dry condition = 648 – 642 = 6 kg

The estimated requirement for added water, therefore, becomes = 148 + 6 + 6 = 160 kg/m^3

A-12 MIX PROPORTIONS AFTER ADUSTMENT FOR DRY AGGREGATES

Cement = 412 kg/m^3

Water (to be added) = 160 kg/m^3

Fine aggregate (Dry) = 642 kg/m^3

Coarse aggregate (Dry) = 1 228 kg/m^3

Chemical admixture = 4.12 kg/m^3

Free water-cement ratio = 0.36

A-13 The total mass of coarse aggregate shall be divided into two fractions of 20 - 10 mm and 10 - 4.75 mm, in a suitable ratio, to satisfy the overall grading requirements for 20 mm max size aggregate as per Table 7 of IS 383. In this example, the ratio works out to be 60:40 as shown under A-2 (g).

A-14 The slump shall be measured and the water content and dosage of admixture shall be adjusted for achieving the required slump based on trial, if required. The mix proportions shall be reworked for the actual water content and checked for durability requirements.

A-15 Two more trials having variation of ± 10 percent of water-cement ratio in A-10 shall be carried out and a graph between three water-cement ratios and their corresponding strengths shall be plotted to work out the mix proportions for the given target strength for field trials. However, durability requirement shall be met.

Problem 2

Design of **M25** concrete mix as per IS: 10262-2019.

Design stipulations for proportioning

Grade designation: M25
Type of cement: OPC 53 grade confirming to IS 269-2015
Maximum nominal size of aggregates: 20 mm
Minimum cement content: 320 kg/m^3
Maximum water cement ratio: 0.50
Workability: 25-50 mm (slump)
Exposure condition: Mild
Degree of supervision: Good
Type of aggregate: Crushed angular aggregate
Maximum cement content: 450 kg/m^3
Chemical admixture: Not recommended

TEST DATA FOR MATERIALS

Cement used: OPC 43 grade confirming to IS 8112
Specific gravity of cement: 3.15
Specific gravity:
 Coarse aggregate: 2.68
 Fine aggregate: 2.65
Water absorption:
 Coarse aggregate: 0.6 percent
 Fine aggregate: 1.0 percent
Free (surface) moisture
 Coarse aggregate: Nil (absorbed moisture full)
 Fine aggregate: Nil
Sieve analysis
 Coarse aggregate: Conforming to Table 2 of IS: 383
 Fine aggregate: Conforming to Zone I of IS: 383

Solution:-

Problem 3

Design of **M30** concrete mix as per IS: 10262-2019.

Design stipulations for proportioning

Grade designation: M30
Type of cement: OPC 43 grade confirming to IS 8112
Maximum nominal size of aggregates: 20 mm
Minimum cement content: 350 kg/m^3
Maximum water cement ratio: 0.50
Workability: 25 - 50 mm (slump)
Exposure condition: Moderate
Degree of supervision: Good
Type of aggregate: Crushed angular aggregate
Maximum cement content: 450 kg/m^3
Chemical admixture: Not recommended

TEST DATA FOR MATERIALS

Cement used: OPC 43 grade confirming to IS 8112
Specific gravity of cement: 3.15
Specific gravity of
 Coarse aggregate: 2.68
 Fine aggregate: 2.65
Water absorption
 Coarse aggregate: 0.6 percent
 Fine aggregate: 1.0 percent
Free (surface) moisture
 Coarse aggregate: Nil (absorbed moisture full)
 Fine aggregate: Nil
Sieve analysis
 Coarse aggregate: Conforming to Table 2 of IS: 383
 Fine aggregate: Conforming to Zone I of IS: 383

Solution:-

Problem 4

Design of **M35** concrete mix as per IS: 10262-2009.

Design stipulations for proportioning

Grade designation: M35
Type of cement: OPC 53 grade confirming to IS 269-2015
Maximum nominal size of aggregates: 20 mm
Minimum cement content: 350 kg/m^3
Maximum water cement ratio: 0.50
Workability: 25 - 50 mm (slump)
Exposure condition: Moderate
Degree of supervision: Good
Type of aggregate: Crushed angular aggregate
Maximum cement content: 450 kg/m^3
Chemical admixture: recommended

TEST DATA FOR MATERIALS

Cement used: OPC 53 grade confirming to IS 269-2015
Specific gravity of cement: 3.15
Specific gravity of
  Coarse aggregate: 2.68
  Fine aggregate: 2.62
Water absorption
  Coarse aggregate: 0.5 percent
  Fine aggregate: 1.0 percent
Free (surface) moisture
  Coarse aggregate: Nil (absorbed moisture full)
  Fine aggregate: Nil
Sieve analysis
  Coarse aggregate: Conforming to Table 2 of IS: 383
  Fine aggregate: Conforming to Zone I of IS: 383

Solution:-

Exp. No: - **Date:-**

SLUMP TEST

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

APPARATUS:

- pan to mix concrete
- weighing balance
- trowel
- cone
- steel scale
- tamping rod
- mixing tray
-

REFERENCE CODE:

- IS: 456-2000, code for plain and reinforced concrete
- IS: 1199-2018 methods of sampling and analysis of concrete
- IS: 7320- Specification for slump test apparatuses

THEORY:

This is the test extensively used in site work all over the world. Fresh unsupported concrete will flow to the sides and the vertical sinking of concrete is known as slump. 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.

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 and non-absorbent 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. Using the tampering rod or a trowel strike of the excess concrete above the concrete cone. Measure the vertical height of cone (h1).
4. Slowly and carefully remove in the vertical direction. As soon as the cone is removed the concrete settles in vertical direction. Place the steel scale above top of settled concrete in horizontal position and measure the height of cone (h2).
5. Complete the experiment in two minutes after sampling.
6. The difference of two heights (h1-h2) gives the value of slump

OBSERVATIONS:

1) Type of cement=……………….
2) Brand of cement=……………….
3) Density of concrete=...............

Volume of Cone = Area of cone × height = ____________ m^3

Mass of concrete = $\frac{\text{Volume of cone}}{9.81} \times 24 \times 1000$ = _________ Kg

Add 40% Extra dry material required = Mass of concrete × 1.4 = _______ Kg

CALCULATION:-

Grade of concrete =

Mix proportion =

Cement = $\frac{\text{Dry volume}}{\text{Sum of Mix proportion}}$

= _____ kg

Fine Aggregate

= _____ kg

Coarse Aggregate

= _____ kg

Water cement ratio =

Tabular Column:-

Trail No	Proportion					SLUMP in mm			Remarks
	w/c	W -liter	C - kg	FA- kg	CA- kg	IR (mm)	FR (mm)	Final slump value	
1									
2									
3									
4									
5									
6									
7									
8									

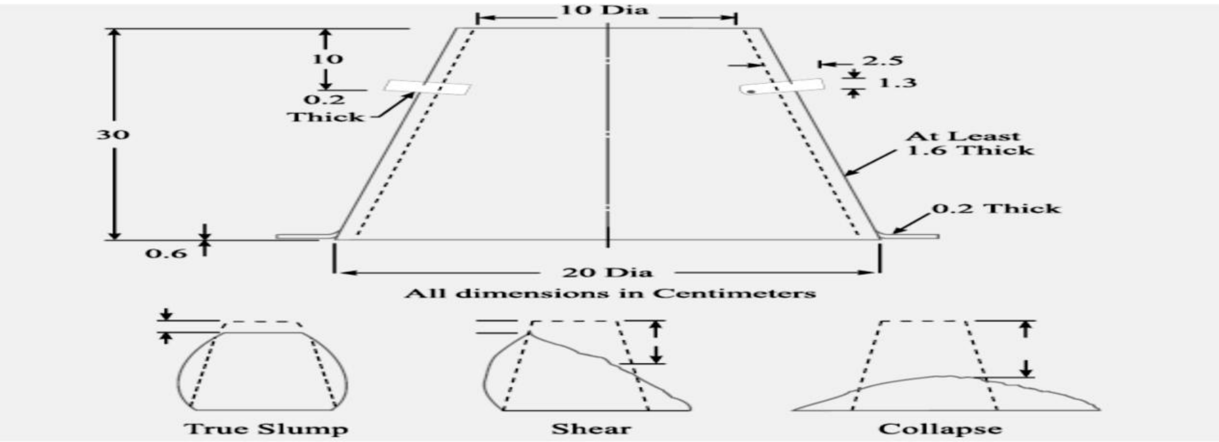


Fig: - Different Types of Slump

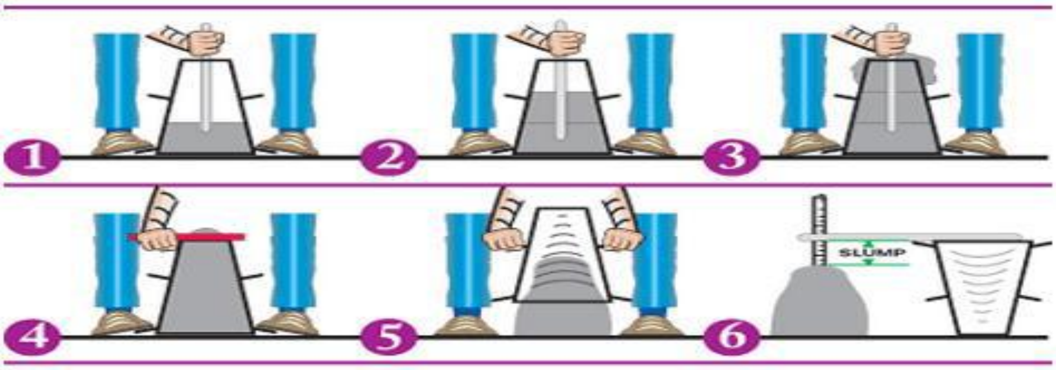


Fig: - Concrete slump test procedure

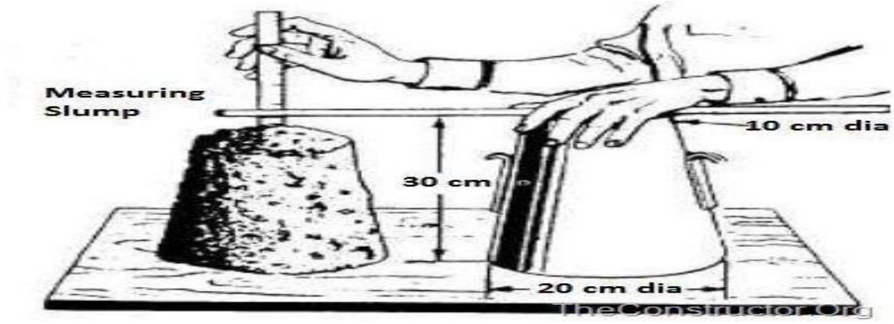


Fig:-Measuring the slump values

Collapse Slump:- In a collapse slump the concrete collapses completely. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which slump test is not appropriate.

Shear Slump: - In a shear slump the top portion of the concrete shears off and slips sideways. OR If one-half of the cone slides down an inclined plane, the slump is said to be a shear slump.

1. If a shear or collapse slump is achieved, a fresh sample should be taken and the test is repeated.
2. If the shear slump persists, as may the case with harsh mixes, this is an indication of lack of cohesion of the mix.

True Slump:-In a true slump the concrete simply subsides, keeping more or less to shape

1. This is the only slump which is used in various tests.
2. Mixes of stiff consistence have a Zero slump, so that in the rather dry range no variation can be detected between mixes of different workability.

However , in a lean mix with a tendency to harshness, a true slump can easily change to the shear slump type or even to collapse, and widely different values of slump can be obtained in different samples from the same mix; thus, the slump test is unreliable for lean mixes.

Applications of Slump Test

1. The slump test is used to ensure uniformity for different batches of similar concrete under field conditions and to ascertain the effects of plasticizers on their introduction.
2. This test is very useful on site as a check on the day-to-day or hour- to-hour variation in the materials being fed into the mixer. An increase in slump may mean, for instance, that the moisture content of aggregate has unexpectedly increases.
3. Other cause would be a change in the grading of the aggregate, such as a deficiency of sand.
4. Too high or too low a slump gives immediate warning and enables the mixer operator to remedy the situation.
5. This application of slump test as well as its simplicity is responsible for its widespread use.

Result:

The Slump value 0.40 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

The Slump value 0.45 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

The Slump value 0.50 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

The Slump value 0.55 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

The Slump value 0.60 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

The Slump value 0.65 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

Conclusion:

Table 3: Recommended values for slump based on Degree of workability

Degree of workability	Slump		Use for which concrete is suitable
	mm	in	
Very low	0-25	0-1	Very dry mixes; used in road making. Roads vibrated by power operated machines.
Low	25-50	1-2	Low workability mixes; used for foundations with light reinforcement. Roads vibrated by hand operated Machines.
Medium	50-100	2-4	Medium workability mixes; manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibrations.
High	100-175	4-7	High workability concrete; for sections with congested reinforcement. Not normally suitable for vibration

Exp. No: - **Date:-**

COMPACTION FACTOR TEST

AIM: To determine the workability of freshly mixed concrete by the Compacting Factor Test.

APPARATUS:

- Compaction factor apparatus
- Weighing balance
- tamping rod Trowel
- Scoop about 150 mm long
- Tamper(16 mm in diameter and 600 mm length)
- Ruler
- Tools and containers for mixing or concrete mixer etc.

REFERENCE CODE:

- IS; 1199-2018 methods of sampling and analysis of concrete
- IS:5515-1983 Specification for compressive factor apparatus

THEORY:

The compaction factor is defined as the ratio of the weight of partially compacted concrete to the weight of fully compacted concrete. The compacting factor test is designed primarily for use in the laboratory but it can also be used in the field. It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability as are normally used when concrete is to be compacted by vibration.

PROCEDURE:

1. Grease the inner surface of the hoppers and the cylinder and Fasten the hopper doors.
2. Weigh the empty cylinder accurately (W1. Kgs) an Fix the cylinder on the base with nuts and bolts.
3. Mix coarse and fine aggregates and cement dry until the mixture is uniform in colour and then with water until concrete appears to be homogeneous.
4. Fill the freshly mixed concrete in upper hopper gently with trowel without compacting.
5. Release the trap door of the upper hopper and allow the concrete of fall into the lower hopper bringing the concrete into standard compaction.
6. 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.

7. Remove the excess concrete above the top of the cylinder by a trowel.
8. Find the weight of cylinder i.e cylinder filled with partially compacted concrete(W2kgs)
9. Refill the cylinder with same sample of concrete in approx. 4 layers, tamping each layer with tamping for 25 times in order to obtain full compaction of concrete.
10. Level the mix and weigh the cylinder filled with fully compacted concrete (W3 Kg).
11. Repeat the procedure for different for different a trowel.

OBSERVATIONS AND CALCULATIONS:

Grade of concrete =
Mix proportion =
Cement = ________kg
Fine Aggregate = ________kg
Coarse Aggregate = ______kg
Water cement ratio =
Weight of empty cylinder W1 =…………………………. Kgs

Tabular Column:-

Trail no	Quantity of material					Mass of cylinder With partially compaction W2 (Kgs)	Mass of cylinder with fully compaction W3 (Kgs)	Compaction Factor $\frac{(W1 - W2)}{(W3 - W1)}$
	w/c	W litre	C kg	FA kg	CA kg			
1								
2								
3								
4								
5								
6								
7								

CALCULATIONS

$$\textbf{Compaction factor} = \frac{W_2 - W_1}{W_3 - W_1}$$

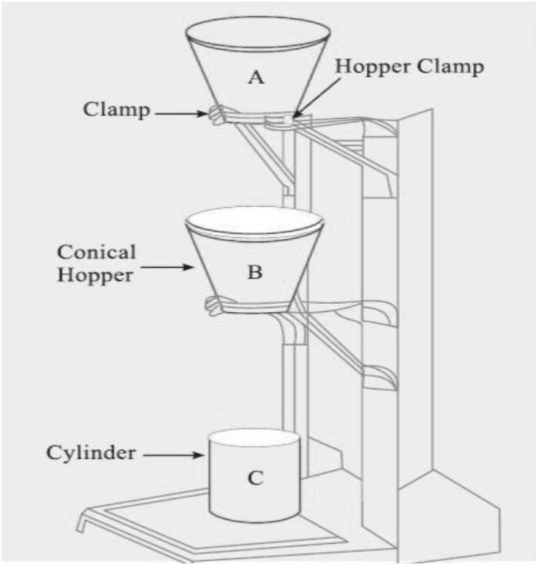


Fig.: Compaction factor Apparatuses

RESULTS:

The Compaction factor value 0.40 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

The Compaction factor value 0.45 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

The Compaction factor value 0.50 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

The Compaction factor value 0.55 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

The Compaction factor value 0.60 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

The Compaction factor value 0.65 w/c =………mm\ (indicate Low/ Medium/ High Degree of workability)

Table 4: Recommended values for Compaction Factor based on Degree of workability

Degree of workability	**Compaction Factor**	**Use for which concrete is suitable**
Very low	0.78	Very dry mixes; used in road making. Roads vibrated by power operated machines.
Low	0.85	Low workability mixes; used for foundations with light reinforcement. Roads vibrated by hand operated Machines.
Medium	0.92	Medium workability mixes; manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibrations.
High	0.95	High workability concrete; for sections with congested reinforcement. Not normally suitable for vibration

Exp. No: - **Date:-**

VEE-BEE CONSISTOMETER

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

APPARATUS:

- Vee-Bee consistometer test apparatus
- Stopwatch
- Standard iron rod
- Weighing device
- Tamper(16 mm in diameter and 600 mm length)
- Tools and containers for mixing

REFERENCE CODE:

- IS: 1199-2018 method of sampling and analysis of concrete
- IS: 456-2000 code of practice for plain and reinforced concrete
- IS: 10510:1983 specification for vee-bee consistometer

THEORY:

The Vee-bee consistometer (measures the remoulding ability of concrete under vibration. The test results reflect the amount of energy required to remould a quantity of concrete under given vibration conditions. The Veebee consistometer is applicable to concrete with slumps less than 5cm.

PROCEDURE:

1. Slump test as described earlier is performed, 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 in the pot. The electrical vibrator is then switched on and simultaneously a stop watch started.
3. The vibration is continued till such a time as the conical shape of the concrete disappears and the concrete assumes a cylindrical shape. This can be judged by observing the glass disc from the top for disappearance of transparency.
4. Immediately when the concrete fully assumes a cylindrical shape, the stop watch is switched off. The time required for the shape of concrete to change from slump cone shape to cylindrical shape in seconds is known as Vee Bee Degree.
5. This method is very suitable for very dry concrete whose slump value cannot be measured by Slump Test, but the vibration is too vigorous for concrete with a slump greater than about 50 mm.

