



Government of Nepal
Ministry of Urban Development
Department of Urban Development & Building Construction
National Research Centre for Building Technology
Babar Mahal, Kathmandu

Laboratory Manual of Material Tests

April 2023

Table of Contents

TESTS ON CEMENT	3
SAMPLING OF CEMENTS	4
NORMAL CONSISTENCY OF CEMENT	7
FINENESS OF CEMENT BY SIEVE TEST METHOD	10
SOUNDNESS OF CEMENT	12
INITIAL AND FINAL SETTING TIME OF CEMENT	14
COMPRESSIVE STRENGTH OF CEMENT	17
TESTS ON CONCRETE	21
WORKABILITY OF FRESH CONCRETE – SLUMP TEST	22
WORKABILITY OF FRESH CONCRETE - COMPACTION FACTOR TEST	26
WORKABILITY OF FRESH CONCRETE – FLOW TABLE TEST	30
SETTING TIME OF CONCRETE BY PENETRATION RESISTANCE	34
COMPRESSIVE STRENGTH OF CEMENT CONCRETE	39
TESTS ON AGGREGATES	45
SAMPLING TECHNIQUE OF AGGREGATES	46
GRADATION ANALYSIS OF AGGREGATES	51
DETERMINATION OF SILT CONTENT IN FINE AGGREGATES	54
DETERMINATION OF BULKING OF SAND	57
DETERMINATION OF SPECIFIC GRAVITY AND WATER ABSORPTION OF COARSE AGGREGATES	59
DETERMINATION OF ELONGATION INDEX	65
DETERMINATION OF FLAKINESS INDEX	68
DETERMINATION OF AGGREGATE CRUSHING VALUE	71
DETERMINATION OF AGGREGATE IMPACT VALUE	75
DETERMINATION OF LOS ANGELES ABRASION VALUE	79
TESTS ON BRICKS	83
DETERMINATION OF WATER ABSORPTION OF BRICK	84
DETERMINATION OF COMPRESSIVE STRENGTH OF BRICK	86

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

ई. मणि राम गेलाल
सचिव

Table of Figures

Figure 1: Tube Sampler for Packaged Cement Volume (Bags).....	4
Figure 2: Slotted Tube Sampler for Bulk Cement Volume	4
Figure 3: Vicat's Apparatus	7
Figure 4: Sieve Pans.....	10
Figure 5: Sieve Shaker.....	10
Figure 6: Le-Chatelier's Apparatus	12
Figure 7: Vicat's Apparatus	14
Figure 8: Compression Testing Machine	17
Figure 9: Slump Cone.....	23
Figure 10: Types of Slump.....	25
Figure 11: Compacting Factor Apparatus	27
Figure 12: Flow Table Apparatus.....	31
Figure 13: Penetration Resistance Apparatus.....	35
Figure 14: Compression Testing Machine.....	39
Figure 15: Cube Mould	39
Figure 16: Stockpile of Sample by Wheel Loader and Truck.....	49
Figure 17: Aggregate Sampling from the Stockpiles	49
Figure 18: Sieve Pans	51
Figure 19: Measuring Cylinder with Scale.....	55
Figure 20: Elongation Apparatus	66
Figure 21: Gauging Trowel.....	69
Figure 22: Open Ended Steel Cylinder with Plunger and Base Plate.....	72
Figure 23: Impact Testing Machine	76
Figure 24: Los Angeles Abrasion Test Setup	79







ई. मणि राम गोलाल
सचिव

TESTS ON CEMENT

[Handwritten marks]

[Handwritten mark]

[Handwritten mark]

ई. मणि राम गेलाल
सचिव

SAMPLING OF CEMENTS

IS: 3535 – 1986

OBJECTIVE:

The main objective is to obtain samples of cement from bags, wagons and bulk storage (Silos etc.) following a specified procedure for laboratory testing.

