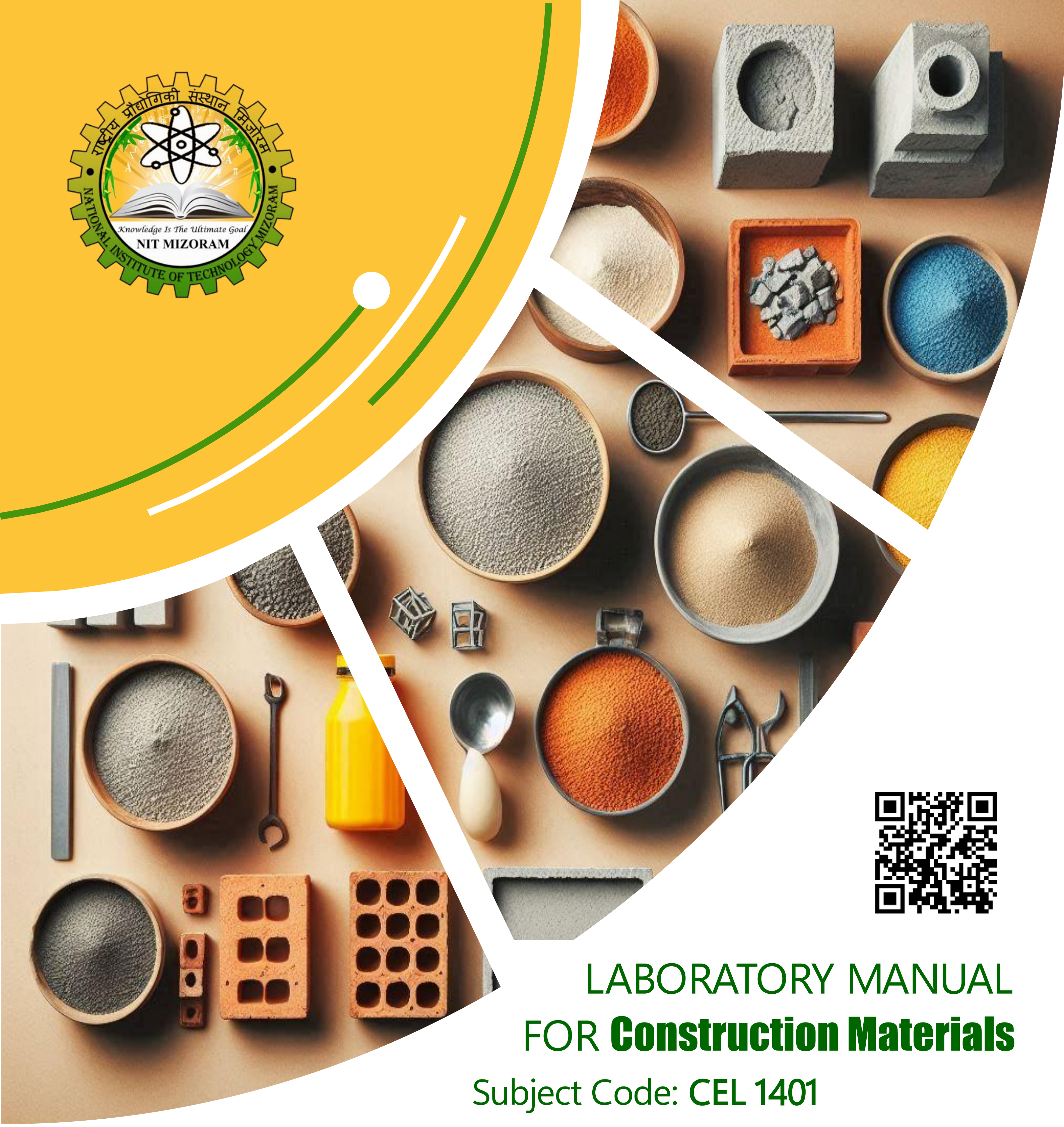


LABORATORY MANUAL FOR **Construction Materials**

Subject Code: **CEL 1401**

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY MIZORAM

LIST OF EXPERIMENTS

EXPERIMENT NO. 01

Determination of Specific Gravity of Cement

AIM: To determine the specific gravity of cement using Le Chatelier's flask or specific gravity bottle.

THEORY: Specific gravity is defined as the ratio between weight of a given volume of material and weight of an equal volume of water. In case of cement, specific gravity is determined by use of a Le Chatelier's flask (Fig. 1.2). Sometimes, a specific gravity bottle (Fig. 1.1) may be employed in place of standard Le Chatelier's flask. To determine the specific gravity of cement, kerosene is used which does not react with cement. The specific gravity of OPC is generally around 3.15.

Determining the specific gravity of cement is essential for accurate concrete mix design, as it influences the material proportions and overall strength of the concrete. This experiment, using Le Chatelier's flask or a specific gravity bottle, helps ensure quality control by verifying the density of the cement, which is crucial for achieving the desired performance in construction projects.

APPARATUS:

1. Le Chatelier flask or specific gravity bottle/pycnometer of 100 ml.
2. Weighing balance capable of weighting accurately upto 0.1 gm.

Fig. 1.1 Specific gravity bottle

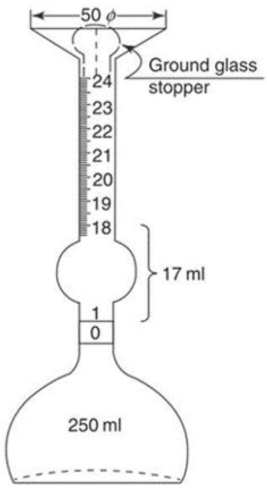


Fig. 1.2 Le Chatelier's specific gravity flask

REQUIRED MATERIALS:

1. Kerosene
2. Ordinary Portland Cement (OPC)

PROCEDURE:

The specific gravity test procedure consists of the following four steps:

1. Ensure that the flask is completely dry and free of any liquid. Weigh the empty flask and record this weight as W1.
2. Next, fill the flask approximately halfway with cement, around 50 gm, and then weigh the flask with its stopper. Record this weight as W_2.
3. Add kerosene to the flask until it is filled to the top. Mix thoroughly to remove any air bubbles. Weigh the flask with the cement and kerosene, and record this weight as W_3.
4. After emptying the flask, fill it with kerosene up to the top, and then weigh it again to obtain W_4.

OBSERVATIONS & CALCULATIONS:

Measurement	Weight (gm)
Weight of empty flask (W_1)	
Weight of flask + Cement (W_2)	
Weight of flask + Cement + Kerosene (W_3)	
Weight of flask + Kerosene (W_4)	

The following formula can be used to calculate the Specific Gravity of cement:

$$S_g = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4) \times 0.79}$$

RESULT AND CONCLUSIONS:

Specific Gravity of the given sample of OPC is ____________ %

PRECAUTIONS:

1. Ensure that all equipment, especially the flask, is completely dry before starting the experiment. Any moisture present can affect the accuracy of the measurements.
2. When adding kerosene to the cement in the flask, mix gently and thoroughly to remove all air bubbles. Air bubbles can lead to incorrect volume measurements and inaccurate results.
3. Mix the cement and kerosene thoroughly to ensure that all the cement particles are fully suspended and no air pockets remain.

4. Perform the test at a consistent room temperature to avoid any variations in the density of kerosene or the cement, as temperature fluctuations can affect the results.
5. Ensure that the cement used is fresh and free from any lumps or moisture. Old or hydrated cement can lead to erroneous specific gravity values.
6. **Kerosene is flammable, so handle it carefully. Avoid open flames or sparks in the vicinity, and work in a well-ventilated area.**

QUESTIONS:

1. Why can't water be used for determining the specific gravity of cement?
2. What are the potential sources of errors in this experiment?
3. How will the results be affected if air bubbles are not completely removed from the flask?
4. Why is it important to maintain a constant temperature in the test chamber during this experiment?

EXPERIMENT NO. 02

Determination of Consistency of Standard Cement Paste

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

THEORY: This test is conducted to calculate the amount of water to be added to the cement to get a paste of standard consistency which is defined as that consistency which will permit the Vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the Vicat mould.

Since different batches of cement differ in fineness, pastes with some water content may differ in consistency when first mixed, because of which the consistency of the cement paste needs to be standardized. An excessive water content leads to high workability but also introduces risks of bleeding and segregation, which negatively impact the strength and durability of the concrete. On the other hand, insufficient water reduces workability, making it challenging to achieve a homogeneous mix, thereby compromising the integrity of the final structure. This test is crucial in establishing the optimal water-cement ratio, ensuring the concrete or mortar attains the desired balance of workability, strength, and durability.

The standard consistency of cement test should be performed as per IS 4031(Part 1):1996 specifications by the Vicat apparatus mentioned in IS 5513:1996.

APPARATUS:

1. Vicat Apparatus conforming to IS 5513:1996
2. Weighing balance
3. Stop Watch
4. Measuring Cylinder
5. Glass Plate
6. Tray
7. Trowel

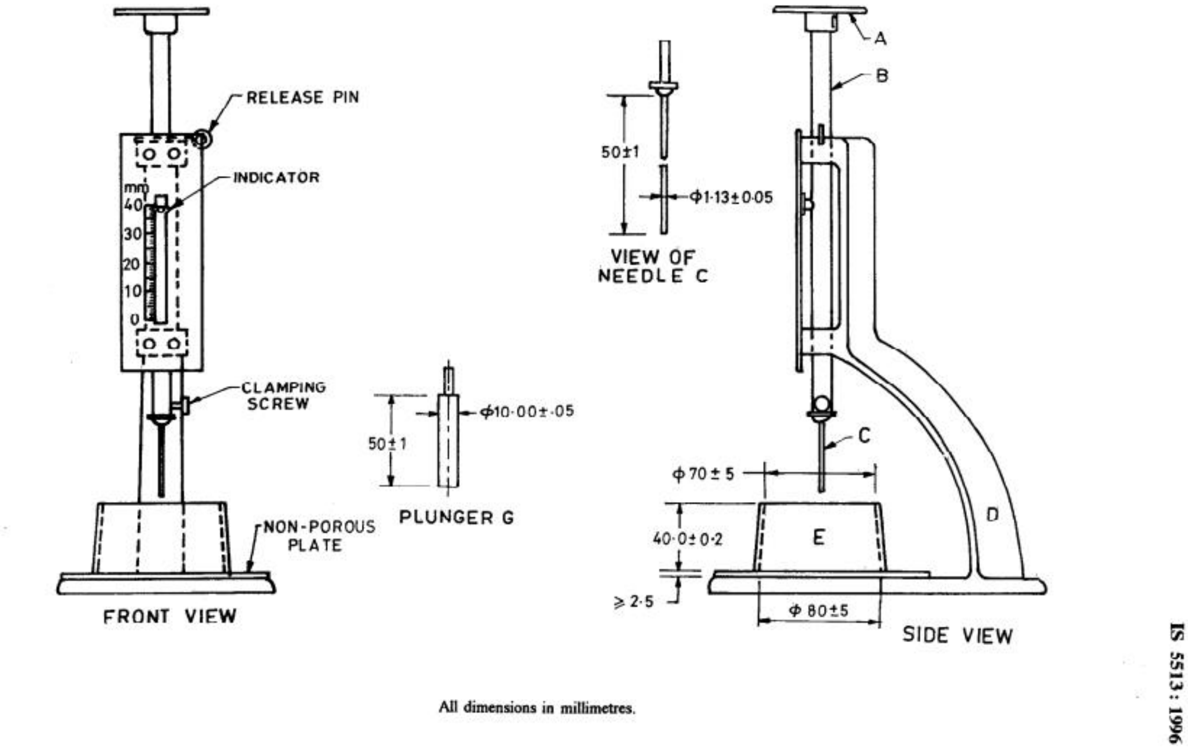


Fig. 2.1 Vicat Apparatus

MATERIALS REQUIRED:

1. Ordinary Portland Cement
2. Potable/distilled water

PROCEDURE:

The standard consistency of a cement paste is defined as that consistency which will permit the Vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the Vicat mould.

1. Prepare a paste using a weighed quantity of cement (400 g) with a measured amount of water, starting at 25% by weight of the cement, and increasing the water content at intervals of 2%. Ensure that the gauging time is not less than 3 minutes and not more than 5 minutes. The gauging process must be completed before any signs of setting occur. The gauging time is counted from the moment water is added to the dry cement until the commencement of filling the mould.
2. Fill the Vicat mould with this paste, ensuring that the mould rests upon a non-porous surface (glass plate). Level the surface of the paste with the top of the mould. The mould may be gently shaken to expel any trapped air.

3. Use clean appliances for gauging. The temperature of the cement, water, and the test room during the operation should be maintained at 27 ± 2°C.
4. When filling the mould, only the operator's hands and the blade of the gauging trowel should be used. The trowel should weigh 210 ± 10 g.
5. Place the test block in the mould, along with the glass plate, under the rod bearing the plunger. Lower the plunger gently to touch the surface of the test block, and then release it quickly, allowing it to sink into the paste. This operation should be performed immediately after filling the mould.
6. Prepare trial pastes with varying percentages of water and test as described above until the amount of water necessary for achieving the standard consistency is determined. Express the amount of water as a percentage by weight of the dry cement.