OBSERVATIONS:

1) Type of cement=……………….
2) Brand of cement=……………….
3) Grade of concrete =
4) Mix proportion =
5) Cement = ________kg
6) Fine Aggregate = _______kg
7) Coarse Aggregate = _____kg
8) Water cement ratio =

Tabular Column:-

Trail no	Quantity of material					Slump value mm	Vee Bee Degree of concrete in sec	Remark
	W/c	W liter	C- kg	FA -kg	CA-kg			
1								
2								
3								
4				`				
5								
6								

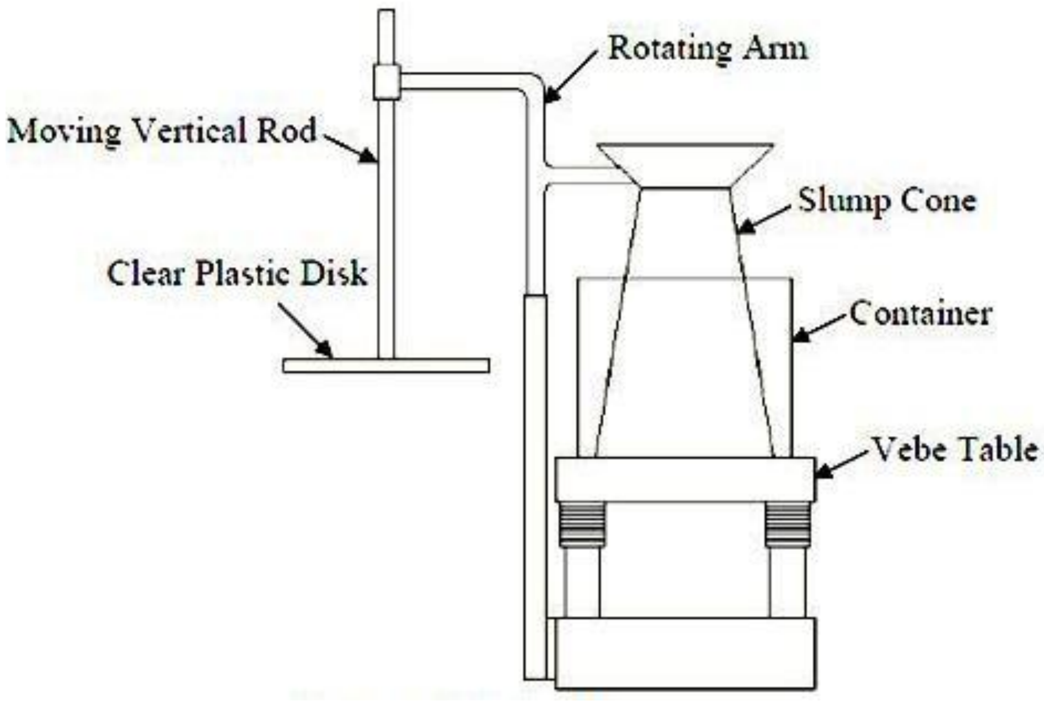


Fig. Vee-bee Consistometer

RESULTS: The Vee-Bee Degree for 0.45 W/C =………Sec
The Vee-Bee Degree for 0.50W/C =………Sec
The Vee-Bee Degree for 0.55 W/C =………Sec
The Vee-Bee Degree for 0.60 W/C =………Sec
The Vee-Bee Degree for 0.65 W/C =………Sec

CONCLUSION:-

Table.5: Consistency Measurement for Different Workability Mix in Slump Test, Compaction Factor Test and Vee -Bee Test

Workability description	Workability measurement		Vee –Bee time seconds
	Slump mm	Compacting factor	
Extremely dry	-	-	32-18
Very stiff	-	0.70	18-20
stiff	0-25	0.75	10-5
Stiff plastic	25-50	0.85	5-3
Plastic	75-100	0.90	3-0
Flowing	150-175	0.95	-

Exp. No.: **Date:**

COMPRESSIVE STRENGTH OF CONCRETE CUBES

AIM: To determine the compressive strength of given concrete mixes.

APPARATUS:

- Testing Machine
- Specimen mould
- tamping rod
- weighing device
- Tools and containers for mixing.

REFERENCE CODE:

- IS : 1199-1959 method of sampling and analysis of concrete
- IS:516 – 2018 method of test for strength of concrete

THEORY:

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.

PROCEDURE:

1. Sampling of Materials - Samples of aggregates for each batch of concrete shall be of the desired grading and shall be in an air-dried condition. The cement samples on arrival at the laboratory shall be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material.
2. Proportioning - The proportions of the materials, including water in concrete mixes used for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work.
3. Weighing - The quantities of cement, each size of aggregate, and water for each batch shall be determined by weight to an accuracy of 0.1 percent of the total weight of the batch.
4. Mixing Concrete - The concrete shall be mixed by hand or preferably in a laboratory batch mixer in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.
5. Mould - Test specimens cubical in shape shall be 15 × 15 × 15 cm.Compacting - The test specimens shall be made as soon as practicable after mixing and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance.
6. Curing - The test specimens shall be stored in a place free from vibration in moist air of at least 90 percent relative humidity and at a temperature of 27° ±

2°C for 24 hours ± ½ hour from the time of addition of water to the dry ingredients.

7. Placing the Specimen in the Testing Machine - The bearing surfaces of the testing machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen which are to be in contact with the compression platens.
8. In the case of cubes the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast that is not to the top and bottom.
9. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine.
10. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained.
11. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted

OBSERVATION:

1) Grade of Concrete =………………………………..
2) Date of casting=…………………………………
3) Date of Testing=………………………………….
4) Age of concrete=………………………………….
5) Curing history=..
6) Dimension of the Specimen =...................

Tabular Column:-

Mix proportions	**Age (days)**	**Weight (Kg)**	**Density (Kg/m^3)**	**Crushing load(kN)**	**Compressive Strength (MPa)**	**Average Compressive Strength (MPa)**
	7					
	28					

sectional area

Compressive strength = ———————

Crushing load Cross

Fig.: Universal Testing Machine

RESULT:

7days Average Compressive strength of Concrete --------N/mm^2

28 days Average Compressive strength of Concrete -------N/mm^2

Significance of Compressive Strength of concrete

Compressive strength test results are primarily used to determine that the concrete mixture as delivered meets the requirements of the specified strength. Strength test results from cast cylinders may be used for quality control, acceptance of concrete, or for estimating the concrete strength in a structure for the purpose of scheduling construction operations such as form removal or for evaluating the adequacy of curing and protection afforded to the structure.

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, tamping rods, weighing device, Tools and containers for mixing, Tamper

REFERENCE CODE:

- IS:456:2000 code of practice for plain and reinforced concrete
- IS:5816:1999 Method of test for split tensile strength of concrete

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.

PROCEDURE:

1. Sampling of Materials - Samples of aggregates for each batch of concrete shall be of the desired grading and shall be in an air-dried condition. The cement samples, on arrival at the laboratory, shall be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material.
2. Proportioning - The proportions of the materials, including water, in concrete mixes used for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work.
3. Weighing - The quantities of cement, each size of aggregate, and water for each batch shall be determined by weight, to an accuracy of 0.1 percent of the total weight of the batch.
4. Mixing Concrete - The concrete shall be mixed by hand, or preferably, in a laboratory batch mixer, in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.
5. Mould - The cylindrical mould shall be of 150 mm diameter and 300 mm height conforming to IS: 10086-1982.
6. Compacting - The test specimens shall be made as soon as practicable after mixing, and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance.
7. Curing - The test specimens shall be stored in a place, free from vibration, in moist air of at least 90 percent relative humidity and at a temperature of 27° ± 2°C for 24 hours ± ½ hour from the time of addition of water to the dry ingredients.

8. Placing the Specimen in the Testing Machine - The bear
9. ing surfaces of the supporting and loading rollers shall be wiped clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers.
10. Two bearings strips of nominal (1/8 in i.e 3.175mm) thick plywood free of imperfections approximately (25mm) wide and of length equal to or slightly longer than that of the specimen should be provided for each specimen.
11. The bearing strips are placed between the specimen and both upper and lower bearing blocks of the testing machine or between the specimen and the supplemental bars or plates.
12. Draw diametric lines an each end of the specimen using a suitable device that will ensure that they are in the same axial plane. Centre one of the plywood strips along the centre of the lower bearing block.
13. Place the specimen on the plywood strip and align so that the lines marked on the ends of the specimen are vertical and cantered over the plywood strip.
14. Place a second plywood strip lengthwise on the cylinder, cantered on the lines marked on the ends of the cylinder. Apply the load continuously and without shock, at a constant rate within, the range of 689 to 1380 kPa/min splitting tensile stress until failure of the specimen
15. Record the maximum applied load indicated by the testing machine at failure. Note the type of failure and appearance of fracture

OBSERVATION AND CALCULATION:

1) Mix proportion =………………
2) Date of casting=………………
3) Date of Testing=………………
4) Age of concrete=……………

Tabular Column:-

Mix proportions	Age (days)	Weight (Kg)	Density (Kg/m^3)	Crushing load P in (kN)	Splitting Tensile Strength (MPa)	Average Splitting Tensile Strength (MPa)
	7					
	28					

Calculate the splitting tensile strength of the specimen as follows:

$$T=2P/\Pi DL$$

where
D: diameter
L : Length, m
P : maximum applied load indicated by testing machine, kN
T : splitting tensile strength,

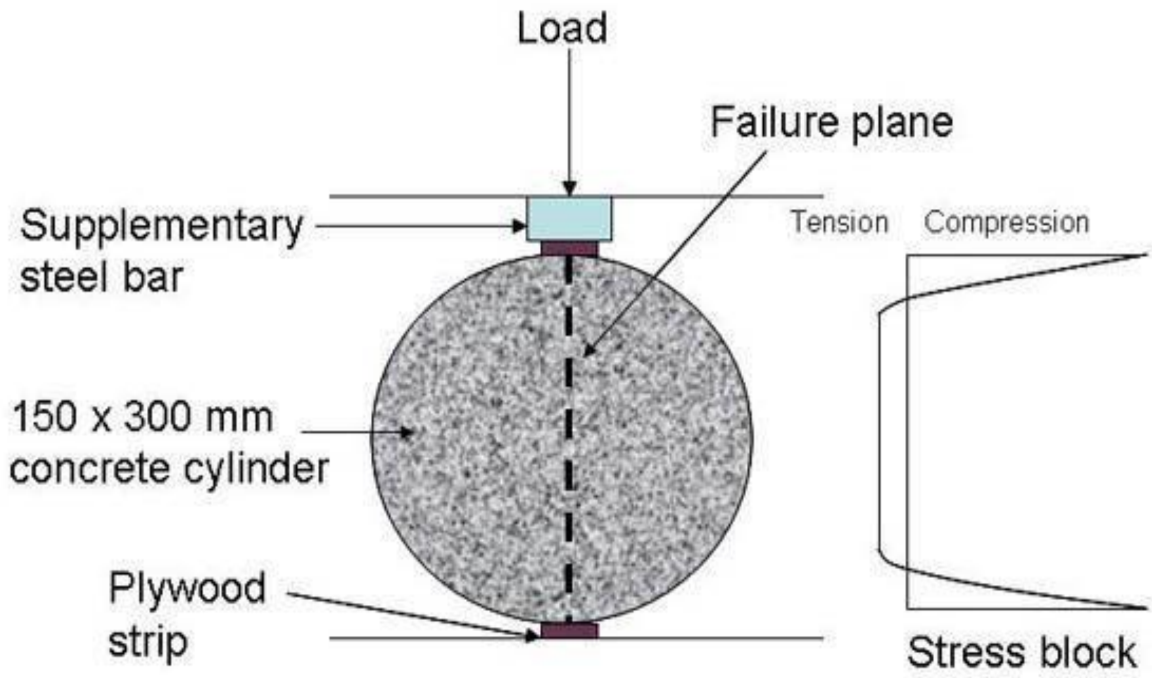


Fig.: Loading Arrangement for Determining Split Tensile Strength

RESULT:

i) The average 7 Days Tensile Strength of concrete sample is found to be …..…..MPa

ii) The average 28 Days Tensile Strength of concrete sample is found to be …..…MPa

Significance of Split Tensile test on concrete

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

Exp. No.: **Date:**

FLEXURAL STRENGTH OF CONCRETE BEAM (IS: 516-2018)

AIM: To find the flexural strength of concrete beam specimen.

APPARATUS: Flexure testing machine, beam moulds and accessories.

THEORY: The testing machine may be of any reliable type of sufficient capacity for the tests and capable of applying the load at the rate7kg/sq cm/min. The permissible errors shall be not greater than ± 0.5percent of the applied load where a high degree of accuracy is required and not greater than ± 1.5 percent of the applied load for commercial type of use. The bed of the testing machine shall be provided with two steel rollers, 38 mm in diameter, on which the specimen is to be supported, and these rollers shall be so mounted that the distance from centre to centre is 60 cm for 15.0 cm specimens or 40 cm for 10.0 cm specimens. The load shall be applied through two similar rollers mounted at the third points of the supporting span that is, spaced at 20 or 13.3 cm centre to centre. The load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to any tensional stresses or restraints.

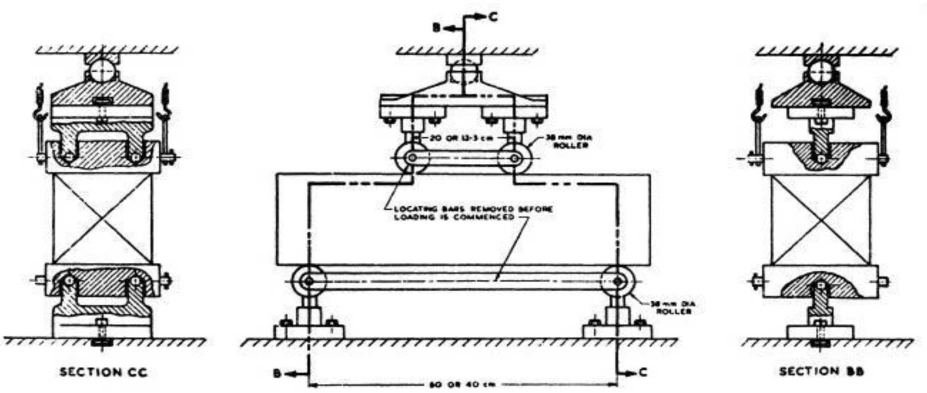


Fig.: Arrangement of Flexural strength

PROCEDURE:

1) The test specimens stored in water for 48 hrs before testing shall be taken and tested immediately in the wet condition only.
2) The dimension of each specimen shall be noted before testing.
3) Any loose sand and other materials are wiped clean from the surface.
4) The specimen shall be kept on the machine such that the centre line of the specimen and the axis is aligned properly. Load is applied at a rate of 7kg/sqcm/min i.e. at 400kg/min for 15cm specimen.
5) The load is applied till the specimen fails and the max load is noted down

CALCULATION:

Modulus of Rupture $f_b = pl/bd^2$

- if **a** is greater than 20cm for 15cm specimen and 13.3cm for 10cm specimen

$$f_b = 3pa/bd^2$$

- If a is less than 20cm but greater than 17cm for 15cm specimen and
- If **a,** is less than 13.3cm and greater than 11cm for 10cm specimen.
- If a is less than 17cm and 11 cm for 15 and 10 cm specimen respectively, the results shall be discarded

b=width of specimen,

l=span (distance between supports)

d=depth of specimen

p= Max load.

RESULT:

1. Size of specimen_______________
2. Max Load ________________
3. Position of fracture (a) _________________
4. Modulus of rupture_______________________(kg/cm^2)

CONCLUSION:

Significance of flexural strength of concrete beam

Designers of pavements use a theory based on flexural strength. Therefore, laboratory mix design based on flexural strength tests may be required, or a cementitious material content may be selected from past experience to obtain the needed design MR (modulus of rupture). Some also use MR (modulus of rupture) for field control and acceptance of pavements. Very few use flexural testing for structural concrete. Agencies not using flexural strength for field control generally find the use of compressive strength convenient and reliable to judge the quality of the concrete as delivered.

Exp. No: **Date:**

NON DESTRUCTIVE TESTS BY
a) REBOUND HAMMER TEST [IS: 13311(2)-1992]

AIM: To determine the compressive strength of concrete and quality of concrete by Non destructive testing

APPARATUS: Rebound hammer

THEORY: Rebound Hammer test is quick method for assessing the quality of concrete based on surface hardness indicated by rebound hammer. Higher the rebound value indicates higher strength, surface hardness of concrete. Most commonly use equipment is submidt rebound hammer. This equipment works on the principle that the spring controlled mass slides on a plunger within a tubular housing.

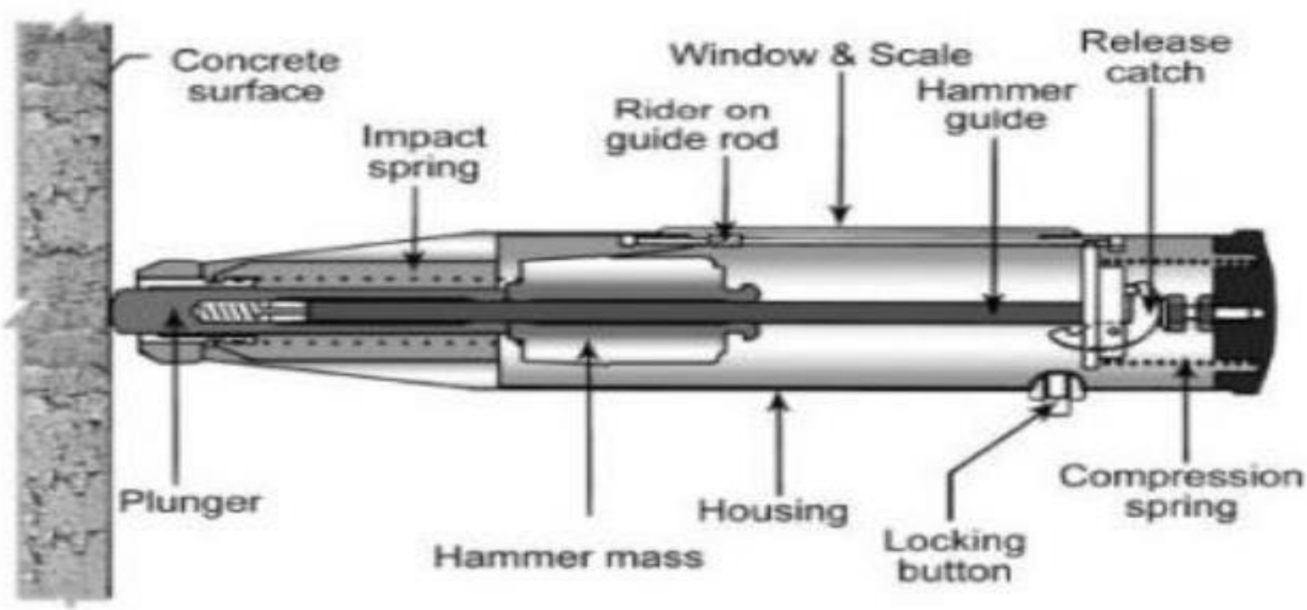


Fig: Component of Rebound Hammer

PROCEDURE:

1. For testing, smooth, clean and dry surface is to be selected.
2. The point of impact should be at least 20mm away from any edge or shape discontinuity.
3. For taking a measurement, the rebound hammer should be held at right angles to them surface of the concrete member.
4. The test can thus be conducted horizontally on vertical surfaces or vertically upwards or downwards on horizontal surfaces.
5. Firmly hold the instrument in a position that allows the plunger to strike the surface.
6. After the impact, note down the reading obtained from the instrument.