APPARATUS:

- Tube Sampler
- Slotted tube sampler



Figure 1: Tube Sampler for Packaged Cement Volume (Bags)



Figure 2: Slotted Tube Sampler for Bulk Cement Volume

[Handwritten signatures]

4

[Handwritten signatures]

[Handwritten signature]

ई. मणि राम गोलाल
सचिव

PRECAUTIONS:

- i) The sampler should be clean and dry when used.
- ii) The sample should be protected from contamination.
- iii) After filling, the container should be sealed air-tight and labeled correctly.
- iv) Store the sample in a temperature controlled room i.e. the normal temperature of the sample should not vary.
- v) The place of sampling shall be clean, dry and free from draught.

PROCEDURE OF SAMPLING:

Sampling from bags:

- a. A lot of the cement is divided into sub-lots as given in the table-1. From each sub-lot a 2% of the bags or a minimum of 5 are selected randomly.
- b. Using a tube sampler as shown in figure 1, insert diagonally from the valve of the bag and draw the cement. Minimum of 2kg from each randomly selected bags to form a gross sample sufficient to reduce to a minimum of 11 kg as described in c. below.
- c. Reduce the gross sample by quartering using splitter or other means and then fill the reduced sample in the sample container.
- d. Sealed the container air tight, label and store for laboratory testing.

[Handwritten scribbles and marks]

[Handwritten signature]

[Handwritten signature]
ई. मणि राम गोलाल
सचिव

Table 1 NUMBER OF SUB-LOTS INTO WHICH A LOT IS TO BE DIVIDED

Clauses 5.2.1, 5.3.1, 5.4.1, 5.5.2 and 5.6.1 of IS 3535 -1986	
Weight of the lot (In Tonnes)	Number of Sub- Lots
Up to 100	2
101 to 200	3
201 to 300	4
301 to 500	5
501 to 1000	6
1001 to 2000	7

Sampling from Wagon/ Bulker.

- The cement lot is divided into sub-lots as per the table-1 and each sub-lot is divided into approximately equal number of Bulklers.
- Select the bulker randomly and using slotted tube sampler as shown in fig. 2, collect the gross sample from different points.
- Reduce the gross sample by quartering using splitter or other means and then fill the reduced sample in the sample container.
- Sealed the container air tight, label and store for laboratory testing.






ई. मणि राम गोलाल
सचिव

NORMAL CONSISTENCY OF CEMENT

IS: 4031 (Part 4) - 1988

OBJECTIVE:

This experiment is intended to determine the quantity of water required to produce a cement paste of standard or normal consistency.

APPARATUS:

- Vicat apparatus conforming to IS: 5513-1976
- Weighing Balance of 1g accuracy
- Gauging Trowel
- Stop Watch