OBSERVATIONS & CALCULATIONS:

No. of Trials	% of Water	Initial Reading	Final Reading	Height Penetrated (mm)

RESULTS:

Standard Consistency of Cement is ____________ %

PRECAUTIONS:

1. The test should be conducted in a controlled environment to avoid any loss of moisture from the cement paste.
2. Ensure the cement paste is homogenous and free from air bubbles before conducting the penetration test.
3. The Vicat apparatus should be free from any vibrations during the test.
4. The entire test should be completed within 3 to 5 minutes to avoid initial setting of the cement.

QUESTIONS:

1. Why is it important to determine the standard consistency of cement paste?
2. How does the water-cement ratio affect the consistency and strength of cement?
3. What are the possible errors that can occur during the consistency test, and how can they be minimized?

4. Why is it necessary to start the test with a 25% water-to-cement ratio?
5. Explain the role of temperature in the consistency test. How does temperature variation affect the test results?
6. How does the consistency of the paste change as the water content increases?
7. Why must the gauging process be completed within 3 to 5 minutes?
8. How would incorrect consistency in cement paste affect the final concrete structure?
9. How does the consistency of cement paste correlate with its workability in actual construction scenarios?

REFERENCES:

1. *Bureau of Indian Standards, IS 4031 (Part 4): Methods of Physical Tests for Hydraulic Cement – Determination of Consistency of Standard Cement Paste. New Delhi, India: BIS, 1988.*
2. *Bureau of Indian Standards, IS 5513: Specification for Vicat Apparatus. New Delhi, India: BIS, 1996.*

EXPERIMENT NO. 03

Determination of Initial and Final Setting Times of Cement

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

THEORY: Determining the initial and final setting times of cement is crucial for understanding how quickly cement begins to set and how long it takes to reach a hardened state. The initial setting time is defined as the period from the moment water is added to the cement until the paste starts to harden and can no longer be stirred with a standard needle. This period is significant because it indicates how long the cement paste remains workable and malleable, which is essential for effective mixing, transportation, and placement of concrete.

On the other hand, the final setting time is the duration from the moment water is added to the cement until the paste reaches a stage where it cannot be marked by the needle of the Vicat apparatus and is considered to have fully hardened. This time is important as it provides information on when the cement paste will achieve a rigid, solid state, ensuring there is adequate time for placement and finishing before it sets.

Determining the initial and final setting times of cement is essential for managing the workability and timing of concrete placement. These tests ensure that the cement remains workable long enough for mixing and placement, while also providing a clear timeline for when the cement will harden. This information is critical for planning construction activities and ensuring the concrete achieves the desired strength and durability.

APPARATUS:

1. Vicat apparatus conforming to IS 5513:1996
2. Weighing balance
3. Gauging trowel
4. Measuring cylinder
5. Stop watch.

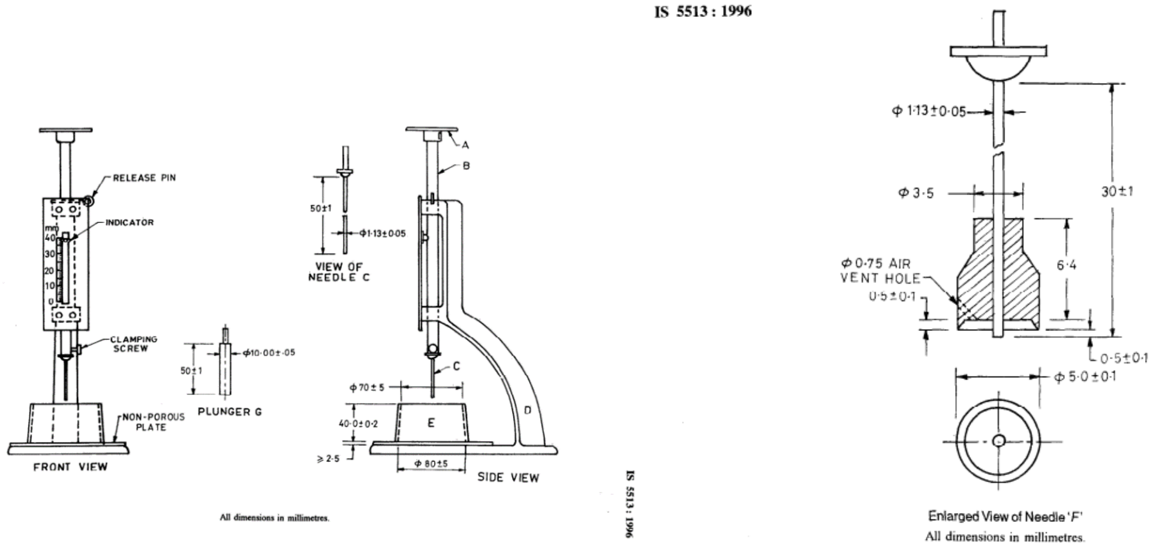


Fig. 3.1 Vicat Apparatus along with Needle F (with annular attachment)

MATERIALS REQUIRED:

1. Ordinary Portland Cement
2. Potable/distilled water

PROCEDURE:

1. Prepare a uniform cement paste by gauging 400 g of cement with 0.85 times the water required to obtain a paste of standard consistency. The procedure for mixing and filling the mould is the same as for standard consistency.

2. Start the stopwatch or note the time when water is added to the cement.

Determination of Initial Setting Time:

3. Place the test block, confined in the mould and resting on the non-porous plate, under the rod bearing the initial setting needle (with a cross-section of 1 mm²). Lower the needle gently until it contacts the surface of the test block and then quickly release it, allowing it to penetrate into the test block.
4. Repeat this procedure until the needle, when brought into 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. Note the time.
5. The difference in time between steps (2) and (4) provides the initial setting time of the cement.

Determination of Final Setting Time:

6. Replace the initial setting needle of the Vicat apparatus with the needle having an annular attachment.
7. The cement is considered finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression, while the annular attachment does not.
8. The time interval between steps (2) and (7) provides the final setting time of the cement.

OBSERVATIONS:

- Weight of given sample of cement is ___________ g.
- The standard consistency of a given sample of cement is ___________ %.
- Volume of water added (0.85 times the water required to obtain a paste of standard consistency) for preparation of test block ____________ ml.

Time (in min.)					
Height needle C fails to penetrate (in mm)					

RESULTS:

- Initial setting time (in min):

The given sample of cement satisfies/ does not satisfy the criterion for initial setting time.

- Final setting time (in min):

The given sample of cement satisfies/ does not satisfy the criterion for final setting time.

PRECAUTIONS:

1. Mix the cement paste thoroughly and uniformly to avoid any inconsistencies in the setting times.
2. Conduct the test in a controlled environment with stable temperature and humidity to avoid fluctuations that can affect setting times.
3. Start the test immediately after mixing the cement and water to ensure accurate timing for the initial setting.
4. Ensure that the Vicat apparatus needle is properly aligned and free of any obstructions before each penetration test.
5. Use a non-porous plate beneath the test block to prevent water absorption, which could alter the setting times.

6. Lower the needle gently to avoid impact forces that could give inaccurate penetration readings

QUESTIONS:

1. What is the significance of determining the initial and final setting times of cement in construction projects?
2. Why is it important to gauge the cement with 0.85 times the water required for standard consistency in this test?
3. How does the environmental temperature affect the setting times of cement, and what precautions should be taken during the test?
4. How do variations in the water-cement ratio influence the initial and final setting times of cement?
5. What could be the potential sources of error in this test, and how can they be minimized?
6. How does the composition of cement affect its initial and final setting times?
7. How can the results of the initial and final setting time tests influence the selection of cement for different construction applications?
8. What steps should be taken if the cement does not achieve the final setting within the expected time?

REFERENCES:

1. *Bureau of Indian Standards, IS 4031 (Part 5): Methods of Physical Tests for Hydraulic Cement – Determination of Consistency of Standard Cement Paste. New Delhi, India: BIS, 1988.*

EXPERIMENT NO. 04

Determination of Compressive Strength of Cement

AIM: To determine the compressive strength of cement.

THEORY: The compressive strength of cement is a crucial measure of its ability to withstand loads without failure, making it a key indicator of quality in construction materials. This property is determined by testing the compressive strength of mortar cubes, typically prepared by mixing cement with standard sand and water. The resulting strength is vital for ensuring that concrete structures, which rely on cement as the primary binder, can bear the stresses and loads they will encounter during their service life.

Several factors influence the compressive strength of cement, including its chemical composition, the water-cement ratio, and curing conditions. Proper curing, in particular, is essential for allowing the cement to develop its full strength over time. This strength is usually assessed at specific intervals, such as 3, 7, and 28 days, to monitor the cement's performance. The results of these tests are critical for quality control and optimizing concrete mix designs to ensure the durability and safety of construction projects.

APPARATUS:

1. Vibration Machine conforming to IS 10080:1982
2. Poking Rod conforming to IS 10080:1982
3. Enamel-coated tray
4. Cube Mould of 70.6 mm size conforming to IS 10080:1982
5. Balance
6. Gauging Trowel

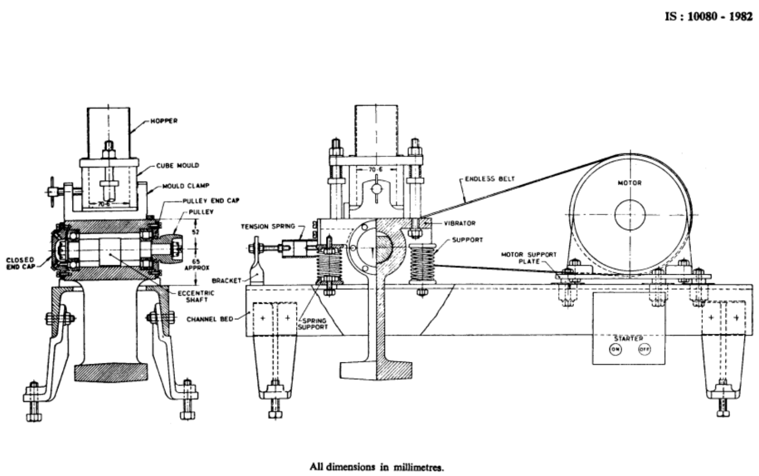


Fig. 4.1 Typical Vibration Machine

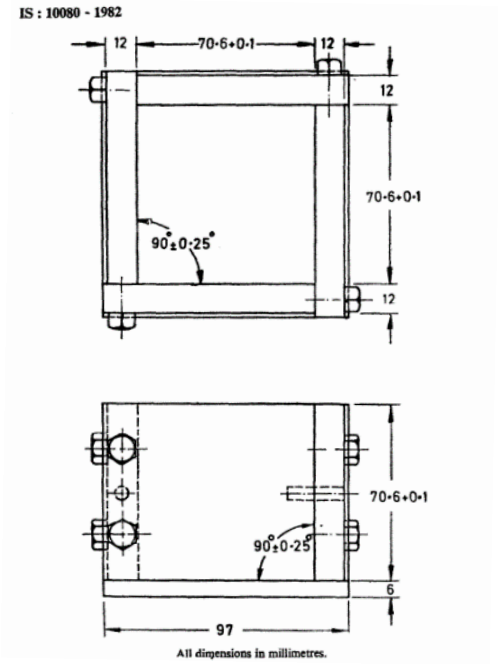


Fig. 4.2 Typical cube mould, 70.6 mm size

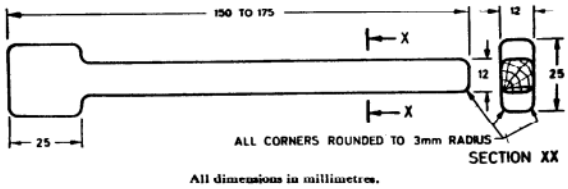


Fig. 4.3 Poking Rod

MATERIALS REQUIRED:

1. Ordinary Portland cement
2. Potable/distilled water
3. Grease
4. Standard sand conforming to IS: 650- 1966

PROCEDURE:

Mix Proportions and Mixing:

1. Use clean appliances for mixing, and ensure that the temperature of the water and the test room remains at 27 ± 2°C during the operations. Prepare the cement mix with potable or distilled water.
2. Mix the materials for each cube separately. Use the following quantities:

   Cement= 200 g

   Standard Sand= 600 g (200 g of each grade)

   $$\text{Water} = \frac{\left(\frac{P}{4}+3.0\right) \times \text{weight of cement and sand in gm}}{100}$$

   Where *P* is the percentage of water needed to produce a paste of standard consistency.

3. Place a mixture of cement and standard sand on a non-porous plate. Mix it dry with a trowel for one minute, then add the weighed quantity of water and mix until the mixture

is of uniform colour. Ensure that the mixing time is at least 3 minutes and does not exceed 4 minutes.