7. Repeat the trail continuously for 8 – 10 trails and note down the reading obtained by each trail.
8. Take mean of all trails and from the standard graph, the strength of concrete can be determined corresponding to value obtained during the experiment.
9. Depending upon the position of plunger, the corresponding curve should be chosen, to determine strength.

OBSERVATION AND CALCULATION

Dimension of concrete Cube = 150mm*150mm

Dimension of concrete Cylinder = 100mm*200mm

Tabular Column:-Rebound Hammer test for Concrete Cube

Sl.No	Description	Trial No.	Rebound Hammer No	Compressive Strength MPa	Average Compressive Strength MPa
1	Vertically downward Scale A	1			
		2			
		3			
2	Horizontal Scale B	1			
		2			
		3			
3	Vertically upward Scale C	1			
		2			
		3			

Tabular Column:-: Rebound Hammer test for Concrete Cylinder

Sl.No	Description	Trial No.	Rebound Hammer No	Compressive Strength MPa	Average Compressive Strength MPa
1	Vertically downward Scale A	1			
		2			
		3			
2	Horizontal Scale B	1			
		2			
		3			
3	Vertically upward Scale C	1			
		2			
		3			

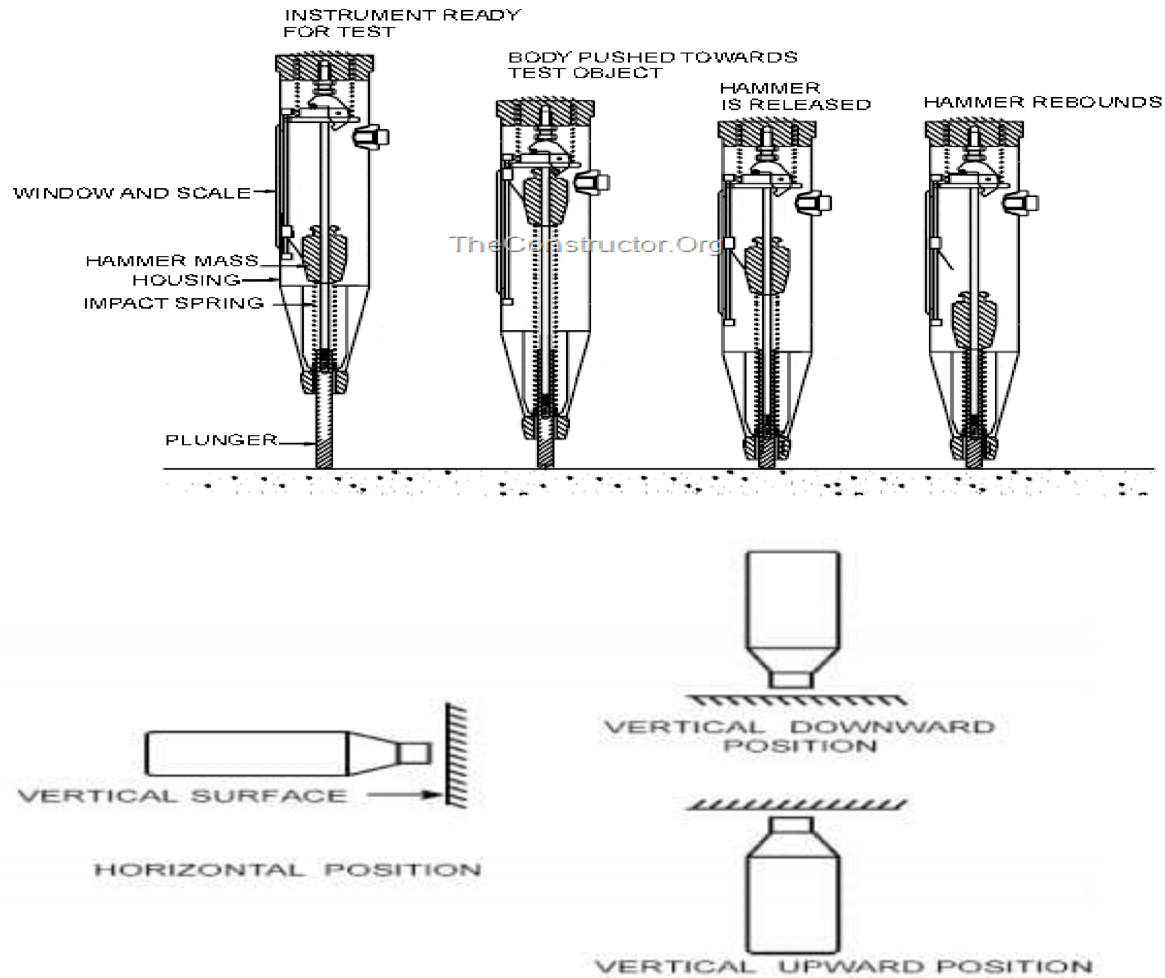
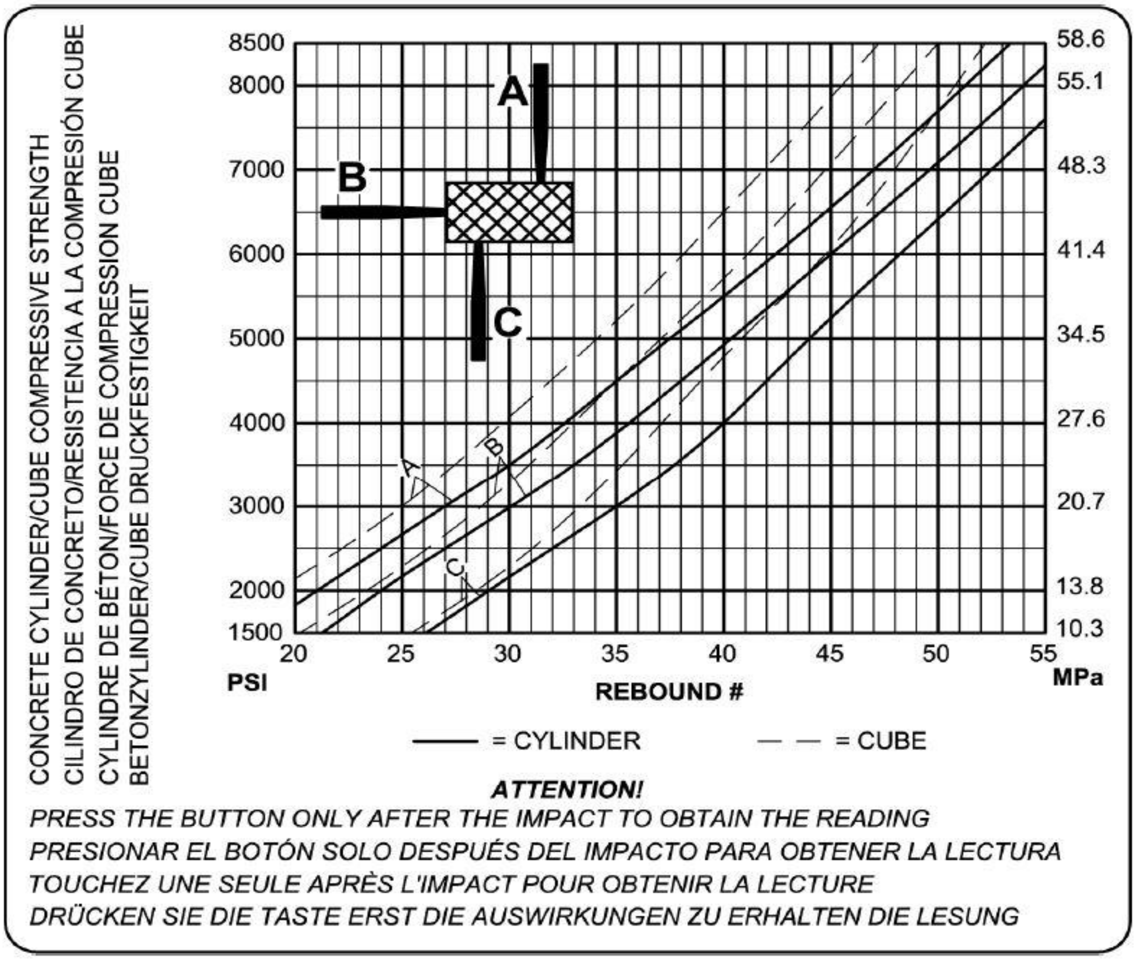


Fig.: Rebound hammers test and it's Position

The impact energy required for the rebound hammer is different for different applications. Approximate Impact energy levels are mentioned in the table-1 below for different applications.

Table-6: Impact Energy for Rebound Hammers for Different Applications As per IS: 13311(2)-1992

Sl.No	Applications	Approximate Impact Energy for Rebound Hammer in Nm
1	For Normal Weight Concrete	2.25
2	For light weight concrete / For small and impact resistive concrete parts	0.75
3	For mass concrete testing Eg: In roads, hydraulic structures and pavements	30.00



Graph: Rebound hammer test

RESULTS:

The compressive strength of given specimen vertically downward Scale A is ___N/mm^2

The compressive strength of given specimen horizontal Scale B is ____N/mm^2

The compressive strength of given specimen vertically upward Scale C is ____N/mm^2

CONCLUSION: The destructive and nondestructive value of compressive strength of given concrete specimen is

Table 7: Recommended Value for Rebound Hammers

Average Rebound Number	Quality of Concrete
>40	Very good hard layer
30 to40	Good layer
20 to 30	Fair
<20	Poor Concrete
0	Delaminated

Exp: **Date:**

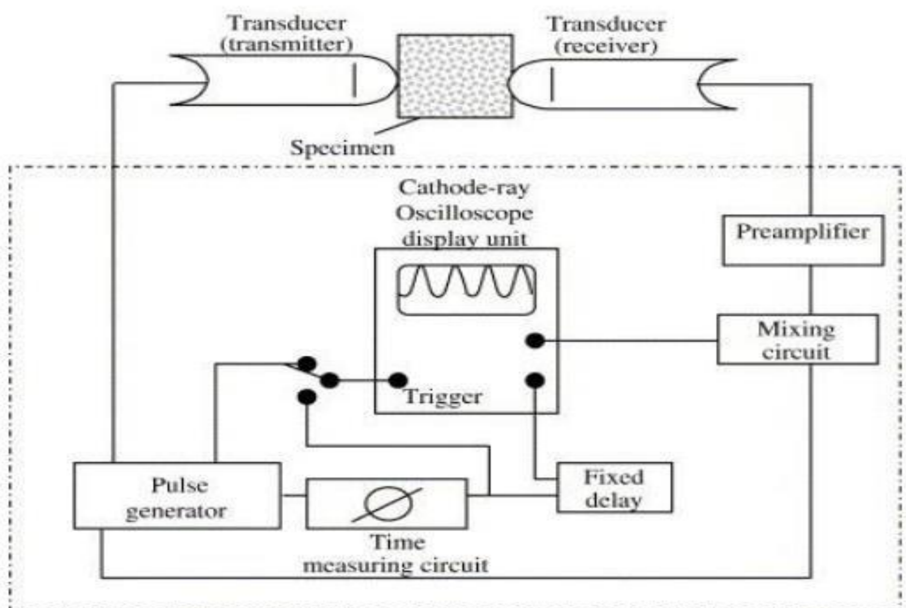
b) PULSE VELOCITY TEST

AIM: To determine the strength and quality of the given concrete specimen using UPV meter.

APPARATUS: PUNDIT (Portable ultrasonic Non- Destructive digital interface), two transducer leads, Reference bar.

THEORY: This method of test is being extensively used to assess the quality and strength of in-situ concrete in structural member. This test is generally used to check the compaction of concrete, uniformity of concrete, determination of cracks, presence of honey combs and also strength estimation. This method covers the determination of pulse velocity of propagation of compression wave in concrete. The pulse velocity v' is related to principle properties of solid by the equation.

$V^2 = KE/D$ where, K = constant, D= density, E = elastic modulus.



PROCEDURE:

1. Before switching on the 'V' meter, the transducers should be connected to the sockets marked "TRAN" and" REC".
2. A reference bar is provided to check the instrument zero. The pulse time for the bar is engraved on it.
3. Apply a smear of grease to the transducer faces before placing it on the opposite ends of the bar.
4. Adjust the 'SET REF' control until the reference bar transit time is obtained on the instrument

read-out.

5. Having determined the most suitable test points on the material to be tested, make
6. Careful measurement of the path length ‘L’.
7. Apply couplant to the surfaces of the transducers and press it hard onto the surface of the material.
8. Do not move the transducers while a reading is being taken, as this can generate noise signals and errors in measurements.
9. Continue holding the transducers onto the surface of the material until a consistent reading appears on the display, which is the time in microsecond for the ultrasonic pulse to travel the distance ‘L’.
10. Pulse velocity is calculated using the formula

$$\text{Pulse velocity (v)} = \frac{\text{path length(L)}}{\text{Travel time(T)}}$$

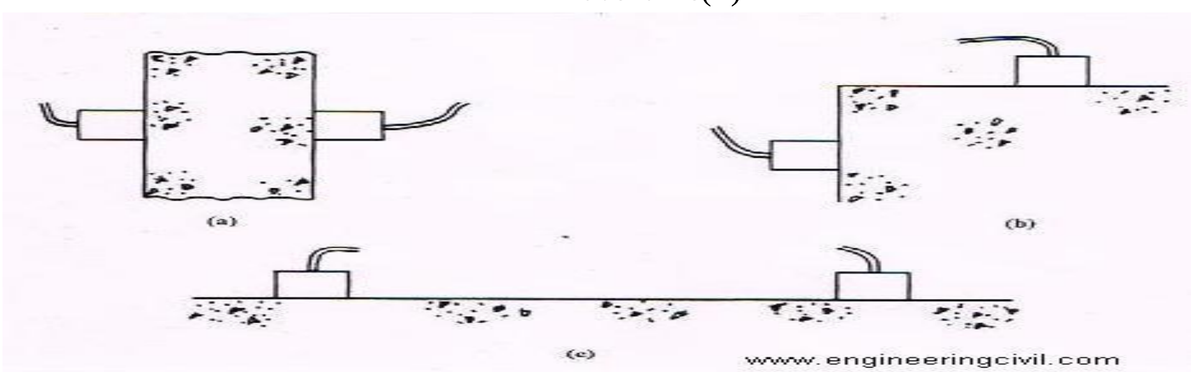
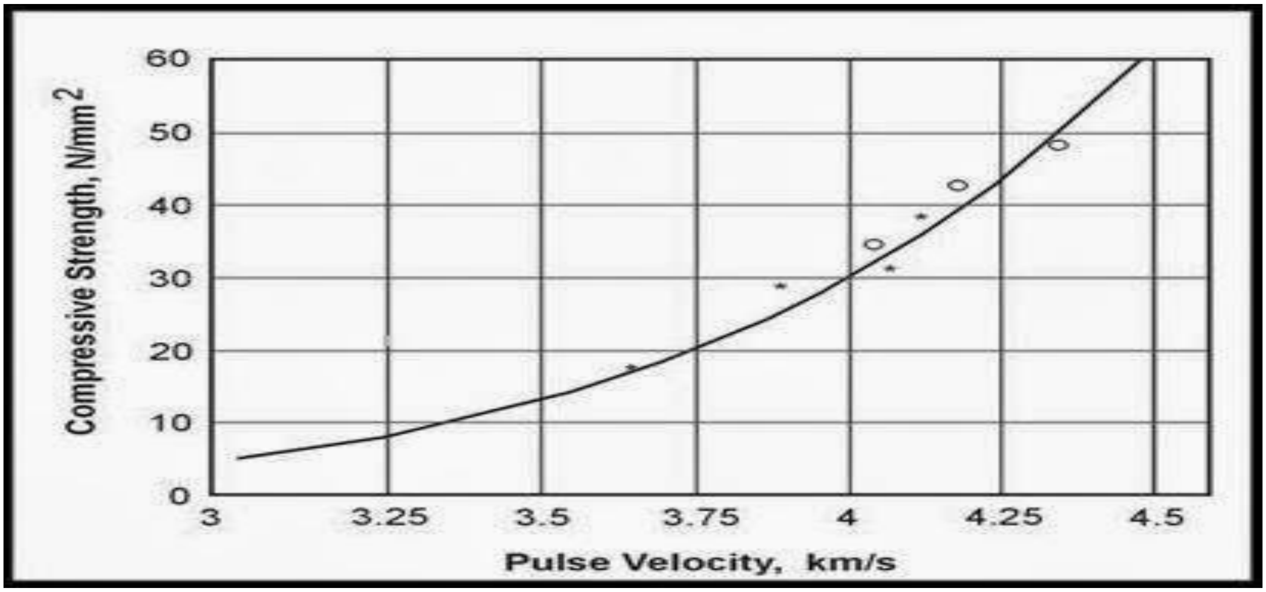


Fig: - a) Direct, b) Semi Direct, c) Indirect Direct method of Pulse Velocity

OBSERVAION AND CALCULATION:

Tabular Column:-

Sl.No	**Description**	**Trial No**	**Path Length (mm)**		**Pulse velocity (km/s)**	**Average Pulse velocity (km/s)**
1	Direct Method	1				
		2				
		3				
2	Semi-Direct Method	1				
		2				
		3				
3	Indirect Method	1	b=	2b=		
		2	b=	2b=		
		3	b=	2b=		



Graph: Pulse velocity

RESULT:-

Direct method of Average pulse velocity =---------km/S
Semi Direct method of Average pulse velocity =---------km/S
Indirect method of Average pulse velocity =---------km/S

CONCLUSION:-

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

Table 8: Recommended Value for pulse velocity

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

Exp:- **Date:-**

DESIGN MIX OF SELF-COMPACTING CONCRETE

GENERAL

Self compacting concrete (SCC) is highly flowable, non-segregating concrete that fills uniformly and completely every corner of formwork by its own weight and encapsulate reinforcement without any vibration, whilst maintaining homogeneity.

Definition: The Self compacting concrete is defined as the concrete compaction under its own weight without any vibration effort. SCC is highly engineered concrete with much higher fluidity without segregation and is capable of filling every corner of form work under its self-weight Thus SCC eliminates the needs of vibration either external or internal for the compaction of the concrete without compromising its engineering properties.

Application Area Self compacting concrete (SCC) may be used in precast concrete applications or for concrete placed on site. SCC is used to cast sections with highly congested reinforcement and in areas that present restricted access to placement and consolidation, including the construction of tunnel lining sections and the casting of hybrid concrete filled steel tubular columns. It may be manufactured in a site batching plant or in a ready-mixed concrete plant and delivered to site by truck mixer. It may be placed either by pumping or pouring into horizontal or vertical forms.

Features of Fresh Self Compacting Concrete A concrete mix can only be classified as self compacting concrete, if the requirements for all below mentioned characteristics are fulfilled: a) Filling ability (Flowability), b) Passing ability, c) Segregation resistance, and d) Viscosity The above tests shall be carried out as per IS 1199 (Part 6)

Filling Ability (flowability):-This is the ability of fresh concrete to flow into and fill all spaces within the formwork, under its own weight. Slump-flow test is performed to test the flowability. Slump-flow value describes the flowablity of a fresh mix in unconfined condition. Visual observation during the test can provide additional information on the segregation resistance and uniformity. The following are typical slump-flow classes for a range of applications:

a) **SF1 (slump flow 550 mm - 650 mm)**. This class of SCC is appropriate for:

1. Unreinforced or lightly reinforced concrete structures that are cast from the top with free displacement from the delivery point (for example, housing slabs).
2. Casting by a pump injection system (for example, tunnel linings).
3. Sections that is small enough to prevent long horizontal flow (for example, piles and some deep foundations).

b) **SF2 (slump flow 660 mm - 750 mm)** is suitable for normal applications (for example, walls, columns).

c) **SF3 (slump flow 760 mm — 850 mm)** is used for vertical applications in heavily reinforced structures, structures with complex shapes, or for filling under formwork. SF3 will often give better surface finish than SF2 for normal vertical applications but segregation resistance is more difficult to control.