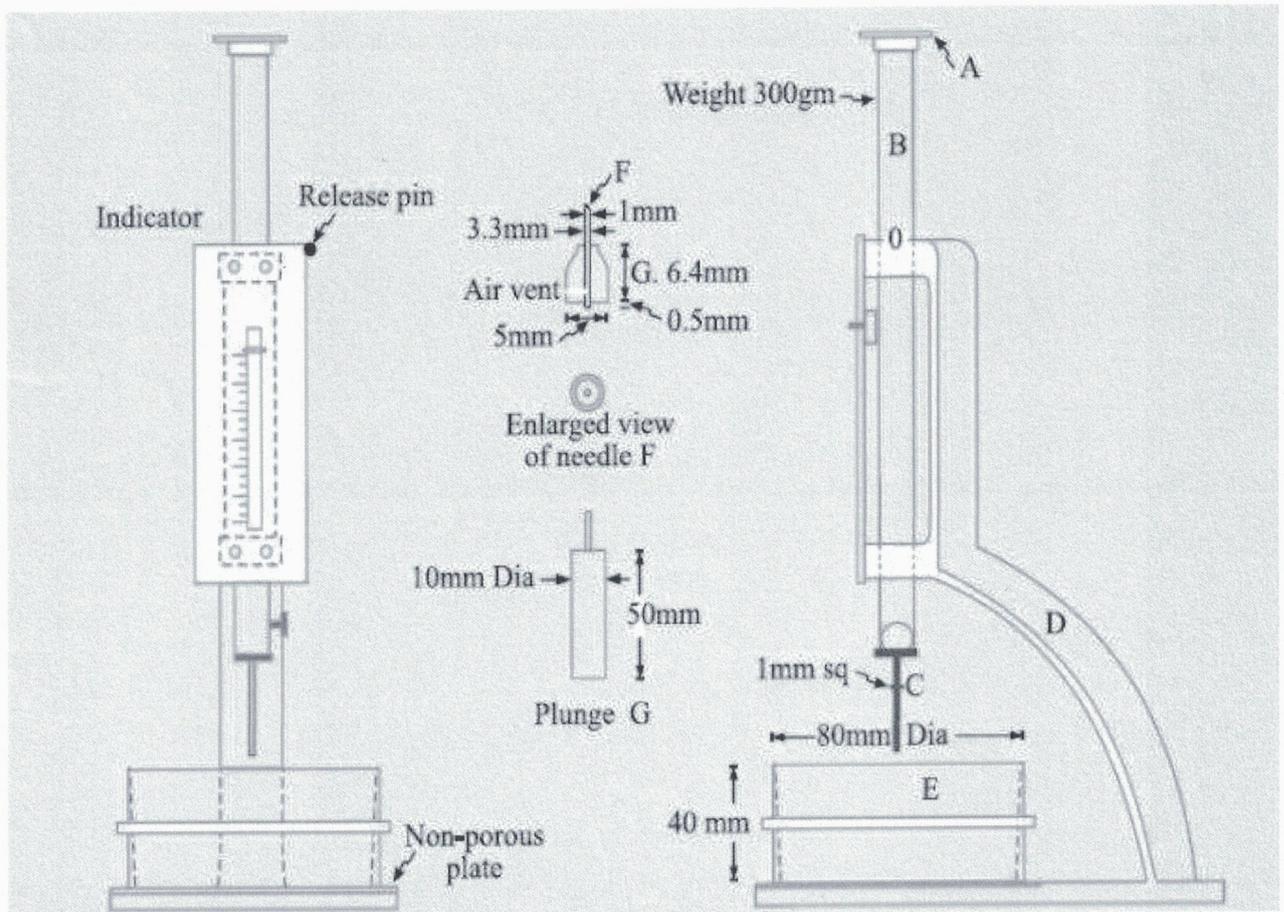


Figure 3: Vicat's Apparatus

(Handwritten signatures)

7

(Handwritten signature)

(Handwritten signature)
ई. मणि राम गोलाल
सचिव

INTRODUCTION:

Consistency is a general term to indicate the degree of fluidity or the degree of mobility i.e. it refers to the ability to flow of a freshly mixed cement paste or mortar. The standard consistency of a cement paste is defined as that consistency which will permit the vicat plunger having 10 mm dia. to penetrate to a point 5 to 7 mm from the bottom of the vicat mould (33 to 35 mm from the top of the vicat mould). The standard consistency of cement paste is used in the determination of initial setting time, final setting time, soundness of cement and compressive strength of cement.

PROCEDURE:

1. Weigh accurately about 300 gms. of cement to be tested and place it in a bowl or crucible.
2. Mix about 25% potable or distilled water by weight of dry cement thoroughly to get a cement paste. Total time taken to obtain cement paste after adding water i.e. "Gauging time" should not be more than 3 to 5 minutes and fill the cement paste in the split mould of the apparatus.
3. Care should be taken to see that it is filled from large end towards shorter end and no pressure is used in filling.
4. After completely filling the mould, trim off the excess cement paste, making it in level with the top of the mould and place the larger end of the mould on non-porous glass plate and whole assembly below the needle of 1cm dia.
5. Adjust the movable rod or plunger so that the end of the needle just touches the surface of the cement paste.
6. Take the initial reading and then immediately release the rod without jerk and allow the needle to penetrate. This operation shall be carried out immediately after filling the mould.
7. Prepare trial cement pastes with varying percentages of water and test as described above until a penetration of 5 to 7mm from the bottom of Vicat mould is obtained, which is the paste of standard consistency.

PRECAUTION:

- Gauging time should be strictly observed (should not be less than 3 minutes and not more than 5 minutes).
- The temperature of water and room should be $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$.
- There should be no vibration on the working table.
- Clean the apparatus thoroughly before testing and after testing.
- The plunger and mould and oil should be applied on the surface during every repetition.