Moulding Specimens:

4. Assemble the moulds by covering the joints between the halves and the interior faces with a thin film of grease. Apply a similar coating between the contact surfaces of the bottom of the mould and its base plate to prevent water from escaping during vibration.
5. Place the assembled mould on the vibration machine table and secure it with a suitable clamp. Attach a hopper of appropriate size and shape to the top of the mould for filling. Do not remove the hopper until the vibration period is complete.
6. After mixing the mortar, immediately place it in the cube mould and prod with a poking rod. Prod the mortar 20 times in about 8 seconds to eliminate entrained air and honeycombing. Fill the remaining mortar into the hopper, prod again as specified for the first layer, and then compact the mortar by vibration.
7. Vibration should last for two minutes at a speed of 12,000 ± 400 vibrations per minute.
8. After vibration, remove the mould and base plate from the machine and smooth the top surface of the cube with the blade of a trowel.

Curing Specimen:

9. Keep the filled moulds in a humidity chamber for 24 hours after vibration. After this period, remove the specimens from the moulds and immediately submerge them in clean, fresh water. Keep the cubes submerged until just before testing. Renew the water every 7 days and maintain it at 27 ± 2°C. Ensure that the cubes do not dry out from the time they are submerged until they are tested.

Testing:

10. Test three cubes each for compressive strength at curing periods of 3 days, 7 days, and 28 days.
11. Place the cubes on their sides during testing, without any packing between the cubes and the steel plates of the testing machine. Ensure that one plate is self-adjusting and supported on a base. Apply the load steadily and uniformly, starting from zero at a rate of 2.9 kN/sec.

OBSERVATIONS:

1. Strength in 3 days:

Sl. No.	Length (L) (in mm)	Breadth (B) (in mm)	Load (F) (in N)	Compressive Strength (in N/mm^2)
Average Load =				

2. Strength in 7 days:

Sl. No.	Length (L) (in mm)	Breadth (B) (in mm)	Load (F) (in N)	Compressive Strength (in N/mm^2)
Average Load =				

3. Strength in 28 days:

Sl. No.	Length (L) (in mm)	Breadth (B) (in mm)	Load (F) (in N)	Compressive Strength (in N/mm^2)
Average Load =				

RESULTS:

- Type and grade of cement:
- Compressive strength of cement at

i) 3 days: ___________ N/mm^2

ii) 7 days: ___________ N/mm^2

iii) 28 days: ___________ N/mm^2

. PRECAUTIONS:

1. Ensure precise measurement and mixing of cement, sand, and water to maintain the correct proportions and consistency.
2. Use clean and dry equipment to prevent contamination or alteration of test results.
3. Fill the cube moulds carefully and compact the mortar evenly to avoid air pockets and ensure uniformity.
4. Maintain consistent curing conditions, including temperature and water quality, to ensure reliable strength development.

5. Position the cubes accurately on the testing machine to avoid uneven loading and incorrect results.
6. Keep the cubes submerged in water until testing to prevent them from drying out and affecting the compressive strength.
7. Conduct the tests promptly after the curing periods to obtain accurate strength measurements.
8. Ensure that the compression testing machine is properly calibrated and functioning to apply the load correctly.

QUESTIONS:

1. Why is it important to test the compressive strength of cement mortar cubes at multiple curing periods (e.g., 3 days, 7 days, and 28 days)?
2. How does the water-cement ratio influence the compressive strength of cement mortar?
3. What role does proper curing play in the development of compressive strength in cement mortar?
4. What are the potential consequences of not compacting the mortar properly when filling the cube moulds?
5. Why is it important to ensure that the cubes are tested on their sides without any packing between the cube and the steel plates of the testing machine?
6. How does the rate of loading (2.9 kN/sec) affect the accuracy of the compressive strength test?
7. How would you interpret compressive strength results that fall below the specified standards for a particular type of cement?
8. In what ways could variations in mixing time or curing conditions affect the compressive strength test results?
9. How can the results of the compressive strength test inform the mix design and quality control of concrete used in construction projects?

REFERENCES:

1. *Bureau of Indian Standards, IS 10080: Methods of Testing for Cement – Determination of Compressive Strength. New Delhi, India: BIS, 1982.*
2. *Bureau of Indian Standards, IS 650: Specification for Standard Sand for Testing of Cement. New Delhi, India: BIS, 1966.*

EXPERIMENT NO. 05

Determination of Fineness Modulus of Coarse and Fine Aggregates

AIM: To determine fineness modulus and grade of fine and coarse aggregate.

THEORY: The fineness modulus (FM) of aggregates is a numerical index used to quantify the average particle size of an aggregate sample. The fineness modulus influences the workability, strength, and durability of concrete by affecting the aggregate's particle size distribution, ensuring the concrete mix achieves the desired properties.

For classification of fine aggregates, the following limits may be taken as guidance:

- Fine sand: Fineness modulus should lie in between 2.2 to 2.6
- Medium sand: Fineness modulus should lie in between 2.6 to 2.9
- Coarse sand: Fineness modulus should lie in between 2.9 to 3.2

Sand having a fineness modulus more than 3.2 is unsuitable for making satisfactory concrete. The coarse aggregates have fineness modulus usually more than 5.

IS 383:1970 specifies four grading zones for fine aggregates. These four grading zones become progressively finer from Grading Zone I to Grading Zone IV (see Table 5.1).

Table 5.1 Grading of fine aggregates

I.S. Sieve Designation	Percentage of Passing by Weight for Grading			
	Zone-I	**Zone-II**	**Zone-III**	**Zone-IV**
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 µm	15-34	35-59	60-79	80-100
300 µm	5-20	8-30	12-40	15-50
150 µm	0-10	0-10	0-10	0-15

The grading of coarse aggregate may vary through wider limits than that of fine aggregates. However, this variation does not much affect the workability, uniformity and finishing qualities of concrete mix. As per IS-383:1970 the grading limit of coarse aggregate, both for single size as well as graded should be as per Table 5.2.

Table 5.2 Grading of single-graded coarse aggregates

IS Sieve Designation	Percentage Passing for Single-Sized Aggregate of Nominal Size						Percentage Passing for Graded Aggregate of Nominal Size			
	63 mm	**40 mm**	**20 mm**	**16 mm**	**12.5 mm**	**10 mm**	**40 mm**	**20 mm**	**16 mm**	**12.5 mm**
80 mm	100	-	-	-	-	-	100	-	-	-

63 mm	85 to 100	100	-	-	-	-	-	-	-	-
40 mm	0 to 30	85 to 100	100	-	-	-	95 to 100	100	-	-
20 mm	0 to 5	0 to 20	85 to 100	100	-	-	30 to 70	95 to 100	100	100
16 mm	-	-	-	85 to 100	100	-	-	-	90 to 100	-
12.5 mm	-	-	-	-	85 to 100	100	-	-	-	90 to 100
10 mm	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55	30 to 70	40 to 85
4.75 mm	-	-	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
2.36 mm	-	-	-	-	-	0 to 5	-	-	-	-

APPARATUS:

1. Set of sieves:
    a. For fine aggregates: 4.75 mm, 2.36 mm, 1.18 mm, 600 µm, 300 µm & 150 µm, pan.
    b. For coarse aggregates: 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, pan.
2. Balance
3. Gauging Trowel
4. Watch

MATERIALS REQUIRED:

1. Fine aggregates: 1 kg
2. Coarse aggregates: 5 kg

PROCEDURE:

Preparation of Sample:

1. Fine Aggregates: Take a 1 kg sample of fine aggregates.
2. Coarse Aggregates: Take a 5 kg sample of coarse aggregates.
3. Ensure that the samples are representative and have been thoroughly mixed.

Sieving of Fine Aggregates:

4. Arrange the fine aggregate sieves in descending order of size (from 4.75 mm to 150 µm).
5. Weigh the initial sample of fine aggregates and record the weight.
6. Pour the fine aggregate sample onto the top sieve and place the set of sieves in the mechanical sieve shaker.

7. Shake the sieves for about 10 minutes, ensuring that the material is adequately sieved.
8. After shaking, carefully remove each sieve and weigh the material retained on each sieve.
9. Record the weight of the material retained on each sieve and the pan.

Sieving of Coarse Aggregates:

10. Arrange the coarse aggregate sieves in descending order of size (from 80 mm to 4.75 mm).
11. Weigh the initial sample of coarse aggregates and record the weight.
12. Pour the coarse aggregate sample onto the top sieve and place the set of sieves in the mechanical sieve shaker.
13. Shake the sieves for about 10 minutes, ensuring that the material is adequately sieved.
14. After shaking, carefully remove each sieve and weigh the material retained on each sieve.
15. Record the weight of the material retained on each sieve and the pan.

OBSERVATIONS & CALCULATIONS:

1. For fine aggregates:

Weight of fine aggregate taken (W_f): ________ kg					
Sl. No.	Sieve Size	Weight Retained (in kg)	Percentage Retained $\left(\frac{C_1}{W_f} \times 100\right)$	Cumulative Percentage Retained	Percentage passed $(100 - C_3)$
		C_1	C_2	C_3	C_4
1	4.75 mm				
2	2.36 mm				
3	1.18 mm				
4	600 µm				
5	300 µm				
6	150 µm				
Sum of cumulative percentage retained, ΣC_3 =					
Fineness Modulus, $\frac{\Sigma C_3}{100}$ =					
Grading Zone of fine aggregate:					

2. For coarse aggregates:

Weight of coarse aggregate taken (W_c): ________ kg					
Sl. No.	Sieve Size	Weight Retained (in kg)	Percentage Retained $\left(\frac{C_1}{W_c} \times 100\right)$	Cumulative Percentage Retained	Percentage passed $(100 - C_3)$

		C_1	C_2	C_3	C_4
1	80 mm				
2	40 mm				
3	20 mm				
4	10 mm				
5	4.75 mm				
Sum of cumulative percentage retained, ΣC_3 =					
Fineness Modulus, $\left(\frac{\Sigma C_3}{100} + 5\right)$ =					
Grade of coarse aggregate:					

RESULTS:

1. Plot the gradation curves, in a semi-log graph, between percentage of aggregate passed (on y-axis, linear scale) and size of sieve (on x-axis, logarithmic scale) both for
    i. Fine aggregate
    ii. Coarse aggregate

A typical grading curve for fine aggregate looks like Fig. 5.1. A similar grading curve will be observed for coarse aggregate.

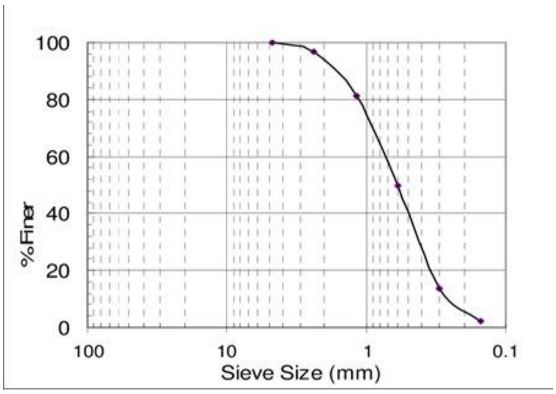


Fig. 5.1 A typical gradation curve for fine aggregate

2. The fineness moduli of given samples are:
    i. Fine aggregate: ___________
    ii. Coarse aggregate: ___________

3. The grading to which the given samples belong are:
    i. Fine aggregate: ___________
    ii. Coarse aggregate: ___________

PRECAUTIONS:

1. Avoid overloading the sieves with aggregate material. Sieving should be thorough to achieve complete separation of particles according to size.

2. Ensure that all sieves, pans, and other equipment are clean and free from any residues before starting the test. Contaminants can affect the accuracy of the results.

3. Use a calibrated balance to measure the weight of aggregates retained on each sieve accurately. Inaccurate weighing can lead to erroneous fineness modulus values.

4. Ensure that aggregates do not clump together during sieving, especially fine aggregates. If agglomeration occurs, gently break apart the lumps without applying excessive force.

5. Use a consistent and standard method of shaking or vibrating the sieves to ensure uniformity in the sieving process. Uneven shaking can lead to incorrect particle size distribution.

6. Ensure that fine aggregates are dry before sieving, as moisture can cause particles to adhere to each other, leading to inaccurate results.

QUESTIONS:

1. What is the significance of measuring fineness modulus of aggregates?
2. What is a well graded aggregate? How grading of aggregates can be controlled?
3. What is the use of gradation curve?
4. Why well graded aggregate is most suitable for concreting purpose?

REFERENCES:

Bureau of Indian Standards, IS 383: Specification for Coarse and Fine Aggregates from Natural Sources for Concrete. New Delhi, India: BIS, 1970.

EXPERIMENT NO. 06

Determination of Percentage of Voids, Bulk Density, Specific Gravity of Coarse and Fine Aggregates

AIM: To determine the percentage of voids, bulk density, and specific gravity of coarse and fine aggregates.

THEORY:

1. **Specific Gravity:** specific gravity is the ratio of the density of the aggregate to the density of water. It indicates the heaviness of the aggregate material relative to water and is used to assess the quality of the aggregate.

   Apparent specific gravity is a measure of the density of the solid particles in an aggregate, excluding any pores or voids within the particles that are not permeable to water. This property is particularly important in understanding the true density of the material, as it focuses on the solid portion only, ignoring any internal voids that might exist.

   Significance:

   - **Determines Aggregate Content:** Helps in calculating the appropriate amount of aggregate needed in a concrete mix.
   - **Indicates Aggregate Quality:** A higher specific gravity typically signifies denser and stronger aggregates.