Passing Ability:- (Free from Blocking at Reinforcement) Passing ability describes the capacity of the fresh mix to flow through confined spaces and narrow openings such as areas of congested reinforcement without segregation. If there is little or no reinforcement, there may be no need to specify passing ability as a requirement. L-box test is performed to check the passing ability. The minimum ratio of the depth of the concrete in the horizontal section relative to the depth of concrete vertical section is considered to be 0.8. If the SCC flows as freely as water, it will be completely horizontal, and the ratio will be equal to 1.0.

Segregation Resistance (Stability):- This is the ability of fresh concrete to remain homogeneous in composition while in its fresh state. Segregation resistance (sieve) test is performed to check this property of fresh concrete. After sampling, the fresh concrete is allowed to stand for 15 min and any separation of bleed water is noted. The top part of the sample is then poured into a sieve with 4.75 mm square apertures. After 2 min, the weight of material which has passed through the sieve is recorded. The segregation ratio (SR) is then calculated as the proportion of the sample passing through the sieve. There are two classes of segregation resistance, namely SR1 and SR2.

SR1 is generally applicable for thin slabs and for vertical applications with a flow distance of less than 5 m and a confinement gap greater than 80 mm.

SR2 is preferred in vertical applications if the flow distance is more than 5 m with a confinement gap greater than 80 mm in order to take care of segregation during flow.

For SR1 class segregation resistance shall be 15 to 20 percent and for SR2 it shall be less than 15 percent. SR2 may also be used for tall vertical applications with a confinement gap of less than 80 mm if the flow distance is less than 5 m, but if the flow is more than 5 m, a target SR value of less than 10 percent is recommended. Segregation resistance becomes an important parameter with higher slump-flow classes and/or the lower viscosity classes, or if placing conditions promotes segregation. If none of these apply, it is usually not necessary to specify a segregation resistance class.

Viscosity Viscosity can be assessed by the V-funnel flow time as per IS 1199 (Part 6). Concrete with a low viscosity will have a very quick initial flow and then stop. Concrete with a high viscosity may continue to creep forward over an extended time. A V-shaped funnel is filled with fresh concrete and the time taken for the concrete to flow out of the funnel is measured and recorded as the V-funnel flow time. The viscosity is divided into two classes, that is, V1 and V2. V1 has good filling ability even with congested reinforcement. It is capable of self-leveling and generally has the best surface finish. V2 class viscosity is more likely to exhibit thixotropic effects, which may be helpful in limiting the formwork pressure or improving segregation resistance. But it may cause negative effects on surface finish and sensitivity to stoppages or delays between successive lifts.

For V1 class, the time taken to pass the concrete from 8 s and for V2 class the time taken≤V-funnel shall be to pass the concrete from V-funnel shall be between 8 s and 25 s.

MIX PROPORTIONING

Mix Proportioning Principles

a) Lower coarse aggregate content,

b) Increased paste content,

c) Low water/powder ratio (see Note),

d) Increased superplasticiser, and e) Sometimes a viscosity modifying admixture.

NOTE — Powder refers to materials of particle size smaller than 0.125 mm. It includes this size fraction from cement, mineral admixtures and aggregate. Water/powder ratio shall be 0.85 to 1.10 by volume. 8.2 Mix Proportioning Approach Laboratory trials shall be used to verify properties of the initial mix composition with respect to the specified characteristics and classes. If necessary, adjustments to the mix composition shall then be made. Once all requirements are fulfilled, the mix shall be tested at full scale in the concrete plant and if necessary, at site to verify both the fresh and hardened properties. The mix design is generally based on the approach outlined below:

a) Determine the target average compressive strength.

b) Select the air content based on the specified nominal maximum size of aggregate and concrete grade.

c) Select water-cement/Cementitious materials ratio.

d) Select the proportions for initial mix.

e) Select water content and cement/fly ash(or other supplementary cementitious material) content.

f) Select admixture content.

g) Select powder content and fine aggregate content.

h) Select coarse aggregate content.

j) Calculate volume of powder content and determine water powder ratio by volume, and make adjustments, if required.

k) Work out the mix proportions for trial 1.

m) Produce the fresh SCC in the laboratory mixer, perform the required tests as per 7.2, and make adjustments.

n) Test the properties of the SCC in the hardened state.

p) Produce trial mixes in the plant mixer. Licensed to IRICENLIB library@iricen.gov.in 12 IS 10262 : 2019

Typical Ranges of Mix Constituents

a) Sufficient amount of fines (< 0.125 mm) preferably in the range of 400 kg/m3 to 600 kg/m3 , inclusive of suitable quantities of fine aggregate and mineral admixtures like fly ash in suitable proportions, may be used for flowability while ensuring compliance with engineering properties particularly shrinkage. Fine aggregate content, typically, 48 to 60 percent by mass of the total aggregate, balances the volume of the other constituents.

b) Water content between 150 to 210 kg/m^3 .

c) Use of high range water reducing admixture like polycarboxylate ether based high range water reducing admixture (water reduction > 30 percent) and sometimes also using a viscosity modifying admixture (VMA) in appropriate dosages.

In the event that satisfactory performance is not obtained, consideration shall be given to a fundamental redesign of the mix.

Depending on the apparent problem, the following courses of action might be appropriate:

1) Adjust the water/powder ratio and test the flow and other properties of the paste

2) Try different types of additions (if available).

3) Adjust the proportions of the fine aggregate and the dosage of superplasticiser.

4) Consider using a viscosity modifying agent to reduce sensitivity of the mix.

5) Adjust the proportion or grading of the coarse aggregate.

3.3.1 Reporting The mix design report shall include the following:

a) Period of testing (starting and ending date);

b) Details of work/type of structure, if provided;

c) All the data provided for the mix design as per 4.1, and deviations from IS 456, if any;

d) Relevant test data of different materials for the purpose of mix proportioning;

e) Details of materials such as brand of cement, manufacturing date (week/year) percentage of pozzolana/slag, etc, as per manufacturers certificate; source of coarse and fine aggregates (if provided), etc;

f) Details of the trials conducted

g) Recommended mix proportions.

Illustrative Example An illustrative example of concrete mix proportioning for self compacting concrete is given in following. This example is merely illustrative and explains the procedure to be adopted for self compacting concrete. The actual mix proportioning shall be based on various trials with the given materials

E- 1 STIPULATIONS FOR PROPORTIONING

a) Grade designation : M30

b) Type of cement : OPC 43 grade conforming to IS 269

c) Nominal maximum size of aggregate : 20 mm

d) Exposure conditions as per

Table 3 and Table 5 of IS 456 : Severe (for reinforced concrete)

e) Characteristics of SCC

1) Slump flow class : SF3 (slump flow 760 mm – 850 mm)

2) Passing ability by L box test : Ratio of h2 /h1 = 0.9

3) V- Funnel flow time (Viscosity) : Class V1 (flow time ≤ 8s)

4) Sieve segregation resistance : SR1(<15percent)

f) Degree of site control : Good

g) Type of aggregate : Crushed angular aggregate

h) Maximum cement content (OPC Content) : 450 kg/m3

j) Chemical admixtures type

1) Super plasticizer : Normal (PCE type)

2) Viscosity modifying agent

k) Mineral admixture : Fly ash conforming to IS 3812 (Part 1)

E-2 TEST DATA FOR MATERIALS

a) Cement used : OPC 43 Grade conforming to IS 269

b) Specific gravity of cement : 3.15

c) Chemical admixture : Superplasticizer conforming to IS 9103

d) Specific gravity of

1) Coarse aggregate (at SSD condition) : 2.74

2) Fine aggregate (at SSD condition) : 2.65

3) Chemical admixture : 1.08

e) Water absorption

1) Coarse aggregate : 0.5 percent

2) Fine aggregate : 1.0 percent

f) Free (surface) moisture

1) Coarse aggregate : Nil (absorbed moisture also nil)

2) Fine aggregate : Nil (absorbed moisture also nil)

g) Sieve analysis

1) Coarse aggregate:

IS Sieve Sizes mm	*Analysis of Coarse Aggregate Fraction*		*Percentage of Different Fractions*			*Remarks*
	I (20-10 mm)	II (10 - 4.75 mm)	I 50 percent	II 50 percent	100 percent	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
20	100	100	50	50	100	Conforming of Table 7 of IS 383
10	2.8	78.3	1.4	39.15	40.55	
4.75	Nil	8.70	Nil	4.35	4.35	

2) Fine aggregate : Conforming to grading Zone II of Table 9 of IS 383

Solution:-

E-3 TARGET STRENGTH FOR MIX PROPORTIONING

f'ck = f ck+1.65 S or f'ck = f ck + X whichever is higher.

where f'ck = target average compressive strength at 28 days,

f ck = characteristic compressive strength at 28 days,

S = standard deviation, and

X = factor based on grade of concrete.

From Table 2, standard deviation, S = 5 N/mm^2 . From Table 1, X = 6.5.

Therefore, target strength using both equations, that is

a) f'ck = f ck+1.65 S = 30 + 1.65 × 5 = 38.25 N/mm^2

b) f'ck = f ck + 6.5 = 30 + 6.5 = 36.5 N/mm^2

The higher value is to be adopted.

Therefore, target strength will be 38.25 N/mm^2 as 38.25 N/mm2 > 36.5 N/mm^2 .

E-4 APPROXIMATE AIR CONTENT From Table 3, the approximate amount of entrapped air to be expected in normal (non-air-entrained) concrete is 1.0 percent for 20 mm nominal maximum size of aggregate.

E-5 SELECTION OF WATER-CEMENT RATIO From Fig. 1, the free water-cement ratio required for the target strength of 38.25 N/mm^2 is 0.43 for OPC 43 grade curve. This is lower than the maximum value of 0.45 prescribed for 'severe' exposure for reinforced concrete as per Table 5 of IS 456. 0.43<

0.45, hence O.K.

E-6 the initial mix shall be first estimated based on the typical ranges of mix constituents as per 8.3 and keeping in view, the characteristics of the fresh concrete such as flowability, passing ability, segregation resistance and viscosity as per the data for the mix proportioning in E-1. The initial mix shall be tested for various characteristics as per IS 1199 (Part 6) and adjustments to the initial mix shall be made till satisfactory characteristics are achieved. The various mix design parameters given in this example are only indicative and it may be necessary to carry out adjustments to these parameters during the use of the concrete mix at the project site.

E-7 PROPORTIONING FOR INITIAL MIX

E-7.1 Selection of Water Content and Cement/Fly Ash Content The class of slump flow is specified to be SF3 having a slump flow between 750 and 850 mm. To start with, a water content of 190 kg/m3 along with a superplasticizer @ 0.6 percent by mass of cementitious material content is selected for the initial mix. However, the water content can be reduced further by increasing the dose of super plasticizer. This water content of 190 kg/m3 will correspond to a cement content of 442 kg/m3 for water cement ratio of 0.43 as worked out in E-5.

The cement content of 442 kg/m3 can be further divided into OPC and fly ash. Generally fly ash content of 25 to 50 percent is adopted for SCC. In this illustration, as the cement content is on the higher side, the fly ash content is taken as 35 percent. Therefore, the OPC content is for 287 kg/m3 and fly ash content will be 155 kg/m^3.

E-7.2 Selection of Admixture Content Taking an admixture dose of 0.6 percent by mass of cementitious material, the mass of admixture = 0.6/100 × 442 = 2.65 kg/m^3 .

E-7.3 Selection of Powder Content and Fine Aggregate Content

The powder content (fines < 0.125 mm) required for SCC is generally in the range of 400 to 600 kg/m3. Since, the SR of class 1 and viscosity of V1 is required; the mix shall be sufficiently cohesive, (having enough fines). Therefore a powder content of 520 kg/m3 is selected. This powder content will constitute the entire OPC, entire fly ash, and around 10 percent of Zone II fine aggregates. Fines required to be contributed by fine aggregate = Total powder content – (Fly ash content + cement content)

$$= 520 - (155 + 287) = 78 \text{ kg/m}^3$$

The fine aggregate has 8 percent materials < 0.125 mm (see 8.1). Therefore, the fine aggregate quantity = 78/0.08 = 975 kg/m3 .

E-7.4 Selection of Coarse Aggregate Content

Let Vca be the volume of coarse aggregate.

Assuming 1 m^3 of concrete,

Vca = (1 - Air content) - (Vol of water + Vol of cement + Vol of fly ash + Vol of admixture + Volume of fine aggregate)

$$Vca = (1- 0.01) – (190/(1×1000)+ 287 /(3.15× 1\,000)+155/ (2.2 ×1000)+2.65 /(1.08×1000)+ 975 /(2.65×1000)$$

$$= 0.99 – (0.19 + 0.091 + 0.07 + 0.002\,5 + 0.368) = 0.269\ m^3$$

Mass of coarse aggregate = Vca x specific gravity of coarse aggregate × 1 000

$$= 0.268 × 2.74 × 1\,000 = 737.06\ kg/m3 \approx 737\ kg/m^3$$

E-7.5 Calculation of Volume of Powder Content

Vol of powder content

= Vol of OPC + Vol of fly ash + Vol of portion of fine aggregate < 0.125 mm

= (287/(3.15×1000)+ 155/(2.2 ×1000)+ (2.65×1000) = 0.191 m3

Ratio of water to powder by volume = 0.190/ 0.191 = 0.99

NOTE — The water to powder ratio is expected to be between 0.85 and 1.10.

In this case, it is ok. If water to powder ratio is found to be less than 0.85, then the fine aggregate content shall be reduced to increase the ratio; if the ratio is more than 1.1, then the fine aggregate content shall be increased to decrease the ratio. In such cases, all the values shall be recalculated.

E-8 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement = 287 kg/m3

Flyash = 155 kg/m^3 Water (net mixing) = 190 kg/m^3

Fine aggregate (SSD) = 975 kg/m^3

Coarse aggregate (SSD) = 737 kg/m^3

Chemical admixture = 2.65 kg/m^3,

Free water-cement ratio = 0.43 Powder content = 520 kg/m^3

Water powder ratio by volume = 0.99

NOTE — Aggregates shall be used in saturated surface dry condition. If otherwise, when computing the requirement of mixing water, allowance shall be made for the free (surface) moisture contributed by the fine and coarse aggregates. On the other hand, if the aggregates are dry, the amount of mixing water shall be increased by an amount equal to the moisture likely to be absorbed by the aggregates. Necessary adjustments are also required to be made in mass of aggregates. The surface water and percent water absorption of aggregates shall be determined according to IS 2386 (Part 3).

E-9 The total mass of coarse aggregate shall be divided into two fractions of 20 - 10 mm and 10 - 4.75 mm, in a suitable ratio, to satisfy the overall grading requirements for 20 mm max size aggregate as per Table 7 of IS 383. In this example, the ratio works out to be 50:50 as shown under E-2 (g).

E-10 The various tests for flowability (slump flow test), for passing ability (L box test), for sieve segregation resistance and for viscosity (V funnel) shall be carried out and the values obtained shall be verified as per the data given in E.1 (e). In the event that satisfactory performance is not obtained, the initial mix shall be redesigned. Depending on the apparent problem, the following courses of action might be appropriate:

Adjust the cement/powder ratio and the water/ powder ratio and test the flow and other properties of the paste.

- Try higher doses of fly ash and/or different types of additives (if available).
- Adjust the proportions of the fine aggregate and the dosage of superplasticiser.
- Consider using a viscosity modifying agent to reduce sensitivity of the mix.
- Adjust the proportion or grading of the coarse aggregate.

In the present case, based on trials the need was felt to use a small dose (0.2 percent by weight of cementitious materials) of viscosity modifying agent to improve sensitivity of the mix, that is, improve the cohesiveness of the mix.

E-11 Two more trials having variation of ± 10 percent of water-cement ratio in E-10 shall be carried out and a graph between three water-cement ratios and their corresponding strengths shall be plotted to work out the mix proportions for the given target strength for field trials. However, durability requirement shall be met.

Exp. No: **Date:**

SLUMP FLOW TEST FOR SELF COMPACTING CONCRETE

(ASTM C 1611/C 1611M-05, EFNARC -2005, IS 1199 Part 6)

AIM: To assess the flow ability and the flow rate of self-compacting concrete in the absence of obstructions.

APPARATUS: Abrams cone**,** Base plate (900X900mm), Rule, Weighted collar

THEORY: The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It gives no indication of the ability of the concrete to pass between reinforcement without blocking, but may give some indication of resistance to segregation. In case of severe segregation most coarse aggregate will remain in the centre of the pool of concrete and mortar and cement paste at the concrete periphery. In case of minor segregation a border of mortar without coarse aggregate can occur at the edge of the pool of concrete. If none of these phenomena appear it is no assurance that segregation will not occur since this is a time related aspect that can occur after a longer period.

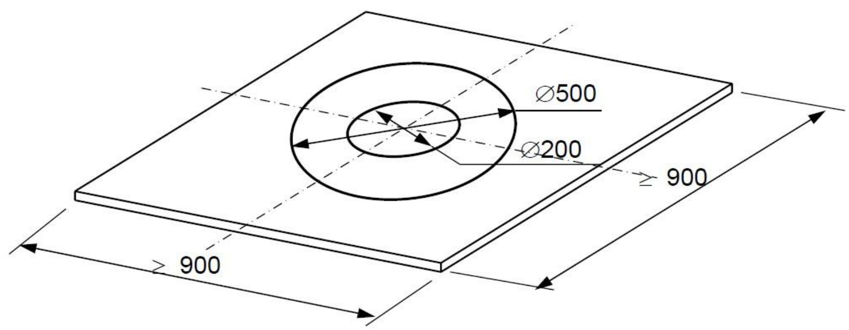


Fig.: Slump cone test apparatus

PROCEDURE:

1. About 6 liter of concrete is needed to perform the test, sampled normally.
2. Wipe the internal and external surfaces of the slump cone and plate with wet cloth.
3. Place base plate on level stable ground and the slump cone centrally on the base plate and hold down firmly.
4. Fill the cone with the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel.
5. Remove any surplus concrete from around the base of the cone.
6. Raise the cone vertically and allow the concrete to flow out freely.
7. Measure the largest diameter of the flow spread and record as d_m to the nearest 10 mm. Then measure the diameter of the flow spread at right angles to d_m to the nearest 10 mm and record as d_r to the nearest 10 mm.

8. Calculate the average of the two measured diameters.

CALCULATIONS

Largest diameter of slump flow (d_m) =________mm

Diameter perpendicular to largest diameter (d_r) =________mm

$$\text{Slump flow} = \frac{(d_m+d_r)}{2}$$

RESULTS:

The slump flow of Self compacting concrete is________mm

CONCLUSION

a) **SF1 (slump flow 550 mm - 650 mm)**.