8




इ. मणि राम गेलाल
सचिव

OBSERVATION:

S. No.	Weight of cement (gm)	Weight of water (gm)	Plunger penetration (mm)	Consistency (%)

CALCULATION:

$$\text{Standard Consistency (\%)} = \frac{\text{Weight of water added}}{\text{Weight of cement}}$$

RESULT:

The quantity of water expressed as percentage by weight of cement at which the penetration of 1 cm dia. pin is 33 to 35 mm from the top of the vicat mould is reported as Normal Consistency of that cement.

[Handwritten signatures and initials]

ई. मणि राम गेलाल
सचिव

FINENESS OF CEMENT BY SIEVE TEST METHOD IS: 4031 (Part 1): 1996

OBJECTIVE:

This experiment is intended to determine the fineness of the given cement sample.

APPARATUS:

- Sieve 90 micron- Cylindrical frame of 150 mm to 200 mm nominal diameter and 40 mm to 100 mm depth, fitted with 90 pm mesh sieve cloth of woven stainless steel, or other abrasion-resisting and non-corrodible metal wire. The sieve cloth shall comply with the requirements of IS 460 (Part 1) : 1985 and IS 460 (Part 3) : 1985 and shall be free of visible irregularities in mesh size when inspected optically by the methods of IS 460 (Part 3) : 1985. A tray fitting beneath the sieve frame and a lid fitting above it shall be provided to avoid loss of material during sieving.
- Standard Balance- Capable of weighing up to 10 g to the nearest 10 mg.
- Gauging Trowel
- Brush



Figure 5: Sieve Pans



Figure 4: Sieve Shaker

INTRODUCTION:

Fineness is the size of the particles of the cement. The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence the faster and greater the development of strength. The fineness of cement is measured by sieving it on standard sieve.

~~AA~~ ~~A~~ ~~S~~

10

1/2

B



ई. मणि राम गोलाल
सचिव

PROCEDURE:

1. Agitate the sample of cement to be tested by shaking for 2 min in a stoppered jar to disperse agglomerates. Wait 2 min. Stir the resulting powder gently using a clean dry rod in order to distribute the fines throughout the cement.
2. Fit the tray under the sieve, weigh approximately 10 g of cement to the nearest 0.01 g and place it on the sieve, being careful to avoid loss.
3. Weigh accurately about 10 gms. of cement to the nearest 0.01gm and take it on a standard IS Sieve No.9 (90 micron).
4. Break down any air-set lumps in the cement sample with fingers.
5. Continuously sieve the sample giving circular and vertical motion for a period of 15 minutes. A sieve shaker may also be used.
6. Weigh the residue left on the sieve, Express its mass as a percentage, R1 of the quantity first placed in the sieve to the nearest 0.1 percent.
7. Repeat the whole procedure using a fresh 10 g sample to obtain R2.
8. Then calculate the residue of the cement R as the mean of R1 and R2 as a percentage, expressed to the nearest 0.1 percent.
9. When the results differ by more than 1 percent absolute, carry out a third sieving and calculate the mean of the three values.

PRECAUTION:

- The cleaning of the sieve should be done very gently with the help of a brush i.e. 25 mm or 40 mm bristle brush with 25 cm handle.
- After sieving, the cement must be removed from the bottom surface of the sieve gently.
- Weighing machine should be checked before use.
- Sieving must be carried out continuously.

OBSERVATION:

S. No.	Weight of sample taken (gm)	Weight of residue(R1) (gm)	Weight of residue(R2) (gm)	Weight of residue(R3) (gm)	Average Weight of Residue (gm)	Fineness (%)

CALCULATION:

$$\text{Fineness (\%)} = \frac{\text{Weight of cement retained on the sieve}}{\text{Weight of cement sample taken}}$$

11

ई. मणि राम गेलाल
सचिव

SOUNDNESS OF CEMENT

IS: 4031 (Part 3) - 1988

OBJECTIVE:

This experiment is intended to determine the soundness of given cement sample by Le-Chatelier Method.