2. **Bulk Density:** Bulk density is defined as the mass of aggregate per unit volume, including the voids between the particles. It is a crucial property that affects the mix design of concrete. Bulk density is influenced by the grading, shape, and compaction of the aggregates.

   Significance:

   - **Determines Mix Proportions:** Helps in calculating the correct amounts of cement, water, and aggregates required for the mix.
   - **Influences Concrete Properties:** Affects the workability, stability, and strength of the concrete.

3. **Percentage Of Voids:** The percentage of voids in aggregates is the volume of the spaces between the aggregate particles in a given mass. This property is important for understanding the packing efficiency of the aggregates, which influences the water-cement ratio in concrete mixes.

   Significance:

   - **Cement Paste Requirements:** Affects the amount of cement paste needed to fill the voids and coat the aggregates effectively.
   - **Concrete Durability:** Influences the porosity of the concrete, which impacts its overall durability and performance.

APPARATUS:

1. Pycnometer
2. Measuring Cylinder Of 1000 ml Capacity

3. Measuring Cylinder Of 3000 ml Capacity
4. Thermostatically Controlled Oven
5. Tamping Rod
6. Filter papers
7. Funnel
8. Weighing balance of capacity 5 kg weight,
9. Box wire basket 200 mm in diameter,
10. Water container for immersing the wire basket,
11. Absorbent cloth for surface drying of the sample
12. 4.75 mm is sieve
13. Straight edge or spatula

MATERIALS REQUIRED:

1. Fine Aggregate: 500 g
2. Coarse Aggregate: 5 kg

PROCEDURE:

I. Specific Gravity of Fine Aggregates:

Immersion of fine aggregates:

1. Place 500 g of fine aggregate in a clean tray and cover it with distilled water, ensuring the water temperature is between 22°c and 32°c.
2. To remove any air entrapped within the aggregate or bubbles on its surface, gently agitate the water using a rod.
3. Allow the sample to remain fully immersed in water for 24 hours.

Draining and surface drying:

4. Carefully drain the water from the sample by decantation, using a filter paper to catch any fine particles.
5. Air-dry the aggregate and any solid matter retained on the filter paper until the surface moisture is removed.
6. Once the material reaches a "free-flowing" condition, weigh the saturated surface-dry sample and record this weight as w_1.

Filling the pycnometer:

7. Transfer the surface-dry aggregate into a pycnometer. Fill the pycnometer with distilled water until it reaches the desired level.
8. To remove any entrapped air, gently rotate the pycnometer on its side, covering the hole in the apex of the cone with your finger.
9. Weigh the pycnometer in this condition and record the weight as w_2.

Emptying and refilling the pycnometer:

10. Empty the contents of the pycnometer into a tray, ensuring all the aggregate is transferred.
11. Refill the pycnometer with distilled water up to the same level as before and weigh it again. Record this weight as w_3.

Drying the aggregate:

12. Drain the remaining water from the sample by decantation through a filter paper.
13. Oven-dry the aggregate in the tray at a temperature of 100°C to 110°C for 24 hours. Stir the aggregate occasionally during this period to ensure even drying.
14. After drying, allow the aggregate to cool and then weigh it. Record this weight as w_4.

II. Specific Gravity of Coarse Aggregate:

Preparation and immersion:

1. A sample of not less than 2 kg of aggregate shall be thoroughly washed to remove finer particles and dust. Drain the washed aggregate and place it in a wire basket. Immerse the basket in distilled water at a temperature between 22°c and 32°c, ensuring there is at least 5 cm of water above the top of the basket.
2. Immediately after immersion, remove the entrapped air from the sample by lifting the basket containing the aggregate 25 mm above the base of the tank and allowing it to drop back into the water. Repeat this process 25 times, at a rate of approximately one drop per second.
3. The basket and aggregate shall remain completely immersed in water for 24 ± 0.5 hours.

Weighing in water:

4. After the soaking period, jolt the basket gently to dislodge any trapped air and weigh the basket with the aggregate still submerged in water at a temperature of 22°c to 32°c. Record this weight as w5.

Weighing the empty basket:

5. Remove the basket with the aggregate from the water and allow it to drain for a few minutes. Gently empty the aggregate onto a dry cloth, then return the empty basket to the water and weigh it. Record this weight as w6.

Surface drying and weighing:

i. Surface dry the aggregate by gently patting it with the dry cloth, transferring it to a second dry cloth if the first becomes too damp to remove further moisture. Weigh the surface-dried aggregate and record the weight as w_7.

Drying and final weighing:

6. Place the aggregate in a shallow tray and dry it in an oven at a temperature of 100°c to 110°c for 24 ± 0.5 hours. After drying, cool the aggregate in an airtight container and weigh it. Record this weight as w8.

III. Bulk Density of Fine Aggregates:

Preparation of sample:

1. Obtain a representative sample of fine aggregates (approximately 2 kg) and sieve it through a 4.75 mm is sieve to remove any oversized particles.
2. Dry the sample in an oven at 100°c - 110°c to a constant weight and then allow it to cool to room temperature.

Filling the measuring cylinder (loose bulk density):

3. Gently fill the measuring cylinder with the dried fine aggregate sample without any compaction.
4. Level the top surface of the aggregate using a straight edge or spatula.
5. Weigh the measuring cylinder filled with the aggregate and record the weight. Subtract the weight of the empty cylindrical measure to obtain the mass of the fine aggregate alone.

Compacting the sample (compacted bulk density):

6. Refill the measuring cylinder with the fine aggregate sample in three layers, tamping each layer 25 times with the tamping rod to ensure uniform compaction.
7. Level the top surface of the compacted aggregate using a straight edge or spatula.
8. Weigh the measuring cylinder with the compacted aggregate and record the weight. Subtract the weight of the empty cylindrical measure to find the mass of the compacted aggregate alone.

IV. Bulk Density of Coarse Aggregates:

Preparation of sample:

1. Obtain a representative sample of coarse aggregates (approximately 5 kg) and ensure it is clean and free from dust and finer particles.
2. Dry the sample in an oven at 100°c - 110°c until it reaches a constant weight. Allow it to cool to room temperature before testing.

Filling the cylindrical measure (loose bulk density):

3. Fill the measuring cylinder with the dried coarse aggregate sample without any compaction.
4. Level the top surface of the aggregate using a straight edge or spatula.

5. Weigh the measuring cylinder filled with the aggregate and record the weight. Subtract the weight of the empty cylindrical measure to obtain the mass of the coarse aggregate alone.

Compacting the sample (compacted bulk density):

6. Refill the measuring cylinder with the coarse aggregate sample in three layers, tamping each layer 25 times with the tamping rod to ensure uniform compaction.
7. Level the top surface of the compacted aggregate using a straight edge or spatula.
8. Weigh the measuring cylinder with the compacted aggregate and record the weight. Subtract the weight of the empty cylindrical measure to find the mass of the compacted aggregate alone.

V. Percentage Of Voids of Fine Aggregates:

Preparation of sample:

1. Obtain a representative sample of fine aggregates, approximately 2 kg, by sieving the material through a 4.75 mm is sieve to remove any oversized particles.
2. Dry the sample in an oven at 100°c - 110°c to a constant weight and then cool it to room temperature.

Determination of loose bulk density:

3. Fill the measuring cylinder with the dried fine aggregate sample without any compaction.
4. Level the top surface of the aggregate using a straight edge.
5. Weigh the measuring cylinder filled with the aggregate and record the weight. Subtract the weight of the empty measuring cylinder to find the weight of the aggregate only.

VI. Percentage of Voids of Coarse Aggregates:

Preparation of sample:

1. Obtain a representative sample of coarse aggregates, approximately 5 kg, and ensure it is clean and free of any dust or finer particles.
2. Dry the sample in an oven at 100°c to 110°c until it reaches a constant weight, then allow it to cool to room temperature.

Determination of loose bulk density:

3. Fill the measuring cylinder with the dry coarse aggregate sample in three layers, tamping each layer 25 times with the tamping rod to ensure uniform compaction.
4. Level the top surface of the aggregate using a straight edge or spatula.

5. Weigh the measuring cylinder filled with the aggregate, and subtract the weight of the empty measuring cylinder to find the weight of the aggregate alone.

OBSERVATIONS AND CALCULATIONS:

I. Specific Gravity of Fine Aggregate:

Calculate the specific gravity (g), apparent specific gravity (g_{app}) using the following formulae:

- Specific Gravity (g):

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

- Apparent Specific Gravity (g_{app}):

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

Sl. No.	Weight Of Saturated Surface-Dry Sample, W_1 (in gm)	Weight Of Pycnometer Containing Sample and Filled with Distilled Water, W_2 (in gm)	Weight Of Pycnometer Filled with Distilled Water W_3 (in gm)	Weight Of Oven Dried Sample W_4 (in gm)	Specific Gravity, g	Apparent Specific Gravity, g_{app}
				Average		

II. Specific Gravity of Coarse Aggregate:

Calculate the Specific Gravity (g), Apparent Specific Gravity (g_{app}) Using the Following Formulae:

- Specific Gravity (g):

$$g = \frac{W_8}{W_7 - (W_5 - W_6)}$$

- Apparent Specific Gravity (g_{app}):

$$g_{app} = \frac{W_8}{W_8 - (W_5 - W_6)}$$

Sl. No.	Weight Of Saturated Surface-Dry Sample, W_5 (in gm)	Weight Of Pycnometer Containing Sample and Filled with Distilled Water, W_6 (in gm)	Weight Of Pycnometer Filled with Distilled Water W_7 (in gm)	Weight Of Oven Dried Sample W_8 (in gm)	Specific Gravity, g	Apparent Specific Gravity, g_{app}

				Average		

III. Bulk density of fine aggregates:

i. Weight of empty measuring cylinder: _______ kg

ii. Weight of measuring cylinder filled with loose fine aggregate: _______ kg

iii. Mass of loose fine aggregate: _______ kg

iv. Loose bulk density (ρ_{loose}): _______ kg/m^3

v. Weight of measuring cylinder with compacted fine aggregate: _______ kg

vi. Mass of compacted fine aggregate: _______ kg

vii. Compacted bulk density ($\rho_{compacted}$): _______ kg/m^3

Calculate the loose bulk density (ρ_{loose}) using the formula:

$$\rho_{loose} = \frac{Mass\ of\ fine\ aggregate}{Volume\ of\ measuring\ cylinder}\ (kg/m^3)$$

Calculate the compacted bulk density ($\rho_{compacted}$) using the formula:

$$\rho_{compacted} = \frac{Mass\ of\ compacted\ fine\ aggregate}{Volume\ of\ measuring\ cylinder}\ (kg/m^3)$$

IV. Bulk Density of Coarse Aggregates:

i. Weight of empty measuring cylinder: _______ kg

ii. Weight of measuring cylinder filled with loose coarse aggregate: _______ kg

iii. Mass of loose coarse aggregate: _______ kg

iv. Loose bulk density (ρ_{loose}): _______ kg/m^3

v. Weight of measuring cylinder with compacted coarse aggregate: _______ kg

vi. Mass of compacted coarse aggregate: _______ kg

vii. Compacted bulk density ($\rho_{compacted}$): _______ kg/m^3

Calculate the loose bulk density (ρ_{loose}) using the formula:

$$P_{loose} = \frac{Mass\ of\ coarse\ aggregate}{Volume\ of\ measuring\ cylinder}\ (kg/m^3)$$

Calculate the compacted bulk density ($\rho_{compacted}$) using the formula:

$$\rho_{compacted} = \frac{Mass\ of\ compacted\ coarse\ aggregate}{Volume\ of\ measuring\ cylinder}\ (kg/m^3)$$

V. Percentage of Voids of Fine Aggregates:

The percentage of voids in the fine aggregate can be determined using the loose bulk density (ρ) and the specific gravity (g) of the aggregate.

i. Weight of empty measuring cylinder: _______ kg
ii. Weight of measuring cylinder filled with loose fine aggregate: _______ kg
iii. Weight of fine aggregate: _______ kg
iv. Volume of measuring cylinder: _______ m^3
v. Loose bulk density of fine aggregate (ρ): _______ kg/m^3
vi. Specific gravity of fine aggregate (g): _______
vii. Percentage of voids (v): _______ %

Calculate the loose bulk density (ρ) of the coarse aggregate using the formula:

$$\rho = \frac{Mass\ of\ fine\ aggregate}{Volume\ of\ measuring\ cylinder}\ (kg/m^3)$$

Calculate the percentage of voids (v) using the formula:

$$V = \frac{G - \frac{\rho}{1000}}{G} \times 100$$

VI. Percentage of Voids of Coarse Aggregates:

The percentage of voids in the coarse aggregate can be determined using the loose bulk density (ρ) and the specific gravity (g) of the aggregate.

i. Weight of empty cylindrical measure: _______ kg
ii. Weight of measuring cylinder filled with loose coarse aggregate: _______kg
iii. Weight of coarse aggregate: _______ kg
iv. Volume of cylindrical measure: _______ m^3
v. Loose bulk density of coarse aggregate (ρ): _______ kg/m^3
vi. Specific gravity of coarse aggregate (g): _______
vii. Percentage of voids (v): _______ %

Calculate the loose bulk density (ρ) of the coarse aggregate using the formula:

$$\rho = \frac{Mass\ of\ coarse\ aggregate}{Volume\ of\ measuring\ cylinder}\ (kg/m^3)$$

Calculate the percentage of voids (v) using the formula:

$$V = \frac{G - \frac{\rho}{1000}}{G} \times 100$$

RESULTS:

I. The specific gravity (g) of the fine aggregates is found to be _______.
The apparent specific gravity (g_{app}) of the fine aggregates is found to be _______.