1. Unreinforced or lightly reinforced concrete structures that are cast from the top with free displacement from the delivery point (for example, housing slabs).
2. Casting by a pump injection system (for example, tunnel linings).
3. Sections that is small enough to prevent long horizontal flow (for example, piles and some deep foundations).

b) **SF2 (slump flow 660 mm - 750 mm)** is suitable for normal applications (for example, walls, columns).

c) **SF3 (slump flow 760 mm — 850 mm)** is used for vertical applications in heavily reinforced structures, structures with complex shapes, or for filling under formwork. SF3 will often give better surface finish than SF2 for normal vertical applications but segregation resistance is more difficult to control.

SIGNIFICANCE:

It is a method to determine consistency of fresh concrete. Flow table test is also used to identify transportable moisture limit of solid bulk cargoes. The slump flow test allows a comparison of the lateral flow and filling potential of different SCC mixtures. A common range of slump flow for SCC is 18 to 30 in. (450 to 750 mm). The slump flow should not differ by more than 2 in. (50 mm) from batch to batch. If consistency is not at the desired level, concrete will not have the required strength and other qualities once it has set. If concrete is too pasty, cavities may form within it. Rebar may become corroded, and concrete will crack. Cavities also reduce the concrete strength.

EXP:- **Date:-**

V-FUNNEL TEST FOR SELF COMPACTING CONCRETE
(EFNARC -2005, IS 1199 Part 6)

AIM: To determine viscosity and filling ability (flow ability) of the self compacting concrete with a maximum aggregate size of 20mm.

APPARATUS: V-funnel, Container, Stop watch

THOREY: The V-funnel flow time is the period a defined volume of SCC needs to pass a narrow opening and gives an indication of the filling ability of SCC provided that blocking and/or segregation do not take place; the flow time of the V-funnel test is to some degree related to the plastic viscosity.

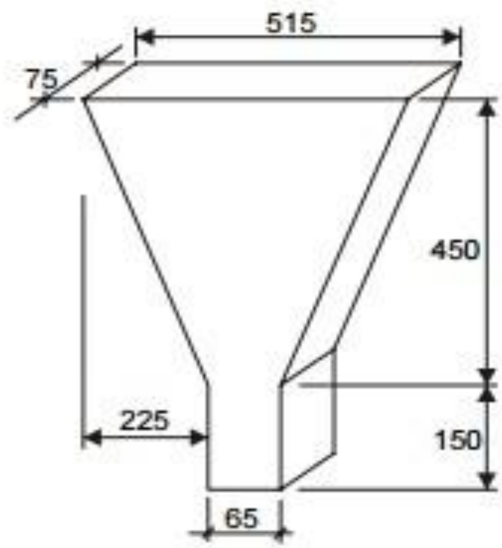


Fig.: V-Funnel apparatus

PROCEDURE:

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

CALCULATIONS:

V funnel flow time (t_V) =__________sec

RESULTS:

The V-funnel flow time t_V is the period from releasing the gate until first light enters the opening, expressed to the nearest 0.1 second. (t_V) =______sec

CONCLUSION: For V1 class, the time taken to pass the concrete from 8 s and for V2 class the time taken≤V-funnel shall be to pass the concrete from V-funnel shall be between 8 s and 25 s. The above value within the limit.

SIGNIFICANCE

This test measures the ease of flow of the concrete; shorter flow times indicate greater flow ability. For SCC a flow time of 12 seconds is considered appropriate. The inverted cone shape restricts 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.

Exp: - Date:-

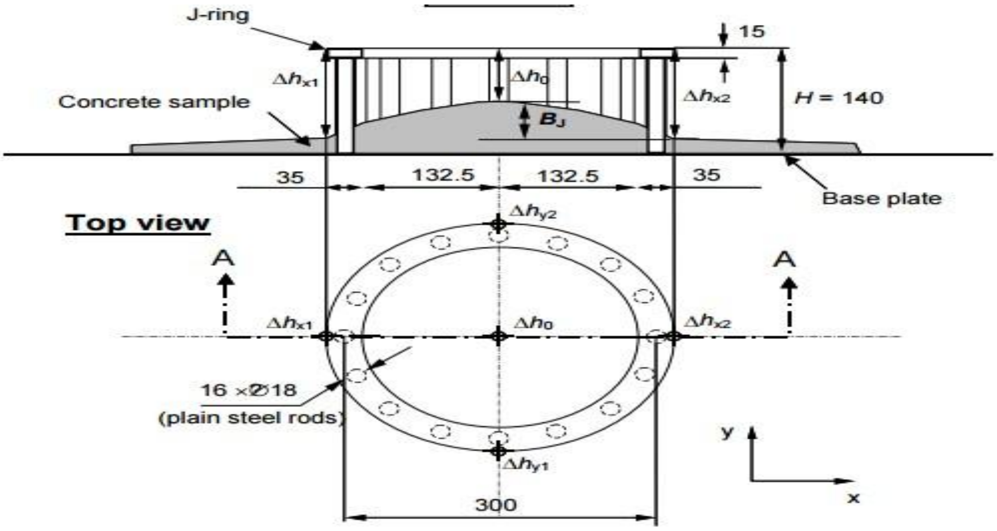
J-RING TEST FOR SELF COMPACTING CONCRETE

(**ASTM C1621/C1621M-06 EFNARC -2005, , IS 1199 Part 6**)

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

APPARATUS: J-ring, Slump cone, Trowel, Scoop and stop watch

THOREY: The J-ring test measures three parameters: flow spread, flow time T50 (optional) and blocking step. The J-ring flow spread indicates the restricted deformability of SCC due to blocking effect of reinforcement bars and the flow time T50 indicates the rate of deformation within a defined flow distance. The blocking step quantifies the effect of blocking.



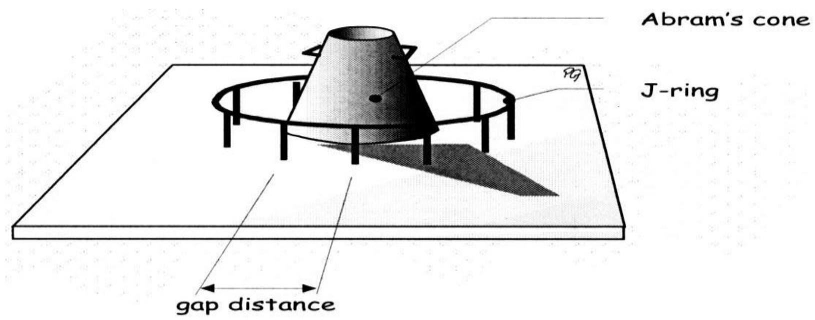


Fig:- J-ring with slump cone apparatus.

PROCEDURE:

1. About 6 liter of concrete is needed to perform the test, sampled normally.
2. Moisten the base plate and inside of slump cone, Place base-plate on level stable ground.
3. Place the J Ring centrally on the base-plate and the slump-cone centrally inside it and hold down firmly.
4. Fill the cone with the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel.
5. Remove any surplus concrete from around the base of the cone.
6. Raise the cone vertically and allow the concrete to flow out freely. Measure the final diameter of the concrete in two perpendicular directions.

7. Calculate the average of the two measured diameter (in mm).
8. Measure the difference in height between the concrete just inside the bars and that just outside the bars. Calculate the average of the difference in height at four locations (in mm).

CALCULATIONS:

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

$$SJ = \frac{(d_{max} + d_{perp})}{2} = \_\_\_\_\_\_\_\_\_\_ mm$$

The J-ring blocking step BJ is calculated as,

$$BJ = \frac{(\Delta h_{x1} + \Delta h_{x2} + \Delta h_{y3} + \Delta h_{y2})}{4} - \Delta h_0$$

Where, Δh_{x1} and Δh_{x2} are height differences between the lower edge of the straight rod and the concrete surface in the x-direction.

Δh_{y1} and Δh_{y2} are height differences between the lower edge of the straight rod and the concrete surface in the y-direction (perpendicular to x as shown in figure).

Δh_0 is the height differences between the lower edge of the straight rod and the concrete surface at the central position.

Calculate the difference between slump flow and J ring flow

BJ =________mm

RESULTS: J-ring flow spread SJ of self compacting concrete____mm

CONCLUSION:

J Ring Test is a property of passing ability .Typical ranges of values from 0 mm Minimum to10 mm Maximum .The self-compacting concrete passing J-ring thickness as per EFNARC -2005,IS 1199 part 6. The above value within the limit.

SIGNIFICANCE

Table 10: Recommended value for J Ring

Difference Between Slump Flow and J-Ring Flow	Blocking Assessment
0 to 1 in (0 to 25 mm)	No visible blocking
> 1 to 2 in (>25 to 50 mm)	Minimal to noticeable blocking
> 2 in (>50 mm)	Noticeable to extreme blocking

Exp:- **Date:-**

U BOX TEST FOR SELF COMPACTING CONCRETE

(**ASTM C1621/C1621M-06 EFNARC -2005, IS 1199 Part 6**)

AIM: To measure the filling and passing ability of self-compacting concrete with a maximum coarse aggregate size of 25 mm or less using a U-shaped or Box-shaped container.

APPARATUS: U-shaped or Box-shaped container, measuring scale, stopwatch, Trowel and Scoop.

THOREY: An opening with a sliding gate is filled between the two compartments. Reinforcing bars with nominal diameter of 13mm are installed at the gate with centre to centre distance of 50mm. this creates a clear spacing 35mm between the bars.

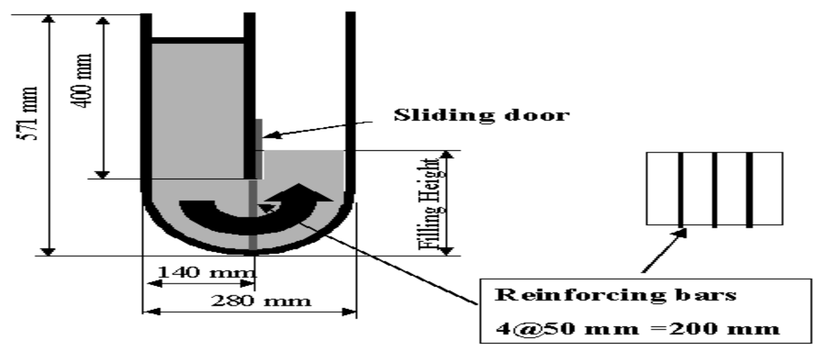


Fig: U box apparatuses

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.
3. Moisten the inside surfaces of the apparatus, remove any surplus water.
4. Fill the one compartment of the apparatus with the concrete sample.
5. Leave it to stand for 1 minute.
6. Lift the sliding gate and allow the concrete to flow out into the other compartment.
7. After the concrete has come to rest, measure the height of the concrete in the compartment that has been filled, in two places and calculate the mean (H1). Measure also the height in the other compartment (H2)
8. Calculate (H1- H2) the filling height. The whole test has to be performed within 5 minutes.

CALCULATIONS:

1. Filling time, Express the measured filling time, TU (sec) =______sec
2. Height in the pouring compartment (H1) = _______
3. Height in the other compartment (H2) = ______
4. Calculate (H1- H2) = ________

RESULTS:

The filling height of self compacting concrete is ______mm

CONCLUSION: U box Test is a property of passing ability .Typical ranges of values from 0 mm Minimum to 30 mm Maximum (H_2-H_1) mm .The self-compacting concrete filling height as per EFNARC -2005 and IS 1199 Part 6. The above value within the limit.

SIGNIFICANCE:

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

Exp:- **Date:-**

L BOX TEST FOR SELF COMPACTING CONCRETE
(ASTM C1621/C1621M-06 EFNARC -2005 IS 1199 Part 6)

AIM: To assess the flow of concrete and passing ability of Self Compacting Concrete by determining its blocking ratio.

THEORY: Test measures the filling and passing abilities of SCC. The apparatus shown in figure consists of a rectangular section L-shaped box. The extent to which concrete flows down the horizontal portion of box depends on yield stress of the concrete. The stability, ie., resistance to segregation can be visually assessed.

APPARATUS: L-box, measuring scale. Trowel, Scoop and stop watch

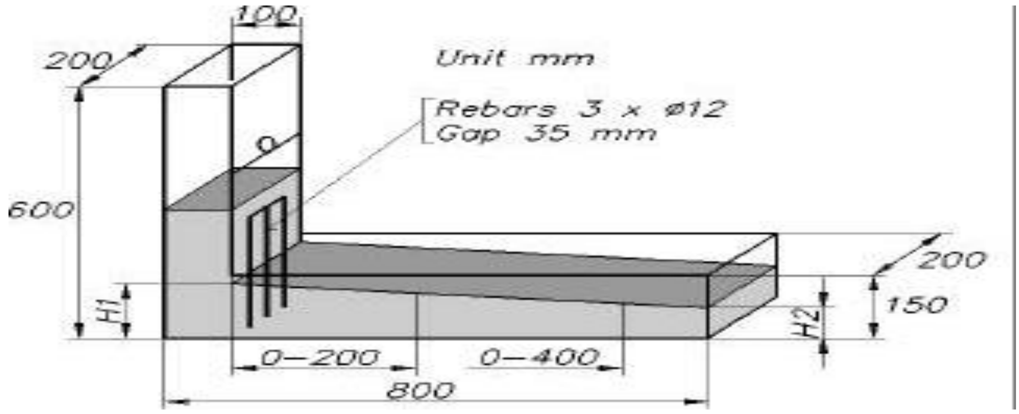


Fig : L-Box test apparatus.

PROCEDURE:

1. About 14 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.
3. Moisten the inside surfaces of the apparatus, remove any surplus water
4. Fill the vertical section of the apparatus with the concrete sample. Leave it to stand for 1 minute.
5. Lift the sliding gate and allow the concrete to flow out into the horizontal section.
6. Simultaneously, start the stopwatch and record the times taken for the concrete to reach the 200 and 400 mm marks.
7. When the concrete stops flowing, the distances "H1" and "H2" are measured.
8. Calculate H2/H1, the blocking ratio. The whole test has to be performed within 5 minutes.

CALCULATIONS:

1. The depth of concrete behind the gate after the flow (H1) =____________mm
2. The depth of concrete at the end of horizontal box after the flow (H2) = mm
3. The blocking ratio (H2/H1) = _________mm

RESULTS:

The blocking ratio of self compacting concrete is ___________

CONCLUSION: L box Test is a property of passing ability .Typical ranges of values from 0.8 Minimum to 1.0 Maximum (H_2/H_1) mm .The self-compacting concrete blocking ratio as per EFNARC -2005 and IS 1199 Part 6. The above value within the limit.

SIGNIFICANCE:

If the concrete flows as freely as water, at rest it will be horizontal, so H2/H1= 1. Therefore the nearer this test value, the ‘blocking ratio’, is to unity, the better the flow of the concrete. The EU research team suggested a minimum acceptable value of 0.8. Obvious blocking of coarse aggregate behind the reinforcing bars can be detected visually. Higher blocking ratios correspond to less blocking, greater filling ability. Low blocking ratios exhibits inadequate filling ability, passing ability.

Exp. No.: **Date:**

SHAPE TEST

(a) FLAKINESS INDEX

AIM: To determining the flakiness index of the coarse aggregate.

APPARATUS:

- metal gauge
- Weighing Balance
- Gauging Trowel
- Sieves.

REFERENCE:

- IS : 2386 (Part I) – 1963 Method of tst for aggregates for concrete
- IS: 383-2016 specification for coarse and fine aggregate from natural source for concrete

THEORY:

The flakiness index of an aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than three-fifths of their mean dimension. Particle shape and surface texture influence the properties of freshly mixed concrete more than the properties of hardened concrete. Rough-textured, angular, and elongated particles require more water to produce workable concrete than smooth, rounded compact aggregate. Consequently, the cement content must also be increased to maintain the water-cement ratio. Generally, flat and elongated particles are avoided or are limited to about 15 % by weight of the total aggregate.

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. Then each fraction shall be gauged in turn for thickness on a metal gauge of the pattern shown in Fig 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 passing the gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

CALUCULATIONS:

i) Flakiness Index = (X) / (W) X 100 % ____
ii) Elongation Index = (Y)/ (W) X 100%

Where, X 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.

Y is the weights of material retained on the various Length gauge

Tabular Column: - Flakiness Index and Elongation Index

Size of aggregates		Weight of fraction consisting of at least 200 pieces,g	Thickness gauge size, mm	Weight of aggregates in each fraction passing thickness gauge,mm	Length gauge size, mm	Weight of aggregates in each fraction retained on length gauge,mm
Passing through IS Sieve, mm	Retained on IS Sieve, mm					
63	50		23.90		–	–
50	40		27.00		81.00	
40	31.5		19.50		58.00	
31.5	25		16.95		–	–
25	20		13.50		40.5	
20	16		10.80		32.4	
16	12.5		8.55		25.5	
12.5	10		6.75		20.2	
10	6.3		4.89		14.7	
Total	**W =**		**X =**		**Y =**	

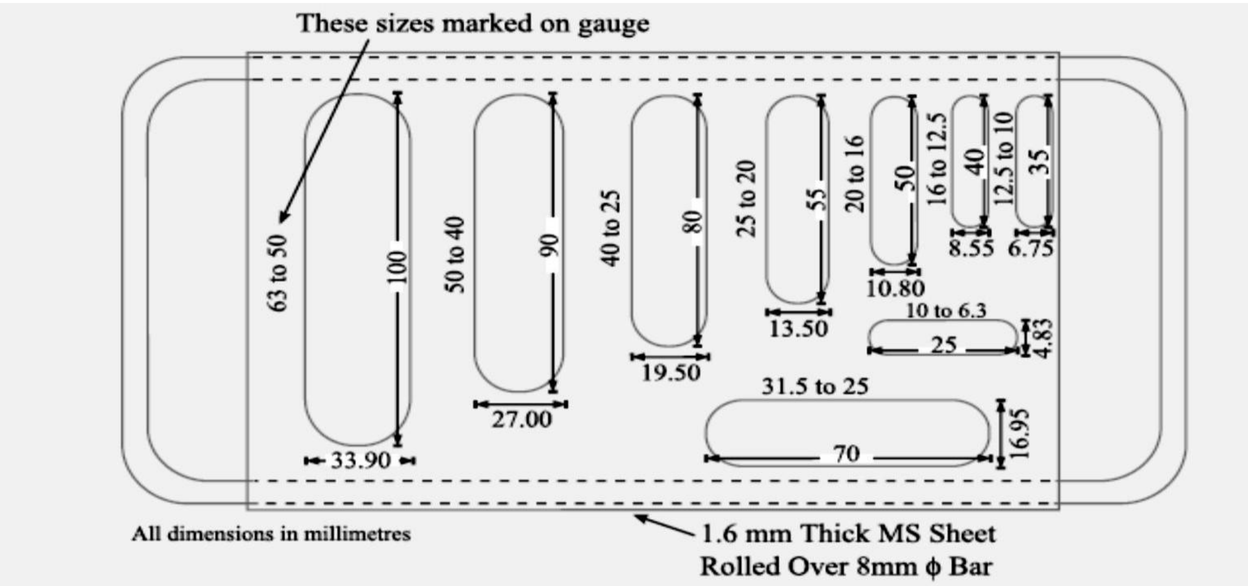


Fig:-Thickness Gauge

Results: Flakiness index=..%

(b) ELONGATION INDEX

AIM: To determining the elongation index of the coarse aggregate.

APPARATUS:

- metal gauge
- weighing Balance
- Gauging Trowel
- Sieves.

REFERENCE CODE:

- IS : 2386 (Part I) – 1963 Method of test for aggregates for concrete
- IS: 383-2016 specification for coarse and fine aggregate from natural source for concrete

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.

CALUCULATIONS:

Elongation index=(Y)/ (W) X 100 %

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.

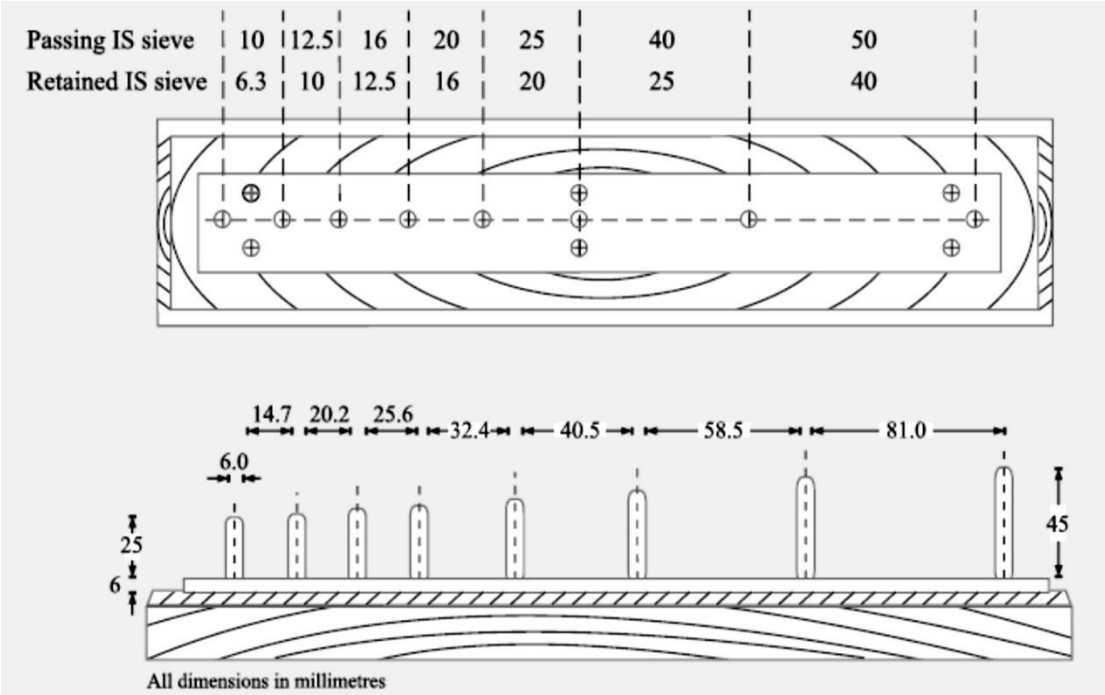


Fig.: Length Gauge

Tabular Column:- Dimensions of Length gauge

Size of Aggregate (mm)		Weight Retained on Length Gauge	Length Gauge (mm)	Weight of elongation particles X gms
Passing through IS sieve	Retained on IS sieve			
63	50		-	
50	40		81.0	
40	31.5		58.5	
31.5	25		-	
25	20		40.5	
20	16		32.4	
16	12.5		25.5	
12.5	10		20.2	
10	6.3		14.7	

RESULTS: Elongation Particles=………………………………………. %

CONCLUSION:

The shape test gives only a rough idea of the relative shape of the aggregates, if flaky & elongation aggregates all present the strength & workability of concrete get reduce. According to BS 882:1982 limit for coarse aggregate Flakiness Index and Elongated index should be between 15%.

Exp. No.: **Date:**

ANGULARITY NUMBER TEST

AIM: To determine the angularity number of coarse aggregate.

REFERENCE CODE:

- IS : 2386 (Part I) – 1963 Method of test for aggregates for concrete
- IS: 383-2016 specification for coarse and fine aggregate from natural source for concrete

THEORY: Angularity test helps us to determine the angularity of the coarse aggregate. Higher the angularity number better is the interlocking of the aggregate.

APPARATUS REQUIRED: Metal cylinder, Tamping rod, balance, metal scoop.

TEST DESCRIPTION:

First the metal mould calibrated by filling it with water and determining the weight of water in it. Then the mould is filled with clean dried aggregates in three layers. The weight of aggregate in the mould is recorded. Determine the specific gravity of the aggregate. Finally the angularity number of aggregate is calculated.

TEST SAMPLE PREPARATION

The test sample consist of aggregate retained between the appropriate pair of IS sieves from the following sets

Table 11: Sample Preparation of aggregates

PASSING	RETAINED
20 mm	16 mm
16 mm	12.5 mm
12.5 mm	10 mm
10 mm	6.3 mm
6.3 mm	4.75 mm

PROCEDURE:

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 (water) with cylinder is then weighed. Three separate determinations are made and mean weight of the aggregate in the cylinder is calculated.

OBSERVATION AND CALCULATION:

Tabular Column:-

SL.No	Description	Trial 1	Trial 2	Trial 3
1	Empty Weight of Cylinder (W1) Gms			
2	Weight of Cylinder +Water (W2) Gms			
3	Weight of Cylinder +Coarse aggregate (W3) Gms			
4	Weight of Coarse aggregate W= (W3- W1)			
5	Weight of water C= (W2- W1)			
6	Angularity Number=67- $\left(\frac{W}{C\times Gs}\right)\times 100$			
7	Average Angularity Number			

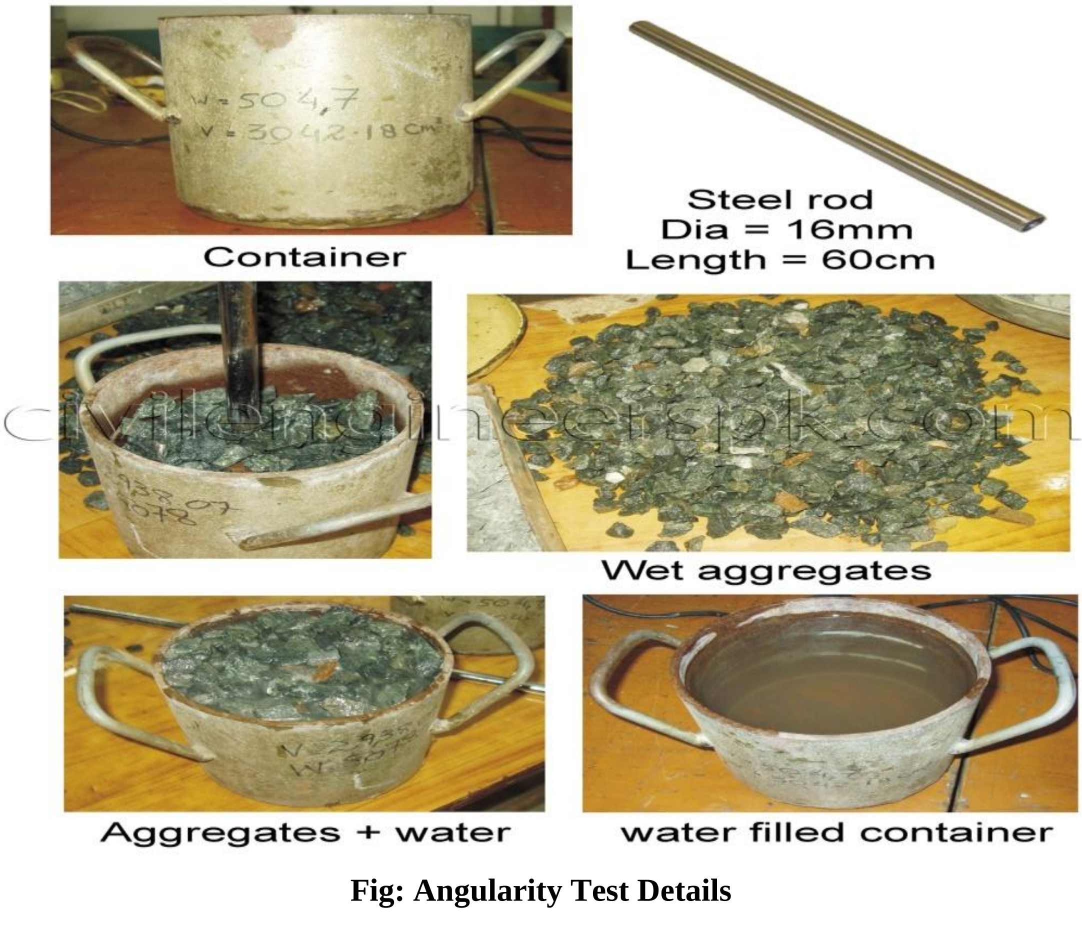


Fig: Angularity Test Details

CALCULATION:

W= (W3- W1) =

C= (W2- W1) =

Where **Gs** = Specific Gravity of Given sample of Coarse aggregate =

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

RESULT:

The Average Aggregate angularity number of given sample of Coarse aggregate =......%

CONCLUSION:-

The angularity number of aggregate value is in between 0-11.So that given sample angularity number is ______ %.It is well within the permissible limit.

Exp. No.: **Date:**

AGGREGATE IMPACT VALUE TEST

AIM: To determine the aggregate impact value of given aggregates

APPARATUS REQUIRED:
- Impact testing machine
- cylinder, tamping rod
- IS Sieve
- Weighing balance.

REFERENCE CODE:
- IS : 2386 (Part IV) – 1963 methods of test for aggregate for concrete
- IS:383:2016- specification for coarse and fine aggregate from natural source for concrete
- IS:9377:1979-specification for apparatus for aggregate impact value test

THEORY:
The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differs from its resistance to a slow compressive load.

PROCEDURE:
1. The test sample consists of aggregates passing 12.5mm sieve and retained on 10mmsieve and dried in an oven for 4 hours at a temperature of 100oC to 110oC
2. The aggregates are filled up to about 1/3 full in the cylindrical measure and tamped 25 times with rounded end of the tamping rod
3. The rest of the cylindrical measure is filled by two layers and each layer being tamped 25 times.
4. The overflow of aggregates in cylindrically measure is cut off by tamping rod using it has a straight edge.
5. Then the entire aggregate sample in a measuring cylinder is weighed nearing to 0.01gm
6. The aggregates from the cylindrical measure are carefully transferred into the cup
7. Which is firmly fixed in position on the base plate of machine. Then it is tamped 25 times.
8. The hammer is raised until its lower face is 38cm above the upper surface of aggregate in the cup and allowed to fall freely on the aggregates. The test sample is subjected to a total of 15 such blows each being delivered at an interval of not less than one second. The crushed aggregate is than removed from the cup and the whole

of it is sieved on 2.366mm sieve until no significant amount passes. The fraction passing the sieve is weighed accurate to 0.1gm. Repeat the above steps with other fresh sample.

9. Let the original weight of the oven dry sample be W1gm and the weight of fraction passing 2.36mm IS sieve be W2gm. Then aggregate impact value is expressed as the % of fines formed in terms of the total weight of the sample.

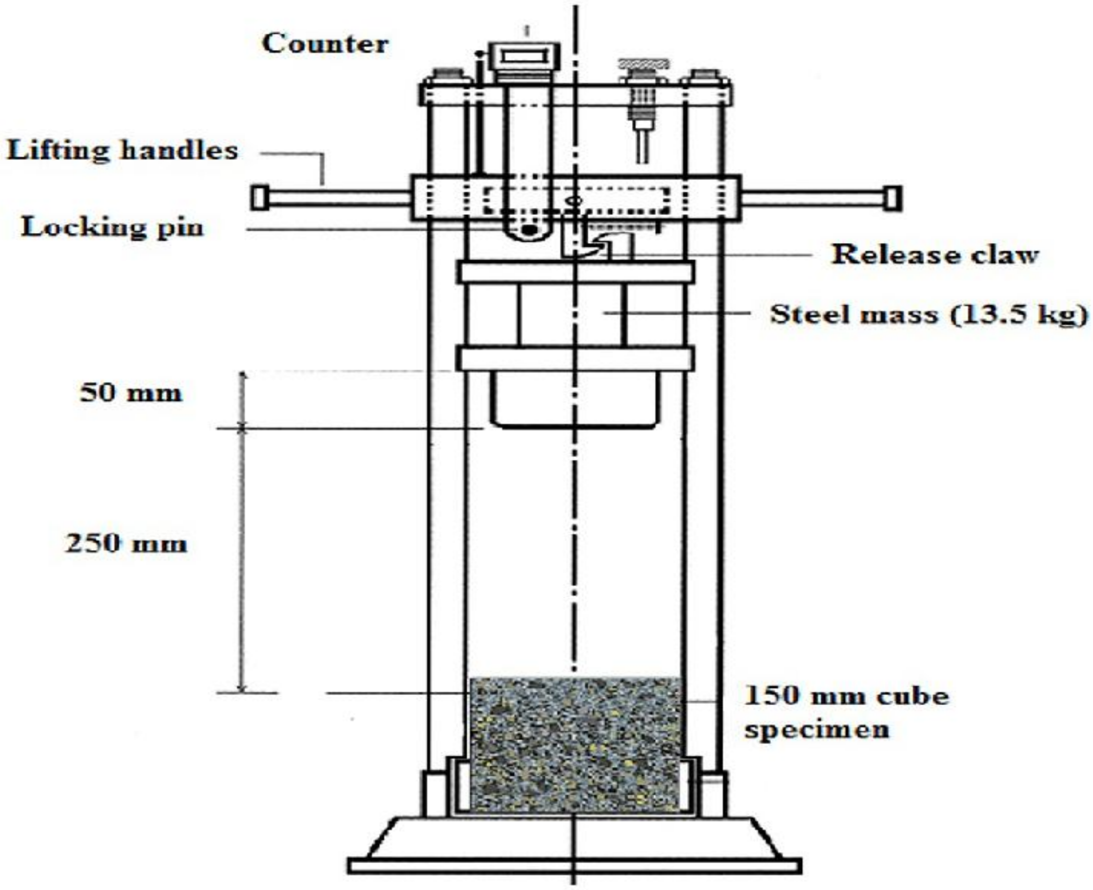


Fig.: Aggregate Impact Test Machine

OBSERVATION AND CALCULATION

Tabular Column:-

Sl No	Details	Trail 1	Trail 2	Trail 3
1	Total weight of the aggregate filling the cylindrical metal measures W1gms			
2	Weight of aggregate passing through 2.36 mm sieve W2gms			
3	Aggregate impact = (W2/W1) X 100 %			
4	Average impact Value			

CALCULATION

Trail 1

Aggregate impact value = (W2/W1) X 100= ________%

Trail 2

Aggregate impact value = (W2/W1) X 100= ________%

Trail 3

Aggregate impact value = (W2/W1) X 100= ________%

RESULT: - Average Aggregate Impact Value = ………. %

CONCLUSION:

The aggregate impact value should not exceed 45% by weight of aggregate used for concrete and other than varying surface and 30% by weight of aggregate used for varying surface such as runway, roads and pavement. The result obtained is less than the permissible limit hence suitable for road and other works

STANDARD 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 11.

Table 11: 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

Exp. No.: **Date:**

AGGREGATE CRUSHING VALUE TEST

AIM: To determine the crushing value of the road aggregates

APPARATUS:

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

- A 15cm diameter open ended steel cylinder with plunger and base plate, of the general form.
- A straight metal tamping rod of circular cross-section 16mm diameter and 45 to 60 cm long, rounded at one end.
- A balance of capacity 3k
- IS Sieves.
- A compression testing machine capable of applying load up to 40tonnes.
- Cylindrical measure having internal dia. of 11.5cm & height 18 cm for measuring the sample.
-

REFERENCE CODE:

- IS : 2386 (Part IV) – 1963 method of test for aggregates for concrete
- IS:383:2016 specification for coarse and fine aggregate from natural source for concrete
- IS: 9376:1979 Specification for apparatus for measuring aggregate crushing value

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 (minimum3kg). The aggregates should be dried by heating at 1000-1100 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

OBSERVATION AND CALCULATION:

Tabular Column:-

Description	Trail 1	Trail
Total weight of dry sample taken= W1 gms		
Weight of aggregate passing through 2.36 mm sieve W_2gms		
Aggregate crushing = (W2/W1)×100 (%)		
Average Aggregate crushing (%)		

Aggregate crushing = (W2/W1) ×100= _________ (%)

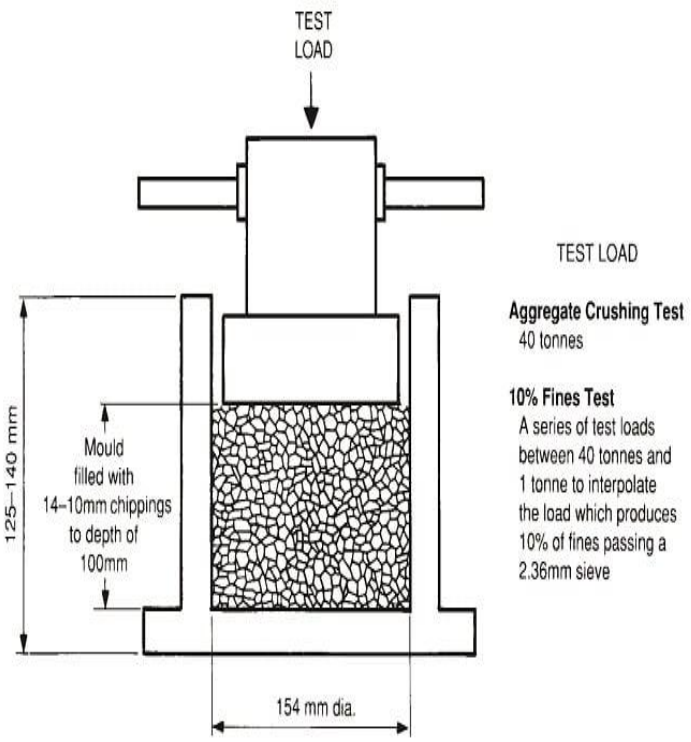


Fig.: Aggregate Crushing Test Apparatus

CALCULATION:

Trail 1

Aggregate crushing Value= (W2/W1)×100= _______%

Trail 2

Aggregate crushing Value= (W2/W1)×100= _______%

Trail 3

Aggregate crushing Value= (W2/W1)×100= _______%

RESULT:

Average Aggregate Crushing Value=………………………%

CONCLUSION:

The crushing value of aggregate is restricted to 30% for concrete used for roads and pavements 45% may be permitted for other structures. So as the crushing value of aggregate is __________ %.so it is fit for concrete use for road and pavement surface.

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

EXP.: **Date.:**

AGGREGATE ABRASION VALUE TEST

AIM: To determining the abrasion value of coarse aggregate by the use of Los Angeles machine.

APPARATUS:

- 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.
- Cast iron or steel balls, approximately 48 mm in diameter and each weighing between 390 to 445 g; 6 to 12 balls are required.
- IS sieve.
- Balance.

REFERENCE CODE: IS: 2386 (Part IV) – 1963, IS: 383-1970.

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 standard balls & rotated in closed inclined cylinders for specific number of revolutions.