II. The specific gravity (g) of the fine aggregates is found to be _______.
The apparent specific gravity (g_{app}) of the fine aggregates is found to be _______.

III. The loose bulk density of the fine aggregate is found to be _______kg/m³.
The compacted bulk density of the fine aggregate is found to be _______kg/m³.

IV. The loose bulk density of the coarse aggregate is _______kg/m³.
The compacted bulk density of the coarse aggregate is _______kg/m³.

V. The percentage of voids in the fine aggregate sample is found to be _______%.

VI. The percentage of voids in the coarse aggregate sample is found to be _______%.

PRECAUTIONS:

1. Ensure that the aggregate sample is representative of the entire batch. Use appropriate sampling methods to avoid segregation of particles.
2. The moisture content of the aggregates should be consistent. Dry the sample to a constant weight if required, or conduct tests under controlled moisture conditions.
3. Remove dust, silt, and other impurities by washing the aggregates if necessary. This ensures that only the aggregate particles contribute to the measurements.
4. When using pycnometers, check for leaks or air bubbles that could affect the specific gravity measurement.
5. When determining bulk density, apply a consistent method for tamping or compaction of the aggregate in the container to avoid variability in results.
6. Conduct multiple tests and average the results to account for any random errors or inconsistencies.
7. Properly label all samples to avoid mix-ups during testing and recording of results.
8. When determining bulk density, do not overload the container, as this can lead to erroneous results.
9. Handle aggregates gently to avoid crushing or breaking the particles, which could alter their characteristics.

QUESTIONS:

1. Why is it important to determine the bulk density of aggregates in concrete mix design?
2. What is the significance of specific gravity in evaluating the quality of aggregates?

3. How do moisture content and absorption capacity of aggregates affect the specific gravity determination?
4. What are the implications of having a high percentage of voids in coarse aggregates when used in concrete?
5. What is the difference between apparent specific gravity and bulk specific gravity?
6. Why is it necessary to dry the aggregate sample to a constant weight before determining its specific gravity?
7. How would you adjust the water content in a concrete mix design if you find that the specific gravity of the coarse aggregate is lower than expected?
8. In a scenario where the bulk density of the aggregate changes significantly between batches, how would you ensure consistency in concrete production?
9. If you observe that the percentage of voids in a batch of fine aggregate is unusually high, what steps would you take to address this issue in a construction project?

REFERENCES:

1. *Bureau Of Indian Standards, IS 2386 (Part 3): Methods of Test for Aggregates for Concrete – Specific Gravity, Density, Voids, Absorption, And Bulking. New Delhi, India: BIS, 1963.*
2. *Bureau Of Indian Standards, IS 383: Specification for Coarse and Fine Aggregate for Concrete. New Delhi, India: BIS, 2016.*
3. *Bureau Of Indian Standards, IS 2430: Methods for Sampling of Aggregates for Concrete. New Delhi, India: BIS, 1986.*
4. *Bureau Of Indian Standards, IS 2386 (Part 1): Methods of Test for Aggregates for Concrete – Particle Size and Shape. New Delhi, India: BIS, 1963.*

EXPERIMENT NO. 07

Measurement Of Workability of Fresh Concrete by Slump Cone Test

AIM: To Determine the Workability of Fresh Concrete using Slump Cone Test.

THEORY: A concrete is said to be workable if it can be easily mixed, placed, compacted and finished. A workable concrete should not show any segregation or bleeding. Segregation is said to occur when coarse aggregate tries to separate out from the finer material and a concentration of coarse aggregate at one place occurs. This results in large voids, less durability and strength. Bleeding of concrete is said to occur when excess water comes up at the surface of concrete. This causes small pores through the mass of concrete and is undesirable.

Unsupported fresh concrete flows to the sides and a sinking in height takes place. This vertical settlement is known as Slump. The Slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. To measure the Slump value, a fresh concrete is filled into a mould of specified shape and dimensions, and the settlement or slump is measured when supporting mould is removed. The slump increases as water-content is increased. For different works different slump values have been recommended. The following table indicates the relationship between degree of workability and slump value.

Table 7.1 Relationship between degree of workability and slump value.

Degree Of Workability	Very Low	Low	Medium	High
Slump Value (in mm)	0-25	25-50	50-100	100-175

Slump test is adopted in the laboratory or during the progress of the work in the field for determining consistency of concrete where nominal maximum size of aggregates does not exceed 40 mm. The pattern of slump indicates the characteristics of concrete in addition to the slump value. If the concrete slumps evenly it is called true slump. If one half of the cone slides down, it is called shear slump. In case of a shear slump, the slump value is measured as the difference in height between the height of the mould and the average value of the subsidence. Shear slump also indicates that the concrete is non-cohesive and shows the characteristic of segregation. Any slump specimen, which collapses or shears off laterally gives incorrect results and at this juncture the test is repeated only true slump should be measured.

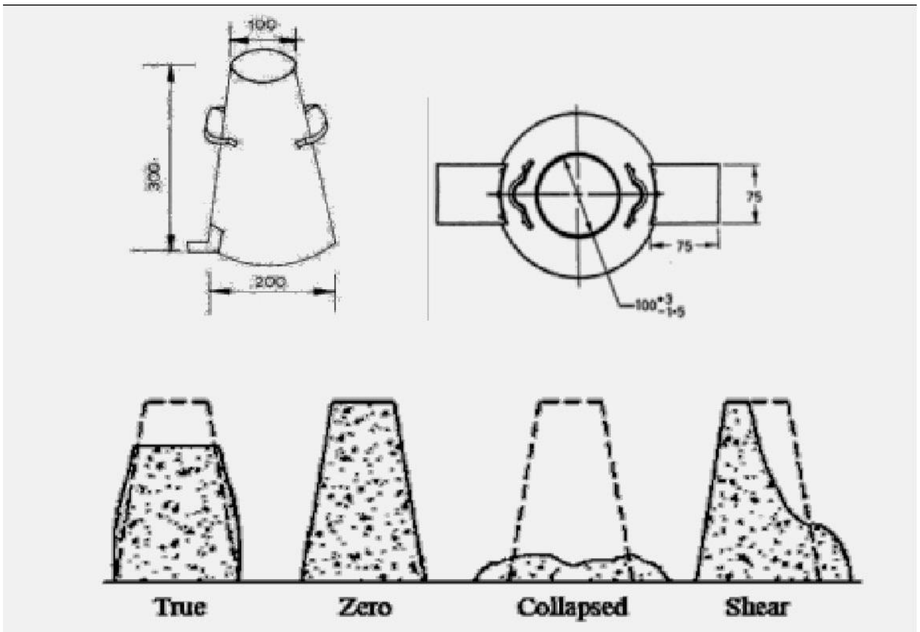


Fig. 7.1 Slump Cone Dimensions And Types of Slump

Although, slump test is popular due to the simplicity of apparatus used and simple procedure, unfortunately, the simplicity is also often allowing a wide variability and many times it could not provide true guide to workability. For example, a harsh mix cannot be said to have same workability as one with a large proportion of sand even though they may have the same slump.

The slump cone experiment is conducted in an apparatus called slump cone (fig.1). This apparatus essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as under: bottom diameter: 20 cm, top diameter: 10 cm, height: 30 cm and the thickness of the metallic sheet for the mould should not be thinner than 1.6 mm.

APPARATUS:

1. Slump Cone Apparatus.
2. Tamping Rod.
3. Metallic Sheet.
4. Trowel
5. Weighing Scale.

Fig. 7.2 Slump Cone

MATERIALS REQUIRED:

1. Cement.
2. Sand.

3. Aggregate.
4. Water.

PROCEDURE:

1. Clean the internal surface of the cone thoroughly and place it in the base plate, and then tighten the cone.
2. Consider a w/c ratio of 0.5 to 0.6 and design mix of proportion about 1:2:4. Weigh the quantity of cement, sand, aggregate and water correctly. Mix thoroughly. Use this freshly prepared concrete for the test.
3. Fill the cone to about one fourth of its height with concrete.
4. Tamp the layer with the round end of the tamping rod with 25 strokes disturbing the strokes uniformly over the cross section.
5. Fill the mould further in 3 layers each time by 1/4th height and tamping evenly each layer as above. After filling the cone, level the top of the cone using a trowel.
6. Lift the mould vertically slowly and remove it.
7. The concrete will subside. Measure the height of the specimen of concrete after subsidence.
8. The slump of concrete is the subsidence, i.e. difference in original height and height up to the topmost point of the subsided concrete in millimetres.

OBSERVATIONS:

W/C Ratio	
Slump Value	

RESULTS:

The slump value of the concrete is ______mm.

The slump value indicates that the concrete has very low/low/medium/high degree of workability.

PRECAUTIONS:

1. Materials should be free from debris.
2. Concrete should be mixed thoroughly.
3. The tamping rod should be made to free fall while tamping, and no external force should be applied.
4. Measurement of the subsidence of the fresh concrete should be done accurately.

QUESTIONS:

1. Define workability of concrete.
2. What are the factors affecting workability of a fresh concrete?
3. What are the differences between shear slump and collapse slump in slump test?
4. What are the different types of slumps?
5. What is segregation?
6. What is consistency in concrete?

7. What is the use of admixtures?
8. What is the importance of workability in concrete?

EXPERIMENT NO. 08

Measurement of Workability of Concrete by Compaction Factor Test

AIM: To determine the workability of a fresh concrete using compaction factor test.

THEORY: This test is adopted to determine workability of concrete where nominal size of aggregate does not exceed 40 mm. It is based on the definition, that workability is that property of concrete, which determines the amount of work required to produce full compaction. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction. The compaction factor is defined as the ratio of the weight of partially compacted concrete to the weight of fully compacted concrete. It shall be stated to the nearest second decimal place. The relationship between degree of workability and compaction factor are:

Degree of workability	Very low	Low	Medium	High
Compaction Factor	0.75-0.8	0.80-0.85	0.85-0.92	>0.92

Compaction factor test apparatus consists of two conical hoppers, A and B, mounted vertically above a cylindrical mould C. The upper hopper A has internal dimensions as: top diameter 250 mm; bottom diameter 125 mm and height 225 mm. The lower hopper B has internal dimensions as: top diameter 225 mm, bottom diameter 125 mm and height 225 mm. The cylinder has internal dimensions as: 150 mm diameter and 300 mm height. The distances between bottom of upper hopper and top of lower hopper, and bottom of lower hopper and top of cylinder are 200 mm in each case. The lower ends of the hoppers are fitted with quick release flap doors. The hoppers and cylinders are rigid in construction and rigidly mounted on a frame. These hoppers and cylinder are rigid easily detachable from the frame. Fig. 8.1 shows the diagram of a compaction factor test apparatus.

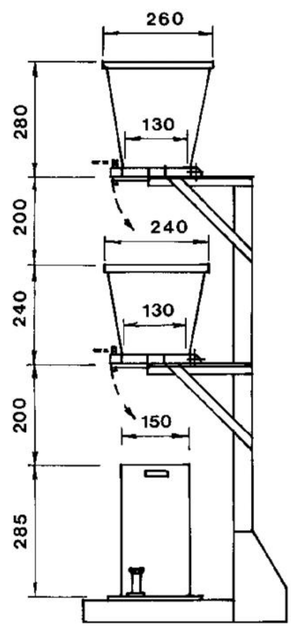


Fig. 8.1 Compaction Factor Test apparatus

APPARATUS:

1. Compaction factor apparatus
2. Tamping rod
3. Metallic sheet
4. Weighing scale

MATERIALS REQUIRED:

1. Cement
2. Sand
3. Coarse aggregate
4. Water

PROCEDURE:

1. Prepare a concrete mix for testing workability. Consider a W/C ratio of 0.5 to 0.6 and design mix of proportion about 1:2:4 (it is presumed that a mix is designed already for the test). Weigh the quantity of cement, sand, aggregate and water correctly. Mix thoroughly. Use this freshly prepared concrete for the test.
2. Place the concrete into the upper hopper up to its brim.
3. Open the trapdoor of the upper hopper. The concrete will fall into the lower hopper.
4. Open the trapdoor of the lower hopper, so that concrete falls into the cylinder below.
5. Remove the excess concrete above the level of the top of the cylinder; clean the outside of the cylinder.
6. Weigh the concrete in the cylinder. This weight of concrete is the weight of partially compacted concrete (W_1).
7. Empty the cylinder and refill with concrete in layers, compacting each layer well (or the same may be vibrated for full compaction). Top surface may be struck off level.
8. Find cut weight of the concrete in the fully compacted state. This weight is the weight of fully compacted concrete (W_2).

OBSERVATIONS & CALCULATIONS:

1. Weight of partially compacted concrete (W_1) = __________ gm
2. Weight of fully compacted concrete (W_2) = __________ gm
3. Compaction factor $\left(F = \frac{W_1}{W_2}\right)$ = _________

RESULTS:

The obtained compaction factor of the concrete is ______.