PROCEDURE:

1. The test sample shall consist of clean aggregate which has been dried in an oven at 105 to 110°C to substantially constant weight and shall conform to one of the grading shown in Table 3.22. The grading or grading used shall be those most nearly representing the aggregate furnished for the work.
2. The test sample and the abrasive charge shall be placed in the Los Angeles abrasion testing machine and the machine 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 1 000 revolutions.
3. The machine shall be so driven and so counter-balanced as to maintain a substantially uniform peripheral speed. If an angle is used as the shelf, the machine shall be rotated in such a direction that the charge is caught on the outside surface of the angle.
4. At the completion of the test, the material shall be discharged from the machine and a preliminary separation of the sample made on a sieve coarser than the l.70 mm IS Sieve.
5. The material coarser than the 1.70 mm IS Sieve shall be washed dried in an oven at 105 to 110°C to a substantially constant weight, and accurately weighed to the nearest gram

Tabular Column:

Specified Abrasive Charge

Grading	Number of spheres	Weight of charge (gm)
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 20
D	6	2500 ± 15
E	12	5000 ± 25
F	12	5000 ± 25
G	12	5000 ± 25

Grading of Test Samples

Sieve Size		Weight in gm. of Test Sample For Grade						
Passing	Retained on	A	B	C	D	E	F	G
mm	mm							
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	-	-	-

OBSERVATIONS:

Tabular Column:

Description	Trail 1	Trail 2
Total weight of dry sample taken= W1 gm		
Weight of portion passing 1.7 mm sieve= W2 gm		
Aggregate abrasion value = (W2/W1)*100 Value (%)		

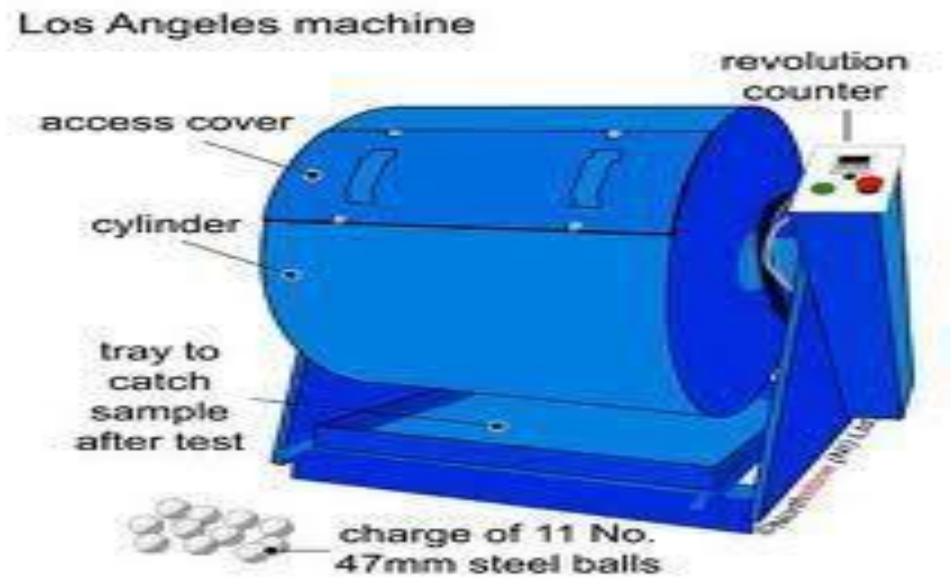


Fig.: Los Angeles Abrasion Testing Machine

RESULT: Mean Los Angeles Abrasion value =…………………………..%

CONCLUSIONS: The following are the conclude values for Los Angeles abrasion test

Table 12: Recommended values of Los Angeles abrasion test

Sl. No.	Type of Pavement	Max. permissible abrasion value in %
1	Water bound macadam sub base course	60
2	WBM base course with bituminous surfacing	50
3	Bituminous bound macadam	50
4	WBM surfacing course	40
5	Bituminous penetration macadam	40
6	Bituminous surface dressing, cement concrete surface course	35
7	Bituminous concrete surface course	30

Exp No: **Date:**

PENETRATION TEST

AIM: To determine the consistency or penetration 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}C containing 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 rock the container. It should be of such capacity as to completely immerse the container during 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.

PROCEDUE:

1. Preparation of test specimen- Soften the material to a pouring consistency at a temperature not more than 60^{0}C for tars and 90^{0}C 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 15^0 C to 30^{0}C for an hour. Then place it along with the transfer dish in the water bath at 25^{0}C ±0.1^{0}C & aloe it remain for one to one and half hour.

2. The test is carried out at 25^0C ±0.1^0C unless otherwise stated.
3. 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.
4. 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.
5. 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.
6. Make the pointer of the dial to read zero or note the initial dial reading.
7. Release the needle for exactly 5 sec.
8. Adjust the penetration machine to measure the distance penetrated.
9. 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

OBSERVATIONS & CALCULATIONS:

Tabular Column:-

Type of needle	Particulars	Test 1	Test 2	Test 3	Penetration Value	Mean Penetration
Solid cone	Penetrometer Dial reading a) Initial					
	b) Final					
Hollow cone	a) Initial					
	b) Final					
Needle cone	a) Initial					
	b) Final					

CALCULATIONS

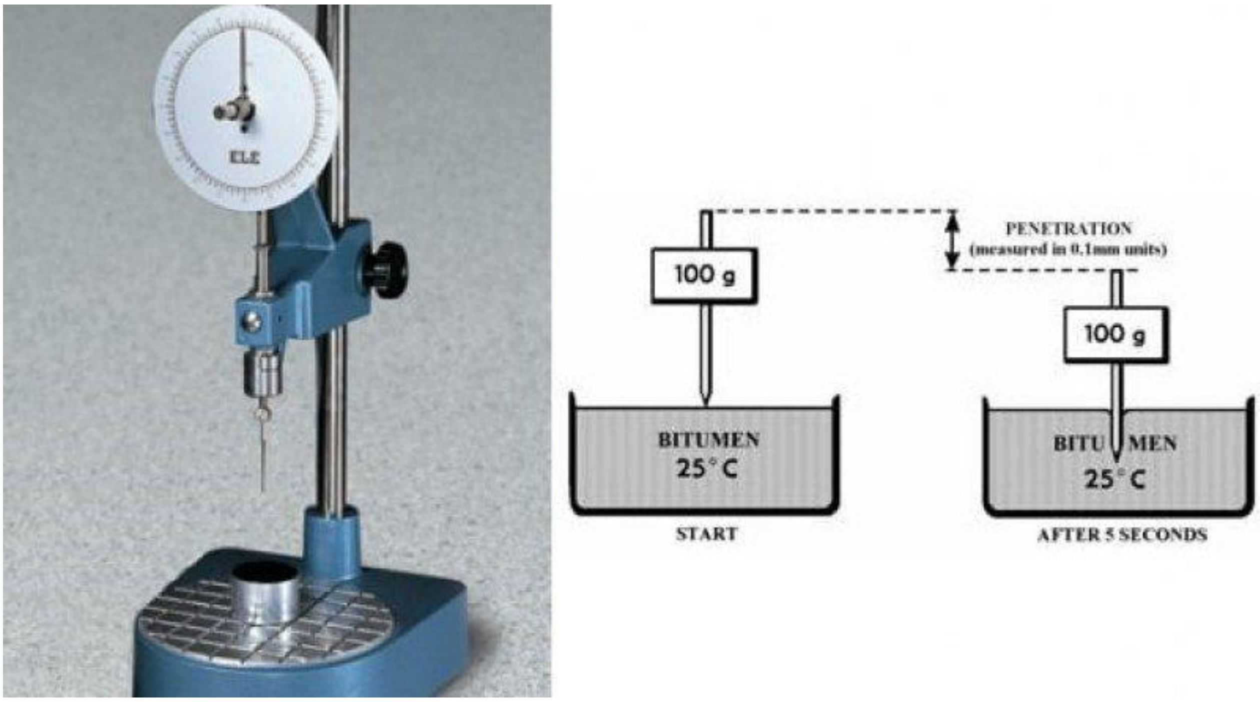


Fig: Penetration apparatus

RESULT:-

The Penetration value of bitumen a) Solid Cone = __________ mm
b) Hollow Cone = __________ mm
c) Needle Cone = __________ mm

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.

Table: 13: Recommended Penetration value of bitumen

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

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.

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 glycerin & 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 of 50mm/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 within 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.

Fig: Ductility testing Machine

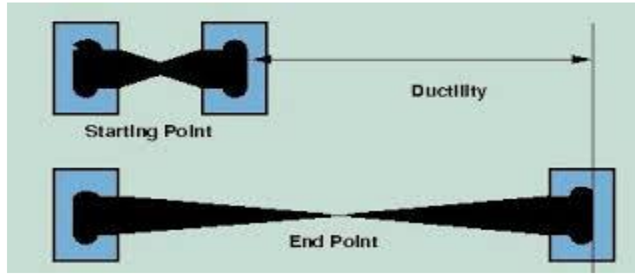


Fig.: Briquette Mould and starting Point end point

OBSERVATIONS AND CALCULATION:

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

RESULT: Ductility of Given Sample 1=________cm
Ductility of Given Sample 2=_________cm

STANDARD RESULTS:

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.

Table 14: Recommended value Ductility of bitumen

`Source of paving bitumen and penetration grade	Minimum ductility value in cms.
Assam petroleum A 25 & A 35	5
Assam petroleum A 25 & A 35	10
Assam petroleum A 65	12
Assam petroleum A90 & A200	15
Bitumen from sources other than Assam petroleum	
S35	50
S45,S65,S90	75

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

12. 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 35^0

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.

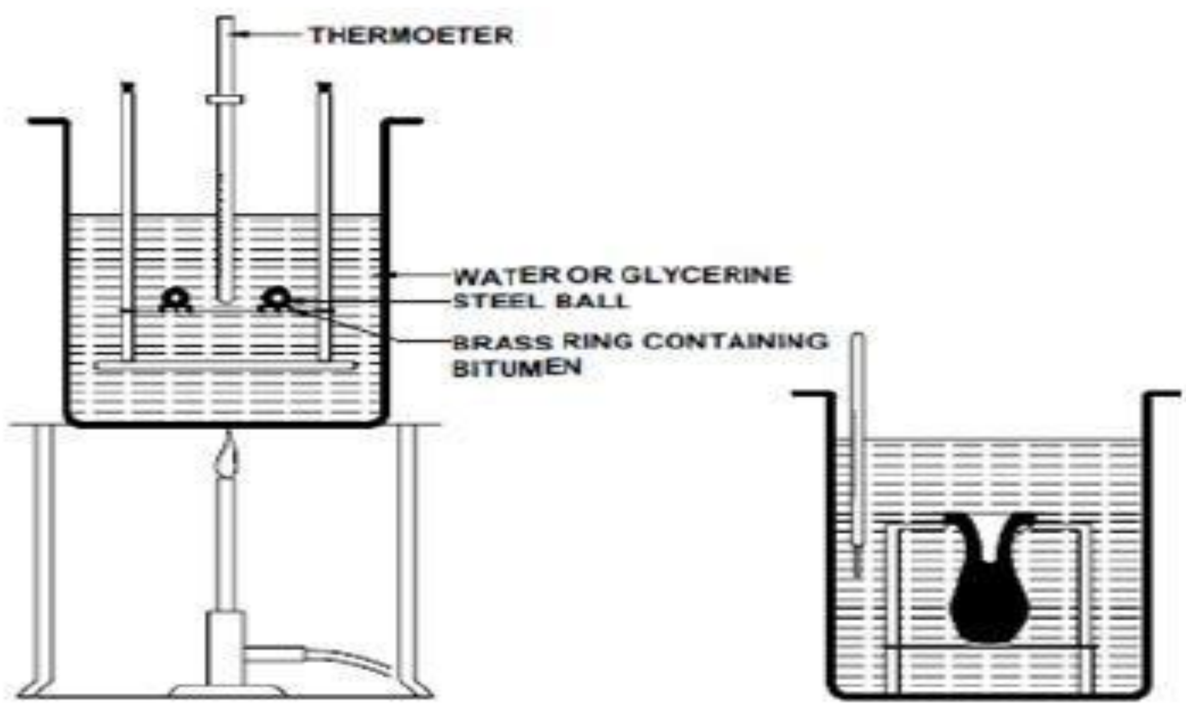


Fig: Assembly of Apparatus for Determination of Softening Point (Ring& Ball)

OBSERVATION & CALCULATIONS:

Liquid Used In the Bath

Tabular Column: -

Sl.No	Temperature when the ball touches bottom (^{0}C)	Average Softening point (^{0}C)
Ball 1		
Ball 2		

RESULTS: The average softening point of given bitumen sample is =________ ^{0}C

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.

Table15: Recommended value Softening point of bitumen

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**

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

Table16: Recommended value Softening point of bitumen

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.

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^{0}c 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 within ±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.

OBSERVATIONS & CALCULATIONS:

Tabular Column:-

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

RESULT:-

The average Viscosity of given bitumen sample is =

Exp No: **Date:**

SPECIFIC GRAVITY TEST ON BITUMEN

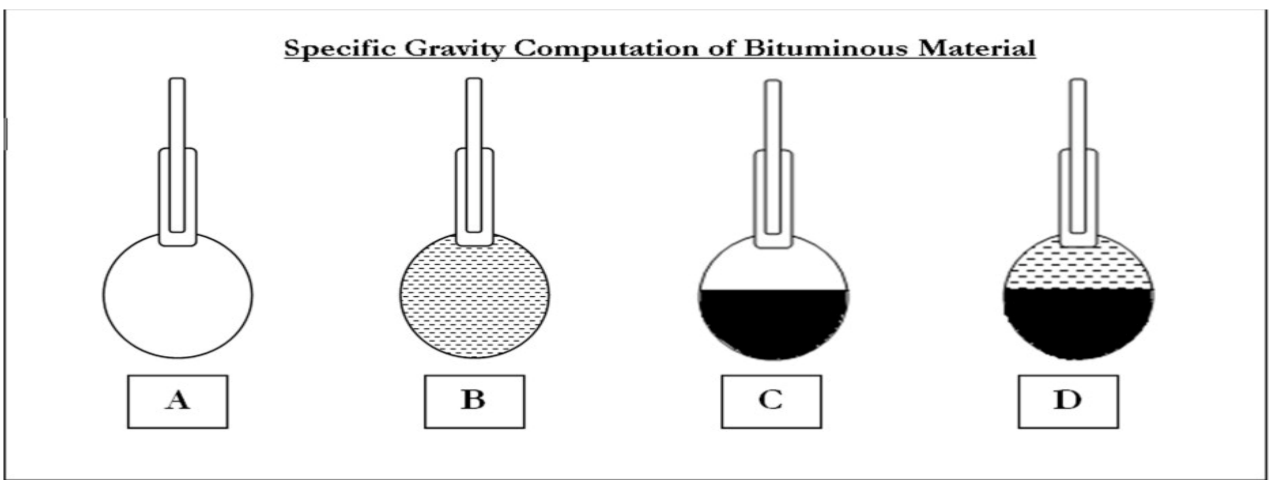
AIM: To determine the specific gravity of given sample of bitumen.

APPARATUS: There are two methods (i) Pyknometer method (ii) Balance method. For pycnometer 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.



CALCULATION

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

$$\text{Specific gravity} = \frac{\text{Weight of bituminous material}}{\text{Weight of equal volume of water at } 27°C} = \frac{(c-a)}{(b-a)-(d-c)}$$

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.

RESULT:

The Specific Gravity of bitumen sample =

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 2

Exp No: **Date:**

BITUMINOUS MIS DESIGN BY MARSHALL METHOD (Demonstration only)

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

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

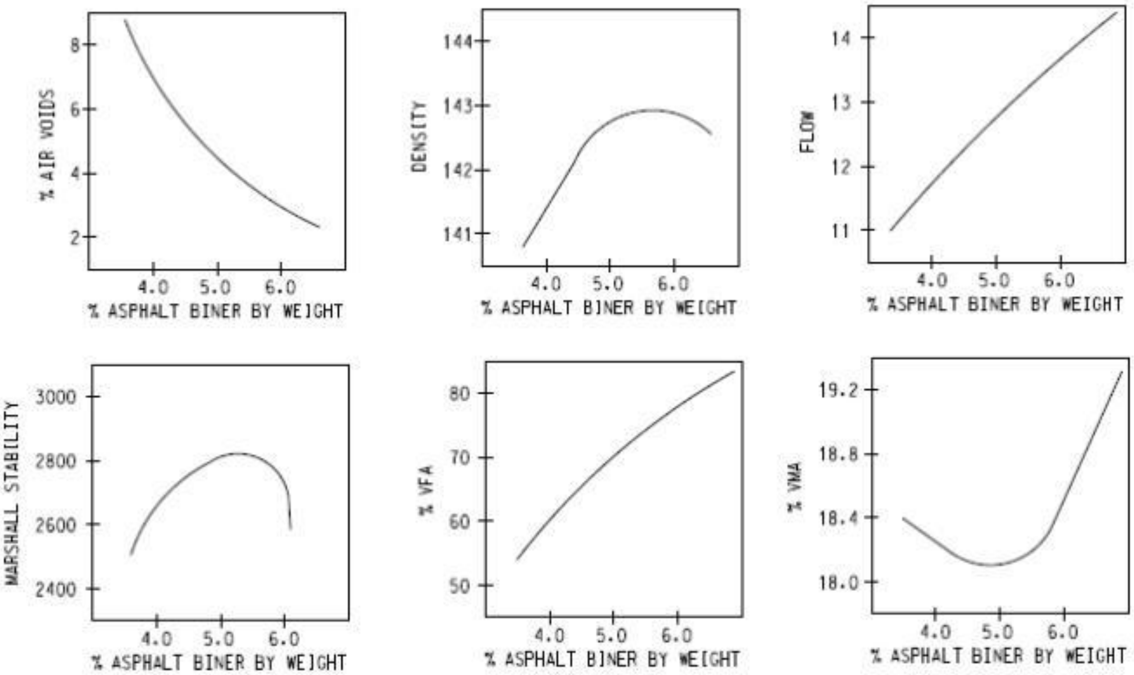
THEORY

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

MARSHALLA STABILITY APPARATUS

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 175oC to 195O C.The compaction mould assembly and rammer are cleaned and kept pre-heated to a temperature of 100oC to 145oC. The bitumen is heated to temperature of 121oC to 138oC 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.
3. Then the mix is heated and a temperature of 150o to 160oC is maintained and then the mix is transferred into the pre-heated mould and compacted by giving seventy five blows on each side.
4. The specific gravity values of different aggregates, filler and bitumen used are determined first. The theoretical specific gravity of the mix is determined.
5. 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.
6. The bulk density value of the specimen if calculated from weight and volume
7. 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.
8. The specimens are taken out one, placed in the marshal test and the marshal stability value and flow are noted.
9. 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.
10. 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.
11. Let the bitumen contents corresponding to maximum density be B1, corresponding to maximum stability be B2 and that corresponding to the specified voids content (at 4.0%) be B3. Then the optimum bitumen content for mix design is given by: Bo(B1+B2+B3)/3



Design graphs for Marshall Mix Design

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

SIGNIFICANCE OF MARSHALL STABILITY TEST

Marshall Stability is related to the resistance of bituminous materials to distortion, displacement, rutting and shearing stresses. The stability is derived mainly from internal friction and cohesion. Cohesion is the binding force of binder material while internal friction is the interlocking and frictional resistance of aggregates. As bituminous pavement is subjected to severe traffic loads from time to time, it is necessary to adopt bituminous material with good stability and flow

Exp:- **Date:-**

WET SIEVE ANALYSIS

IS: 2720 (Part 4)

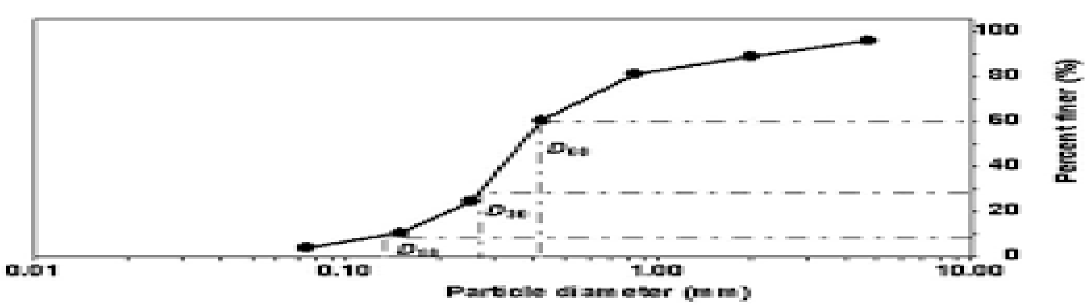
AIM: To evaluate particle size distribution or gradation of a granular material.

APPARATUS: IS Sieves, weighing Balance

THEORY: Soil gradation (sieve analysis) is the distribution of particle sizes expressed as a percent of the total dry weight. Gradation is determined by passing the material through a series of sieves stacked with progressively smaller openings from top to bottom and weighing the material retained on each sieve. The results of testing will reflect the condition and characteristics of the aggregate from which the sample is obtained. Therefore, when sampling, it is important to obtain a disturbed representative sample that is representative of the source being tested because the distribution of different grain sizes affects the engineering properties of soil.

PROCEDURE:

1. 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.
2. Take 200gm of oven dried soil sample and soaked with water by adding sodium hexameta phosphate.
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 retained on 75 micron sieve is collected and dried in oven.
9. It is then sieved through the sieve shaker for ten minutes and retained material on each sieve is collected and weighed.
10. The material that would have been retained on pan is equal to the total mass of soil minus the sum of the masses of material retained on all sieves.
11. Draw the curve for the soil in the semi-logarithmic graph in order to obtain grain size distribution curve.



Graph: Particale Size Distubition

CALCULATIONS:

Weight of Sample taken for Sieve Analysis (W)= _____ gms

Tabular Column:-

Sl no	I.S Sieve No:	Weight of Soil retained in W1 gms	Percent weight retained (W1/W) ×100 (%)	Cumulative percentage (x) gms	Percentage finer (100-x)
	4.75mm				
	2.00mm				
	1.00mm				
	425micron				
	212micron				
	150micron				
	75 micron				
	pan				

Co-efficient of uniformity, Cu

$$C_u = \frac{D_{60}}{D_{10}} = \_\_\_\_\_\_\_\_\_\_$$

Co-efficient of curvature, C_c

$$C_u = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \_\_\_\_\_\_\_\_\_\_$$

RESULT: The given soil sample of Co-efficient of uniformity, Cu=
The given soil sample of Co-efficient of curvature, C_c =

Significant of Wet Sieve Analysis:

Particle size distribution, also known as gradation, refers to the proportions by dry mass of a soil distributed over specified particle-size ranges. Gradation is used to classify soils for engineering and agricultural purposes, since particle size influences how fast or slow water or other fluid moves through a soil.

Exp No: **Date:**

CALIFORNIA BEARING RATIO TEST
IS: 2720 (Part 16)

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

APPARATUS: Loading machine, cylinder moulds, spacer disc, compaction rammer, annular weights dial gauges, proving ring, penetrating needle, filter paper, IS sieve, balance & weights.

PROCEDURE:

1) About 5 kg of soils collected by sieving it through 20 mm IS sieve. The sample is mixed with water equal to the quantity required for Optimum moisture content.
2) The spacer disc is placed in the bottom of the mould along with Filter paper. The sample is filled in the mould in 5 approximately Equal layers,
3) Compacting each layer by giving 56 blows using 4.89 kg rammer
4) After completely filling sample in the mould, level the top surface & annular weights or surcharge in the mould & keep the whole Assembly on the loading machine.
5) Fix the penetrating needle, dial gauge & proving ring. The machine is switched on & the load is applied at the rate of 1.25 mm per Minute.
6) Note down the depth of penetration for different amount of loads.

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%

Table 17: Standard load for CBR

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

Tabular column:-

Dial gauge reading in division		Penetration in mm		Load in division	Load in Kg Load *K (K=0.429)	Load from the Graph	CBR Value in (%)
Ex:	Result	Ex:	Result				
0		0					
50		0.5					
100		1					
150		1.5					
200		2.0					
250		2.5					
400		4					
500		5					
750		7.5					
1000		10					
1250		12.50					
1300		13					

EX:-Example

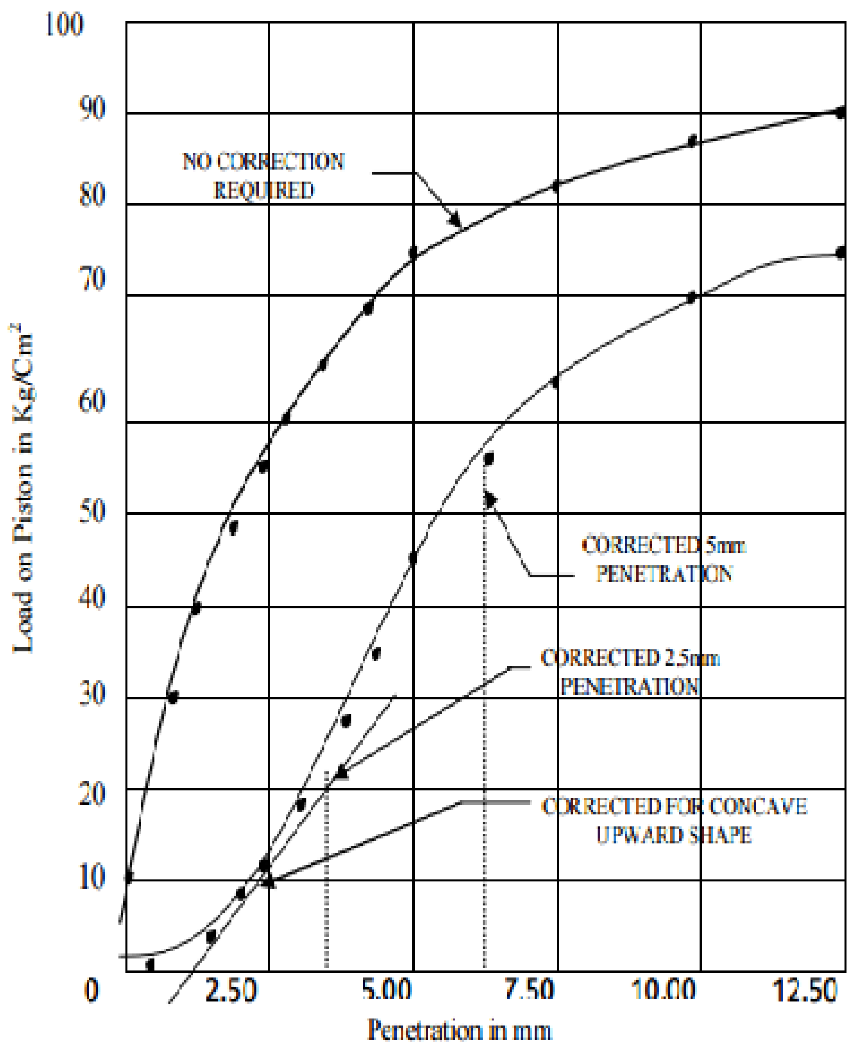
CALCULATION

To calculate the CBR at 2.5mm & 5.0 mm depth of penetration.

$$\text{CBR @ 2.5 mm} = \frac{\text{Load at 2.5 mm depth of penetration from Graph}}{\text{Load taken by standard stone at 2.5 mm depth of penetration}}$$

$$\text{CBR @ 5 mm} = \frac{\text{Load at 5 mm depth of penetration from Graph}}{\text{Load taken by standard stone at 5 mm depth of penetration}}$$

Draw the graph load in Kg verses penetration in mm. After applying the Correction for initial concavity of the curve, calculate the loads at 2.5 mm & 5.0mm depth of penetrations.



Graph: CBR Test

Result:

C.B.R. of specimen at 2.5 mm penetration = _________%

C.B.R. of specimen at 5.0 mm penetration = ________%

Significance of California bearing ratio test

The **California bearing ratio** (**CBR**) is a penetration **test** for evaluation of the mechanical strength of natural ground, sub grades and base courses beneath new carriageway construction. CBR is the ratio of the force per unit area required to penetrate a soil mass with a standard circular piston of 50 mm dia, at the rate of 1.25 mm/min to that of force required to penetrate sample of compacted stone having CBR of 100%.

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. What is Mix Concrete design? List out the different method of mixes design.
15. Define Standard Mixes, Nominal Mixes, and Design Mixes.
16. What are the factors affecting of Mixes design.
17. Explain the procedure for Design of concrete mix as per IS-10262?
18. What is a difference between Destructive and non destructive test on concrete?
19. Explain the working principal of rebound hammer and pulse velocity test?
20. Define Self Compacting concrete? Explain the properties of Self Compacting concrete.
21. What is a difference between conventional concrete and Self Compacting concrete?
22. Explain the Fresh properties test on Self Compacting concrete as per EFNARC Guidelines?
23. What is a Practical application of Self Compacting concrete?
24. List out the various method of Design Mixes Self Compacting concrete?
25. How does strength correlate with other properties of hardened concrete?
26. What are the requirements for curing the specimens?
27. What do you mean by elongation index of an aggregate?
28. What do you infer from elongation index?
29. How the elongation index of the sample helps in deciding the design of a highway?
30. What do you mean by flakiness index of an aggregate?

31. What do you infer from flakiness index?
32. How the flakiness index of the sample helps in deciding the design of a highway?
33. How is the crushing strength test carried out on cylindrical stone specimen? Why is the test not carried out commonly?
34. Explain aggregate crushing value. How would you express?
35. Briefly explain the aggregate crushing value test procedure.
36. What is the specified standard size' of aggregates? How is the aggregate crushing value of non standard size aggregate evaluated?
37. Aggregate crushing value of material A is 40 and that of B is 25. Which one is better and why?
38. What are the applications of aggregate crushing test?
39. What are the recommended maximum values of aggregate crushing value for the aggregates to be used in base and surface courses of cement concrete?
40. What are the uses and applications of the aggregate crushing test?
41. Why Los Angeles abrasion test is considered superior to other tests to find the hardness of aggregates?
42. How is Los Angeles abrasion value expressed?
43. Briefly explain the Los Angeles abrasion test procedure.
44. What are the desirable limits of Los Angeles Abrasion values specified for different types of pavement surfacing?
45. What are the advantages of Aggregate Impact test over Page Impact test?
46. Briefly mention the procedure of aggregate impact test?
47. How is aggregate impact expressed?
48. What are the desirable limits of aggregate impact value specified for different types of pavement surfaces?
49. Aggregate impact value material A is 20 and that of B is 45. Which one is better for surface course? Why?
50. What do you understand by dry and wet impact value?
51. How is penetration value of bitumen expressed?
52. What are the standard load, time and temperature specified for penetration test.
53. Briefly outline the penetration test procedure.
54. What do you understand by 80/ 100 bitumen?

55. What are the effects of: (i) higher test temperature (ii) higher pouring temperature (iii) Exposed bitumen, on penetration test results?
56. Explain ductility of Bitumen and its significance.
57. How is ductility value expressed?
58. Outline the ductility test procedure.
59. What is the minimum area of cross section of the ductility specimen?
60. What are the precautions to be taken while finding the ductility value?
61. What are the factors affecting the ductility test results?
62. What is softening point?
63. What does softening point of bituminous materials indicate?
64. What are the applications of ring and ball test results?
65. Explain the two methods of finding specific gravity of bituminous materials.
66. What precautions should be taken while finding the specific gravity?
67. What are the applications of specific gravity and results?
68. Explain the term viscosity.
69. What are the different methods in determining the viscous characteristics of bituminous materials?
70. What is absolute unit for viscosity?
71. What are the uses of viscosity test?
72. Write a note on float test.
73. What are the precautions to be taken during viscosity test using orifice viscometer?
74. Define flash and fire points.
75. Briefly outline the flash point test procedure.
76. What is the significance of flash point test? Differentiate between flash point and fire point.
77. Why do we need to design bituminous mix?
78. What are the essential properties of bituminous mixes?
79. What is the significance of flow value in Marshall Test?
80. Why is the sample in Marshall Test placed on its periphery while loading?
81. What is the measure taken if a mix results in excessive voids?
82. What is filler?
83. What are different types of fillers?
84. Does Portland cement, if used in bituminous mix, improve strength?

85. Briefly out line Marshall Stability test procedure?
86. How is bituminous mixed designed based on Marshall design approach?
87. What is a significant of wet sieve analysis by soil test
88. What are the practical application of CBR test on soils and other pavement materials?
89. What are the desirable properties of road aggregates? Mention their relative importance.

REFERENCE CODES

Sl No	Experiments	Codes
1	Normal Consistency of Cement	(IS: 4031 - 1988 - 4))
2	Initial & Final Setting Times of Cement	(IS: 4031- 1988 -5)
3	Specific Gravity Of Cement	(IS: 4031-1988)
4	Soundness Of Cement	(IS 4031-1988 PART 3)
5	Compressive Strength Of Cement	(IS269-2015, IS 12269 - 1987, IS 4031-1988 (Part6)
6	Design of Concrete Mix	(IS 10262-2019,IS456,IS 383-2016)
7	Slump Test	(IS 1199-2018, IS 7320-1974)
8	Compaction Factor Test	(IS 1199-2018, IS 5515-1983)
9	Vee-Bee Consistometer	(IS 1199-2018, IS -10510-1983)
10	Compressive Strength Of Concrete Cubes	(IS: 516 – 2018)
11	Split Tensile Strength Of Concrete	(IS: 5816 – 1999)
12	NDT Test rebound Hammer and UP velocity	(IS 13311Part 2)
13	Self-Compacting Concrete	ASTM C 1611/C 1611M-05, EFNARC -2005 IS 10262-2019, IS 1199-Part 6
14	Aggregate Crushing Value Test	(IS 2386- part IV)
15	Aggregate Impact Test	(IS 2386- part IV)
16	Abrasion Test	(IS 2386- part IV)
17	Shape Test	(IS 2386- part I)
18	Softening Point Test	(IS1205-1978)
19	Viscosity Test	(IS1206-1978)
20	Ductility Test	(IS1207-1978)
21	Flash & Fire Point Test	(IS 1209-1978)
22	Specific Gravity of Bitumen	(IS 1202-1978)
23	Penetration Test	(IS1203-1978)
24	Wet Sieve Analysis & CBR Test	IS-2720 Part-4, IS-2720-16

QUESTION PAPER PATTERN:

- All are individual experiments
- Instructions as printed on the cover page of answer script for split up of marks to be strictly followed
- All exercises are to be included for practical examination
-

REFERENCE BOOKS

[1]. 1. M.L.Gambir, “Concrete Manual”, Danpat Rai and sons, New Delhi
[2]. Shetty M.S, “Concrete Technology”, S. Chand & Co. Ltd, New Delhi.
[3]. Mehta P.K, “Properties of Concrete”, Tata McGraw Hill Publications, New Delhi.
[4]. Neville AM, “Properties of Concrete”, ELBS Publications, London.
[5]. Relevant BIS codes.
[6]. S K Khanna, C E G Justo and A Veeraragavan, “Highway Materials Testing
[7]. Laboratory Manual ”, Nem Chand Bros, Roorkee
[8]. L R Kadiyali, “Highway Engineering ”, Khanna Publishers, New Delhi

ADDITIONAL INFORMATION

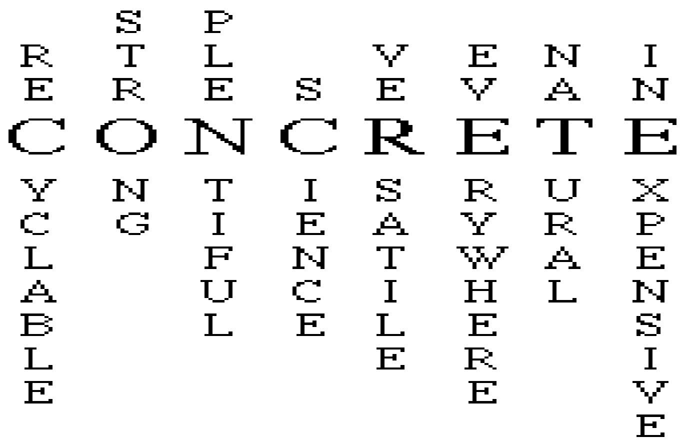
Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement which hardens over time. Most concretes used are lime-based concretes such as Portland cement concrete or concretes made with other hydraulic cements. However, asphalt concrete which is very frequently used for road surfaces is also a type of concrete, where the cement material is bitumen, and polymer concretes are sometimes used where the cementing material is a polymer

When was concrete first made? : 9000 BC 500 BC 100 AD 1756 1824
What is the purpose of cement in concrete?
It acts as a primary binder to join the aggregate into a solid mass.
What role does water play in producing concrete? Water is required for the cement to hydrate and solidify.

Why does concrete harden?
The chemical process called cement hydration produces crystals that interlock and bind together.

Is concrete stronger in compression, tension, or the same in either?
It is stronger in compression.
Here are just a few facts to help convince you that the topic of concrete deserves to become a part of your science curriculum:

Concrete is everywhere!! Roads, sidewalks, houses, bridges, skyscrapers, pipes, dams, canals, missile silos, and nuclear waste containment. There are even concrete canoes and Frisbee competitions.
It is strong, inexpensive, plentiful, and easy to make. But more importantly, it's versatile. It can be molded to just about any shape.
Concrete is friendly to the environment. It's virtually all natural. It's recyclable.
It is the most frequently used material in construction.
Slightly more than a ton of concrete is produced every year for each person on the planet, approximately 6 billion tons per year.
By weight, one-half to two-thirds of our infrastructures are made of concrete such as: roads, bridges, buildings, airports, sewers, canals, dams, and subways
Approximately 60% of our concrete highways need repair and 40% of our concrete highway bridges are structurally deficient or functionally obsolete.
Large cities lose up to 30% of their daily water supply due to leaks in concrete water pipes.
Cement has been around for at least 12 million years and has played an important role in history.



Highway:-

Highway engineering is an engineering discipline branching from civil engineering that involves the planning, design, construction, operation, and maintenance of roads, bridges, and tunnels to ensure safe and effective transportation of people and goods. Highway engineering became prominent towards the latter half of the 20th Century after World War 2.

The first research dedicated to highway engineering was initiated in the United Kingdom with the introduction of the Transport (TRL), in 1930