The obtained compaction factor indicates that the concrete has Low/ Medium/ High Degree of workability.

PRECAUTIONS:

1. Make sure all the trap doors are closed prior to performing the experiment.
2. Concrete should be mixed thoroughly.
3. While filling the upper hopper, the concrete should not be compacted by external force.

QUESTIONS:

1. Define Degree of Compaction Factor.
2. What is the Relation Between Workability and Compacting Factor?
3. What are the limitations of this test?
4. What is the purpose of this test?
5. What are the differences between fully compacted and partially compacted concrete?
6. What is the significance of compacted concrete?
7. Define bleeding in concrete.

EXPERIMENT NO. 09

Consistency Test of Fresh Concrete by Vee-Bee Consistometer Test

AIM: To determine the consistency of a fresh concrete using Vee-Bee consistometer test.

THEORY: The workability of fresh concrete is a composite property, which includes the diverse requirements of stability, mobility, compact ability, place ability and finish ability. There are different methods for measuring the workability. Each of them measures only a particular aspect of it and there is really no unique test, which measures workability of concrete in its totality. This test gives an indication of the mobility and to some extent of the compactibility of freshly mixed concrete. The test measures the relative effort required to change a mass of concrete from one definite shape to another (i.e., from conical to cylindrical) by means of vibration. The amount of effort (called remoulding effort) is taken as the time in seconds, required to complete the change. The results of this test are of value when studying the mobility of the masses of concrete made with varying amounts of water, cement and with various types of grading of aggregate. The time required for complete remoulding in seconds is considered as a measure of workability and is expressed as the number of Vee-Bee seconds. The method is suitable for dry concrete. For concrete of slump in excess of 50 mm, the remoulding is so quick that the time cannot measured.

Vee bee consistometer test is based on the principle that measures the relative effort of the concrete mix to change its shape from one shape to another through the means of vibration. In this test, the concrete shape will change from conical to cylindrical. This test gives the time for a given mobility of concrete from changing one shape to another. Which relates to the water cement ratio and grading of the aggregates. This time is the complete remoulding time of the concrete mix, which is reported as the vee bee time in seconds.

Table 9.1 Relation between Vee-Bee time and condition of earth

Work description	Workability measurement		Vee-Bee time (in seconds)
	Slump (in mm)	Compaction Factor	
Moist Earth	-	-	40 to 25-20
Very dry	-	0.70	20 to 15-10
Dry	0-25	0.75	10 to 7-5
Plastic	25-50	0.85	5 to 4-3
Semi-fluid	75-100	0.90	3 to 2-1
Fluid	150-175	0.95	Less than 1

APPARATUS:

1. Vee-Bee Consistometer
2. Weighing balance
3. Tamping rod
4. Trowel

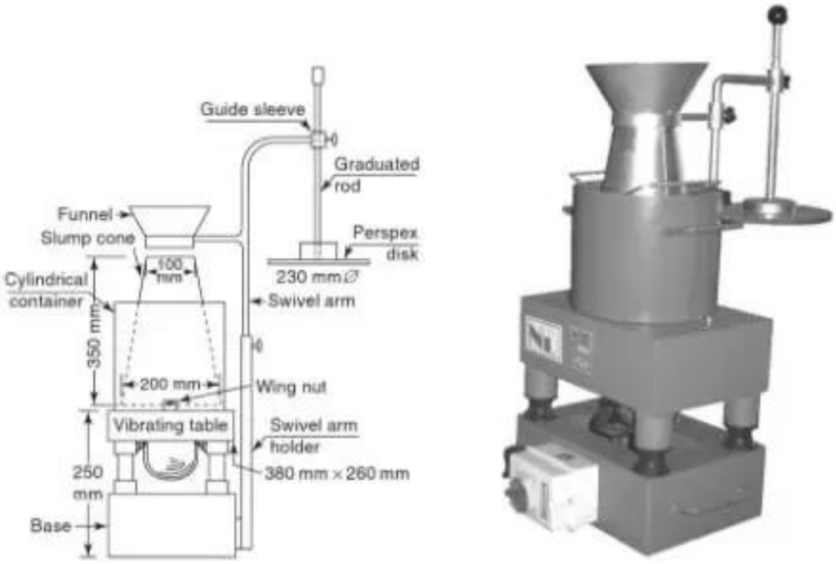


Fig 4: Vee-Bee Consistometer

MATERIALS REQUIRED:

1. Concrete Sample

PROCEDURE:

1. It shall be ensured that Vee Bee Meter (Consistometer) is placed on a rigid horizontal base free from extraneous vibration and shock. Make sure that the container is firmly fixed to the vibrating table by means of wing nuts.
2. Dampen the inside of the mould with a moist cloth and place it in the container.
3. From the sample of concrete obtained, immediately fill the mould in three layers, each approximately one-third of the height of the mould when compacted. When adding the concrete, ensure that it is distributed symmetrically around the mould.
4. Tamp each layer with 25 strokes of the tamping rod. The strokes shall be distributed in a uniform manner over the cross-section area of the mould. For the bottom layer, this will necessitate inclining the rod slightly and positioning approximately half the strokes spirally towards centre. Tamp the second layer and top layer each throughout its depth, so that the strokes just penetrate into the underlying layer. In filling and tamping the top layer, heap the concrete above the mould before tamping is started.
5. The operation of raising the mould shall be performed in 7 ± 2s by a steady upward lift with no lateral or torsional motion being imparted to the concrete. If the concrete shears, collapses or slumps to the extent that it touches the wall of the container, this information shall be recorded.

6. Swing the transparent disc over the top of the concrete, loosen the screw and very carefully lower the disc until it just comes in contact with the concrete. When the disc just touches the highest point of the concrete without disturbing it, tighten the screw.
7. The screw shall be loosened to allow the disc to follow the concrete as it settles under the subsequent vibration. Simultaneously, start the vibration of the table and the timer. Observe through the transparent disc how the concrete is being re-moulded.
8. As soon as the lower surface of the disc is fully in contact with cement paste of the concrete, stop the timer and switch off the vibrating table. Record the time taken to the nearest second. Complete the procedure within a period of 5 min from the start of filling.
9. 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:

Time from completion of mixing of the concrete until the time of removal of the mold = ___________.

Vee-Bee's time = _________ seconds.

RESULTS:

The Vee-Bee's time of concrete = ________ seconds.

PRECAUTIONS:

1. Concrete should be mixed thoroughly.
2. Materials should be free from debris.
3. The tamping rod should be made to free fall while tamping, and no external force should be applied.

QUESTIONS

1. What is the principle of vee-bee's consistometer test?
2. What are the differences between slump cone test and vee-bee's test?
3. What is the vee-bee's consistometer test for low workability?
4. How many tests are there to find workability?
5. Define consistency of fresh concrete.
6. What is Vee-Bee's degree?

7. The vibration of Vee-Bee's consistometer test is too vigorous for a concrete with a slump value greater than _______mm.

EXPERIMENT NO. 10

Test for Determination of Compressive Strength of Concrete

AIM: To determine the compressive strength of a hardened concrete.

THEORY: One of the important properties of concrete is its strength in compression. The strength in compression has a definite relationship with all other properties of concrete i.e. these properties improved with the improvement in compressive strength. Thus, with this single test one judge that whether Concreting has been done properly or not. In India cubical moulds of size 15 cm × 15 cm × 15 cm are commonly used.

Practically, the compression testing system develops a complex system of stresses due to end restraints provided by steel plates of compression testing machine (CTM).

Under compression loading, due to "poisons effect", the cube specimen also undergoes lateral expansion. However, the steel plates don't undergo lateral expansion to the same extent that of concrete. Thus, there exist a differential tendency of lateral expansion between steel plates and concrete cube faces.

As a result of this, tangential forces are induced between the end surfaces of the concrete specimen and the adjacent steel plates of CTM. Therefore, in addition to the applied compressive stress; lateral shearing stresses are also effective in these specimens. Effect of this shear decreases to words the centre of the cube.

Thus, the cube has near vertical crack at cubes centre and sometimes, the cube may completely disintegrate leaving a relatively undamaged central core. Figure 8 shows, typical failure patterns of the concrete cube.

APPARATUS:

1. Moulds for test cubes.
2. Tamping rod.
3. Metallic sheet.
4. Compressive Testing Machine.

MATERIALS:

1. Cement.
2. Sand.
3. Coarse aggregate.
4. Water.
5. Grease.

Fig. 10.1 Compression Testing machine

PROCEDURE:

1. Calculate the material required for preparing the concrete of given proportions
2. Mix them thoroughly in mechanical mixer until uniform colour of concrete is obtained
3. Pour concrete in the lightly greased cube moulds.
4. Fill concrete in two layers each of approximately 75 mm and ramming each layer with 35 blows evenly distributed over the surface of layer.
5. Struck off concrete flush with the top of the moulds.
6. Level the concrete at the top of the mould by means of trowel and give proper identification mark of the specimen.
7. Immediately after being made, they should be covered with wet mats.
8. Specimens are removed from the moulds after 24hrs and cured in water. Keep it for curing up to 28 days. Testing of concrete cubes:
9. Take the cube out of water at the end of three days with dry cloth. Measure the dimensions of the surface in which the load is to be applied. Let be ‘L’ and ‘B’ respectively.
10. Place the cube in compressive testing machine and apply the load uniformly at the rate of 35N/mm2.
11. Note the load at which the cube fails. Let it be ‘P’. Also note the type of failure and appearance cracks
12. Calculate the compressive strength of the cube by using formula P/A. Where A is the area of loaded surface (i.e. L×B).
13. Repeat the same procedure (steps 9 to 12) for other two cubes.
14. Repeat the whole procedure (Step 9 to 13) to find the compressive strength of the cube at the end of 7 days and 28 days.

OBSERVATIONS & CALCULATIONS:

1. For 3 days strength:

Sl. No.	Length (in mm)	Breadth (in mm)	Load (in N)	Compressive Strength (in N/mm^2)	Remark
1.					
2.					
3.					

Average strength of cube = ______________ N/mm^2.

2. For 7 days strength:

Sl. No.	Length (in mm)	Breadth (in mm)	Load (in N)	Compressive Strength (in N/mm^2)	Remark
1.					
2.					
3.					

Average strength of cube = ______________ N/mm^2.

3. For 28 days strength:

Sl. No.	Length (in mm)	Breadth (in mm)	Load (in N)	Compressive Strength (in N/mm^2)	Remark
1.					
2.					
3.					

Average strength of cube = ______________ N/mm^2.

RESULTS:

1. The type and grade of concrete: ______________________________.
2. The compressive strength of concrete at the end of:
   a) 3 days : ______________ N/mm^2.
   b) 7 days : ______________ N/mm^2.
   c) 28 days : ______________ N/mm^2.

PRECAUTIONS:

3. Concrete should be mixed thoroughly.
4. Extra care should be taken while taking the readings.

QUESTIONS

1. What is the effect of w/c ratio on compressive strength of concrete?
2. Mention the factors affecting the compressive strength of concrete?
3. How does the age of a concrete effects the strength of a concrete?
4. Define characteristic compressive strength of concrete.
5. What is meant by gel/space ratio?

EXPERIMENT NO. 11

Rebound Hammer Test

AIM: To determine the strength of an existing concrete structure using rebound hammer test.

THEORY: The rebound hammer test is the most popular method to measure the surface hardness of a concrete mass. The Swiss engineer Ernst Schmidt first developed a practicable rebound test hammer.

The hammer is very simple, not heavy (about 2 kg), and has an impact energy of about 2.2 Nm. It can be operated on vertical, horizontal and inclined surfaces, upwards and downwards, but it has to be at right angles to the measured surface.

This method is based on the principle that the rebound of an elastic mass depends on the hardness of the surface against which mass strikes. When the plunger of rebound hammer is pressed against the surface of the concrete, the spring-controlled mass rebounds and the extent of such rebound depends upon the surface hardness of concrete. The surface hardness and the rebound are therefore taken to be related to the compressive strength of concrete. The rebound value is read off along a graduated scale and is designated as the rebound number or rebound index. The compressive strength can be read directly from the graph provided on the body of the hammer.

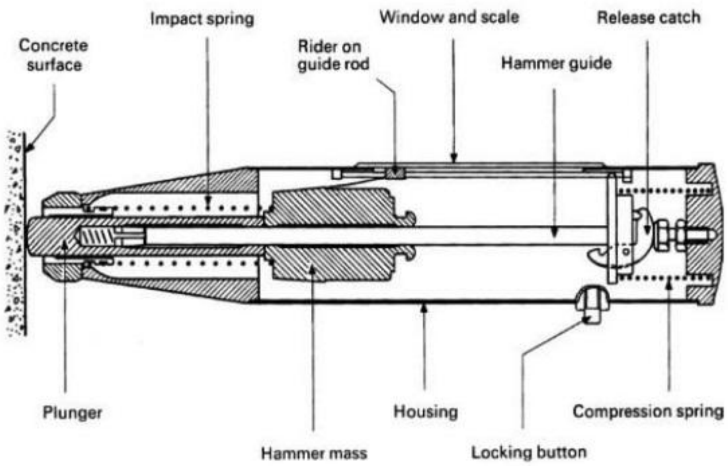


Fig. 11.1 Rebound Hammer

Table 11.1 Relation between quality of concrete and rebound number

Average Rebound Number	Quality of concrete
>40	Very good hard layer
40-30	Good layer
30-20	Fair
<20	Poor concrete

APPARATUS REQUIRED:

1. Rebound hammer.

MATERIALS REQUIRED:

1. Sample concrete block

PROCEDURE:

1. Make sure the device is calibrated.
2. The surface must be smooth, clean and dry. If trowelled surface is unavoidable, use a grinding stone to smoothen the test surface.
3. Hold the instrument firmly so that the hammer-head is perpendicular to the test surface.
4. Gradually push the hammer toward the test surface until the hammer impacts. In case of manual hammer, press the lock button at the side of the hammer.
5. Record the scale reading at the side of the hammer or on the display screen in case of digital hammer.
6. A total of at least 9 readings at different points with not less than 25 mm spacings should be taken in the test specimen.
7. Find the mean of the readings and check that each reading does not exceed 6 units difference from the mean reading.
8. Compressive strength of the testing block can then be found using the calibration graph of compressive strength v/s rebound number as shown below.

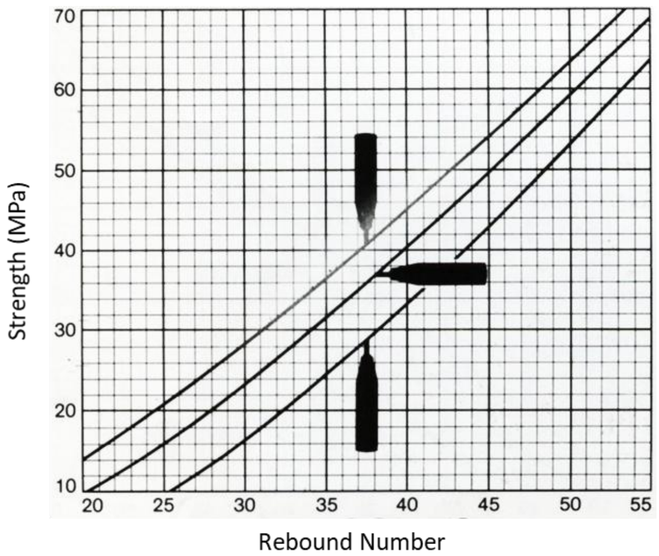


Fig. 7 Rebound hammer graph

OBSERVATIONS:

Specimen No.	Rebound Number (R)	Mean Rebound Number	Compressive strength (MPa)
	N_1 =		

	N_2 =		
	N_3 =		
	N_4 =		
	N_5 =		
	N_6 =		
	N_7 =		
	N_8 =		
	N_9 =		

RESULTS:

From the obtained mean rebound number the average compressive strength of concrete is found to be _____MPa. And the quality of concrete is __________.

PRECAUTIONS:

1. Handle the rebound hammer with care and avoid rough test surfaces and it can impact the readings.
2. It is preferable if the cover layer of the testing block is peeled off prior to testing.
3. Extra care should be taken while reading the graph.
4. Off angled strike should be avoided.

QUESTIONS:

1. What are the limitations of rebound hammer?
2. What are the factors affecting rebound hammer's accuracy and reliability?
3. At what angle is a rebound hammer to be used?
4. Define dispersion in a rebound hammer test.
5. What is rebound angle?

EXPERIMENT NO. 12

Ultrasonic Pulse Velocity Test on Concrete

AIM: To determine the consistency of an existing concrete structure by ultrasonic pulse velocity test.

THEORY: The ultrasonic Pulse Velocity test (UPV) is one of the popular methods which are used to obtain information about the interior of a concrete structure with two accessible surfaces (transducers). The most known instrument, which we used in the lab, is the PUNDIT (Portable Ultrasonic Non-destructive Digital Indicating Tester) this comes with two transducers and one calibration rod to adjust the readings before any test.

One of the important things in this test is having a good acoustical coupling between the face of each transducer and the concrete surface by using a medium such as grease, hand cream or jelly.

The ultrasonic pulse is generated by electro-acoustical transducer which are transmitted through the concrete. While pulses are transmitted through the concrete, it undergoes multiple reflections at the limits of the different phases of the material inside the concrete.

Higher the obtained velocity higher the quality of the concrete in terms of uniformity, homogeneity and density. Lower velocity indicates the presence of cracks or honey-combing and non-uniformity in concrete.

Fig. 12.1 Ultrasonic instrument

While there is presence of cracks in the concrete, generated velocity has to travel longer time to reach transducer and thus, indicates the lower velocity. The transducer first converts electrical signals in to the mechanical signal and then mechanical signals in to electrical signal after reaching the receiver. The time taken by the pulse is measured within the accuracy of ±0.1 micro-seconds. Transducer of frequencies between 50kHz to 100kHz are generally used.

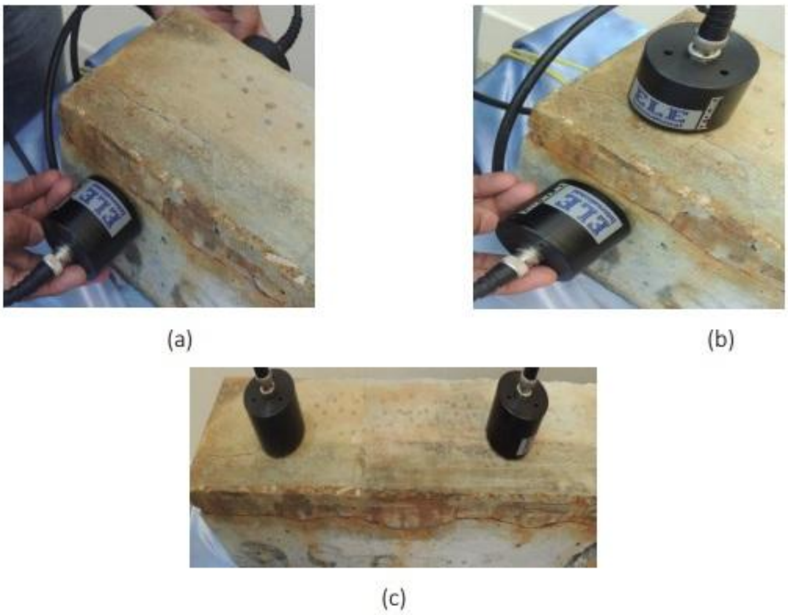


Fig. 12.2 Different methods of measurement: a) Direct method, b) Semi- direct method and c) Indirect method.

Table 12.1 Relation between pulse velocity and concrete quality

Pulse Velocity (in m/s)	**Concrete Quality (Grading)**
Above 4500	Excellent
4500 to 3500	Good
3500 to 3000	Fair
Below 3000	Doubtful

APPARATUS:

1. Ultrasonic instrument.

MATERIAL REQUIRED:

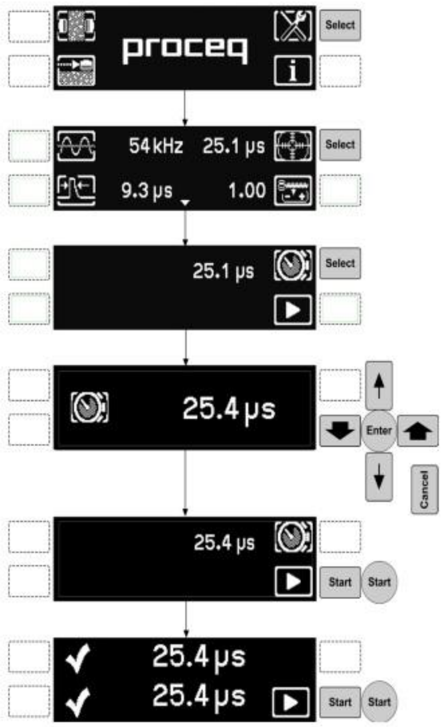
1. Existing concrete block in a building.

PROCEDURE:

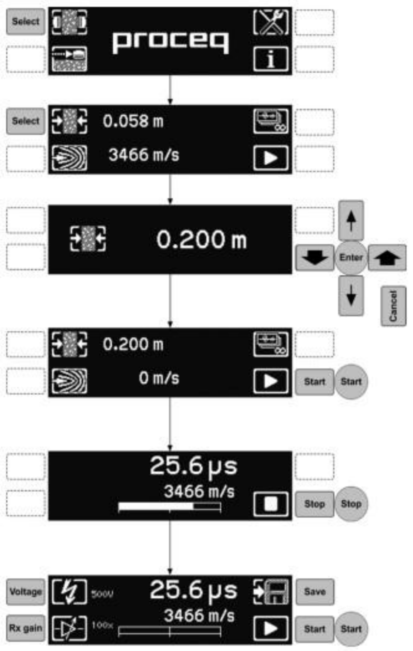
1. Basic measurements:
   i. Switch on the mains and apply little amount of gel to the two transducers faces.
   ii. Use the reference bar to check and adjust the time reading on the instrument to be the same as the calibration number on the bar.

Calibration:

- Select System Settings.
- Set correction factor to 1.0 Select calibration
- If necessary, select to enter the transit time as marked on the calibration rod.
- Variable parameter; set as follows: Up/down keys - fine adjustment Left/right keys - coarse adjustment. Centre key - enters the value and returns to the previous menu.
- Cancel key - cancels the input and returns to the previous menu.
- Press "Start" to begin the calibration sequence.
- The final display shows the expected transit time and below it the measured transit time. This should match the value on the calibration rod.



2. Pulse velocity:
   i. In order to determine the pulse velocity, it is compulsory to measure the path length between the two transducers.
   ii. Press the transducers hardly onto the concrete opposite surfaces, and hold for a while to allow readings to be taken, wait until a consistent reading appears on the display screen of the instrument.
   iii. Record the stable reading, which is the time (T) in microseconds (µs) for the ultrasonic pulse to travel the path length and pulse velocity (V) in m/s.



- Select "Basic Measurements"
- Select parameter setting "path length"
-
- Enter the path length.
- Start the measurement
- The display shows:
  - Transmission time
  - Measured pulse velocity
- Save the result or: Start a new measurement.

3. Compressive strength (N/mm^2):
When the pulse velocity is known it is easy to determine the compressive strength of concrete by using the graph shown in the Figure – 4 below which indicates the relationship between the pulse velocity and compressive strength of concrete.

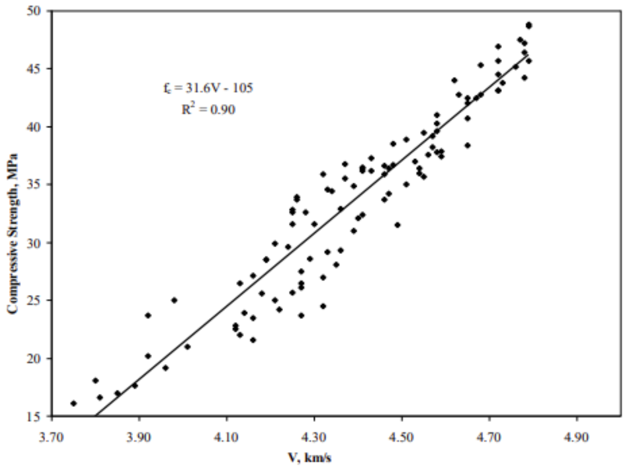


Fig. 12.3 Relationship between pulse velocity and compressive strength of concrete

OBSERVATIONS:

<table>
<tr><th>S. No</th><th>Method of testing</th><th>Length (mm)</th><th colspan="2">Time (T) (µs)</th><th>Pulse Velocity (m/s)</th><th>Average velocity (V) (m/s)</th><th>Quality of concrete</th></tr>
<tr><td>1</td><td rowspan="3">Direct</td><td></td><td colspan="2"></td><td></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>2</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>3</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>4</td><td rowspan="3">Indirect</td><td></td><td></td><td></td><td></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>5</td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td></td><td></td><td></td><td></td></tr>
</table>

RESULTS:

The obtained pulse velocity across the concrete block is __________ and the concrete quality is considered to be ________.

PRECAUTIONS:

1. Handle the instrument with care.
2. No voids should be present between the test specimen and the transducer while taking the readings.
3. Excess use of gel can cause inaccurate readings.

4.

QUESTIONS

1. What are the factors affecting the measurement of a pulse velocity?
2. What are the different techniques for measuring pulse velocity through concrete?
3. Mention the impact of the temperature of the concrete on the pulse velocity.
4. What are the applications of Ultrasonic pulse velocity test?
5. What does lower pulse velocity indicate?
6. Define frequency.
7. Define compression wave.

EXPERIMENT NO. 13

Corrosion Rate of Rebar using Electro-Chemical Half Cell Potentiometer

AIM: To determine the corrosion rate of a rebar from an existing concrete structure using electro-chemical half-cell potentiometer.

THEORY: Corrosion is a natural process that occurs when a structure is exposed to elements like CO_2 or chloride, which can penetrate the concrete all the way to the steel reinforcement. This can have serious durability and safety consequences, which is why it is important to monitor corrosion using an accurate and trusted method. The half-cell potential test is the only corrosion monitoring technique standardized in ASTM C876 – 15: Standard Test Method for Corrosion Potentials of Uncoated Reinforcing Steel in Concrete. It is used to determine the probability of corrosion within the rebar in reinforced concrete structures. This blog dives into the specifics of concrete corrosion, the half-cell potential measurement for testing concrete corrosion, and the ways in which the data from a half-cell potential device can be interpreted.

The schematic in Figure 2a represents a cell where each side is referred to as a half-cell. Each half-cell is represented by an electrode in a solution (electrolyte) and both half-cells are connected together. Since one of the electrodes has a higher tendency to corrode compared to the other, that electrode (anode) will oxidize and in turn will donate electrons.

To keep the system in equilibrium and balance the charges in the electrolytes, there will be an exchange of ions through the salt bridge. The voltmeter will measure the potential difference (voltage) between both electrodes, which indicates the rate of dissolution of the anode.

To apply this concept to concrete and to interpret the results of corrosion potential, a reference electrode with a known potential is needed. Typically, for reinforced concrete applications, a copper/copper sulphate electrode (Cu/CuSO4) or silver/silver chloride electrode (Ag/AgCl) is used for the half-cell reference. This reference electrode is connected to the other half-cell represented by the embedded rebar (Figure 2b). By connecting that reference electrode to the reinforcing steel and placing the reference electrode on the surface of the concrete, it is possible to measure the potential difference between the two half-cells.

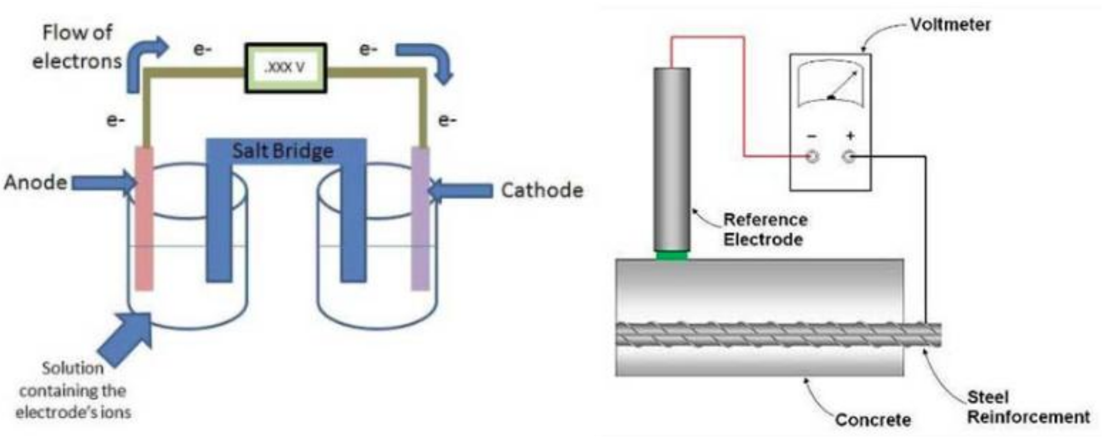


Fig. 13.1 Configuration for measurement of corrosion rate of reinforcement

ASTM C876 provides a guideline on how this measurement can be undertaken, and the relationship between the measured potential values and the corrosion probability. Interpretation of the result is qualitative and is based on the copper sulphate electrode (CSE). Table 1 shows the general interpretation guideline proposed by ASTM, where the measured potential ranges are categorized in three categories; more than 90% chance, less than 10% chance or an uncertain chance of corrosion.

Table 6: Relationship between measured potential and probability of steel corrosion

Measured Potential (mV CSE)	Probability of steel corrosion activity
>-200	Less than 10%
-200 to -350	Uncertain
<-350	More than 90%

APPARATUS:

1. Voltmeter.
2. Copper-sulphate reference electrode.

MATERIAL REQUIRED:

1. Reinforced concrete block specimen.

PROCEDURE:

1. Identify the rebar location. Then, the negative and positive wires are connected to the voltmeter and then the copper-sulphate reference electrode is connected to the positive end of the voltmeter.
2. Make a connection with the reinforcement and make sure that the reinforcement is connected till the area to be observed.
3. Prepare concrete surface through wetting and take the readings at a grid interval of about 50cm.

OBSERVATIONS:

S. No.	Half-Cell Potential (mV)	Average Value (mV)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		

RESULTS:

The average of the obtained half-cell potential is ______mV. This indicates that according to the table given, the probability of steel corrosion activity is _____.

PRECAUTIONS:

1. Make sure that the testing surface is fully wet prior to taking readings.
2. It should be ensured that the reinforcement is continuous to the testing area.

QUESTIONS

1. What is the use of half-cell potentiometer?
2. What is the rate of corrosion in reinforcing bar?
3. Why is it called half-cell potential?
4. What is the chemical formula for the half-cell?
5. How does the corrosion of a reinforcing bar affect the concrete as a whole?
6. What is alkali-aggregate reaction?

EXPERIMENT NO. 14

Core Test on Hardened Concrete

AIM: To determine the compressive strength of an existing concrete structure's core using core test.

THEORY: The core test is critically required when the results of Concrete cubes are not giving satisfactory results or shows some uncertain results.

In case of doubt regarding the grade of concrete used, either due to poor workmanship or based on results of cube strength test, compressive strength test of concrete core may generally be carried out.

In addition, it is used to determine concrete strengths in an existing structure for the evaluation of structural capacity and safety assessment of existing structure or to assess its capacity in case some additional lading is proposed to be put.

The core cutter test is a method used to determine the compressive strength of concrete. In the Concrete Core test, the sample or core is collected from the hardened concrete and extracted using the core cutter machine, and then these cores are used to determine the compressive strength of the concrete.

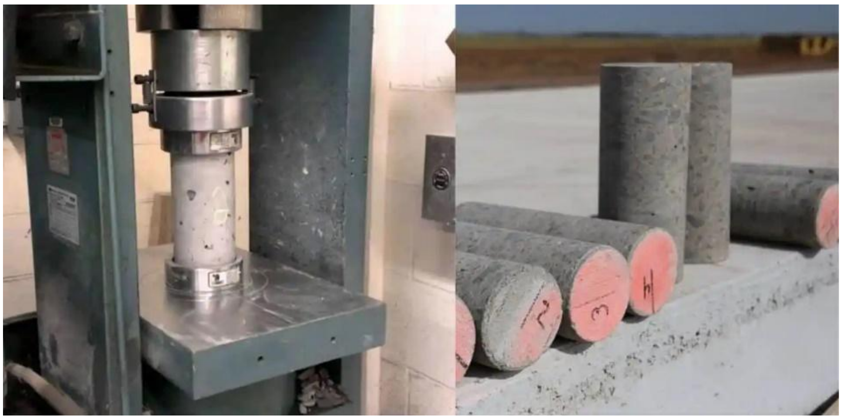


Fig 14.1 Concrete core specimen and compressive testing machine

A Core Test is generally performed for the concrete to determine whether the suspected hardened concrete is fitted acceptance criteria or not. Various types of capping material required different maximum compressive strength, that is given in the below table,

Table 14.1 Types of capping material required for different maximum compressive strength

S. No	Anticipated Strength	Preparation method
1	For any value of strength	Grinding
2	Up to 50 MPa Mortar	Capping with calcium aluminates cement
3	Up to 100 MPa	Capping with high strength sulphur

APPARATUS:

1. Prism mould, with dimensions of 40mm × 40mm × 160mm, complete with a filling frame.
2. Melting pot, with a thermostat to control the temperature of the mixture to 130±10ºC.
3. Ladle.
4. Saw.
5. Compression testing machine.

MATERIAL REQUIRED:

1. Reinforced concrete block specimen

THEORY:

PROCEDURE:

Sample preparation

1. After locating the rebars, use the core cutter to drill through the test specimen.
2. The core specimen shall be sawn perpendicular to its longitudinal axis and the size of the specimen shall be adjustable.
3. The load-bearing surface can be prepared by either capping or grinding to improve contact with the loading machine.

Core test

4. Before placing the core specimen in the testing machine weigh it and also determine its length.
5. Testing machines shall be wiped, cleaned, and freeform any loose material shall be checked.
6. The core cutter specimen shall contact the compression plates.
7. The core specimen shall be placed in the machine in such a manner that the load shall be applied to the top and bottom prepared surface.
8. The axis of the specimen shall be carefully aligned with the center of thrust.
9. The spherical-shaped block is bear to the core specimen and the movable portion shall be rotated gently by the hand.
10. So that uniform block seating is obtained.
11. The load shall be applied on the core specimen without shock and increase continuously at the rate of 14 $N/mm^2/min$.
12. Until the core specimen breakdown and no greater load can be sustained.
13. The maximum load applied to the specimen was then recorded as the reading and the check appearance of the concrete.
14. Also, check any unusual feature in the type of failure shall be noted.

OBSERVATIONS & CALCULATIONS:

The correction factor for determining the compressive strength of the concrete whole is given as:

$$F = 0.11\,N + 0.78$$

Where,

F = Correlation factor.

N = Length/diameter ratio.

Sl. No.	Test Specimen	Obtained Compressive Strength (MPa)	Correlation Factor	Compressive Strength (MPa)
1	Specimen 1			
2	Specimen 2			
3	Specimen 3			
4	Specimen 4			

RESULT:

From the tests performed, the compressive strength of concrete is ________.

PRECAUTIONS:

1. Immediately after drilling mark each core ideally and clearly.
2. Record its location and orientation within the element from which it was drilled if a core is subsequently cut to produce a number of specimens mark each specimen to indicate its position and orientation.
3. Drilling through reinforcement shall be avoided.
4. It shall be trimmed off to obtain a core free from reinforcement the reinforcement detector such as a cover meter can be used for selecting the drilling location free of reinforcement.

QUESTIONS

1. When is it necessary to conduct a concrete core test?
2. How does testing the compressive strength of the concrete core correlate with the concrete structure as a whole?
3. Define capping.
4. What is correlation factor in concrete core test and why is it necessary?
5. What are the factors affecting the accuracy of the correlation of the concrete core and the whole concrete?
6. Why is rebar locator tests required prior to cutting out of concrete core?

EXPERIMENT NO. 15

Concrete Mix Design based on IS Code

AIM: To obtain a Concrete Mix Design using IS Code Method

THEORY: Some special structures require a high strength or a specific strength concrete. In this case special methods needs to be implemented to attain the required strength of the concrete. IS 10262:2019 gives the guidelines for preparing the required concrete mix.

Mix design concrete is a crucial process in the concrete making that involves determining the proportions and ingredients of concrete to achieve the desired strength, workability, durability, and other properties. It is essential to design a concrete mix that meets the specific requirements of a construction project.

Concrete mix design is centred on the rational proportioning of ingredients to achieve the desired properties in both the plastic and hardened states. The plastic state of concrete must be satisfactory to allow for proper compaction, which in turn affects the performance of the hardened concrete and the structure as a whole. Workability governs the ease of placement while the water-cement ratio primarily affects durability, making these factors crucial in proportioning.

The ultimate goal of the mix design is to determine the most suitable proportions of materials to meet the specific requirements of the structure. According to IS 456: 2000, the design mix of concrete is the process of selecting the suitable ingredients of concrete and determining their relative proportions with the objective of producing concrete of the required, strength, durability, and workability as economically as possible.

When proportioning concrete or mortar mixes, the primary aim is to produce a durable material that meets the necessary requirements for strength, water tightness, and other essential properties while keeping the cost as low as possible. To attain these goals, a meticulous selection process must be employed when choosing the cement, aggregate, and water, taking into account the following factors:

1. It is important for the mix to be easily workable to facilitate placement and finishing without excessive effort.
2. As cement tends to be the most expensive component of the mix, the proportion used should be minimized while still achieving the desired properties.

APPARATUS:

1. Trowel.
2. Measuring Jar.
3. Mould.
4. Compression testing machine.

MATERIALS REQUIRED:

1. Cement.
2. Sand.
3. Coarse aggregate.
4. Water.

5. Admixture.
6. Grease.

PROCEDURE:

1. Calculate the mix proportions using the guidelines from IS 10262:2019.
2. Prepare the concrete mix as per the proportions obtained from the mix design.
3. Clean the mould and apply grease inside the mould to prevent adhesion
4. Fill the mould with the concrete mixture and prepare several specimens for testing.
5. Test the specimens consecutively after 3, 7 and 28 days, respectively.
6. Record the compressive strength of concrete.

OBSERVATIONS:

S. No	Specimen	No. of Days	Compressive Strength (MPa)	Average Compressive Strength (MPa)
1		3		
2		7		
3		28		

RESULTS:

The obtained compressive strengths of concrete are:

a) In 3 days: _________MPa.
b) In 7 days: _________MPa.
c) In 28 days: ________MPa.

PRECAUTIONS:

1. Care should be taken while weighing the components of the concrete.
2. No cracks should be present while curing of the concrete specimen.

QUESTIONS

1. What are the applications of concrete mix design?
2. What are the different variables in mix proportioning?
3. Determine the data required for concrete mix design as per IS code.
4. What do you mean by assumed standard deviation?
5. Define target mean strength.
6. Elaborate the principle of concrete mix design.
7. What is superplasticizer? Mention the importance of superplasticizers in fresh concrete.