APPARATUS:

- Le-Chatelier Test Apparatus
- Glass Sheet (2 Nos.)
- Weighing Balance
- Weights
- Gauging Trowel
- Water Bath

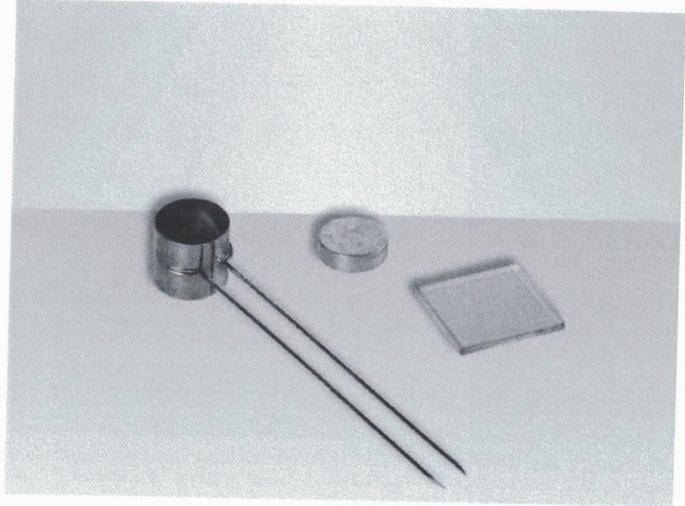


Figure 6: Le-Chatelier's Apparatus

INTRODUCTION:

Soundness of cement can be defined as its ability to retain its volume after it gets hardened. The testing of soundness of cement is done to ensure that the cement does not show any appreciable subsequent expansion or cement shall not undergo any appreciable change in volume after setting. The non-soundness of cement is due to the presence of excess of lime, excess of magnesia or excessive proportion of sulphates. Unsoundness produces cracks, distortion and disintegration there by giving passage to water and atmospheric gases which may have injurious effects on concrete and reinforcement.

PROCEDURE:

1. Weigh accurately about 200 gms. of cement and prepare a cement paste by gauging cement with 0.78 times the water required to give a paste of standard consistency.
2. Oil the mould lightly. Keep it on a lightly oiled glass plate and fill up the mould with cement paste.

(Handwritten marks)

(Handwritten mark)

(Handwritten mark)

(Handwritten signature)
ई. मणि राम गोलाल
सचिव

3. Cover the mould with another piece of lightly oiled glass sheet, put small weight on it and immediately submerge the whole assembly in water at a temperature of $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and keep it there for 24 h.
4. Remove the whole assembly from water and measure the distance separating the indicator points to the nearest 0.5 mm.
5. Submerge the mould again in water at a temperature prescribed above, bring it to boil in 25-30 minutes and keep it boiling for 3 hours.
6. Remove the mould from water, allow it to cool and measure the distance between the indicator points.
7. The difference between these two measurements indicates the expansion of the cement.

PRECAUTION:

- Good care should be taken while taking the measurements.
- More pressure is not applied on the mould while filling it.
- The water level should not fall below the height of the mould during boiling.
- Water should be brought to boiling point gradually in the specified time.
- Le-Chatelier apparatus should be handled by pressing indicator arms.

OBSERVATION:

S.No.	Weight of Cement (gms)	Distance separating the indicator points (mm)		Soundness of Cement (L1-L2)	Mean Value
		Measurement taken after 24 hours of immersion in water at a temp. $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ (L1)	Measurement taken after 3 hours of immersion in water at boiling temp. (L2)		

CALCULATION:

Soundness/expansion of cement = $L1 - L2$

Calculate the mean of two values to the nearest 0.5 mm. This value must not exceed 10 mm for OPC, PPC and High alumina cement.

(Handwritten marks)

(Handwritten mark)

(Handwritten mark)

(Handwritten signature)
 ई. मणि राम गेलाल
 सचिव

INITIAL AND FINAL SETTING TIME OF CEMENT

IS: 4031 (Part 5) - 1988

OBJECTIVE:

This experiment is intended to determine the initial and final setting time of given cement sample.

APPARATUS:

- Vicat apparatus conforming to IS: 5513-1976
- Weighing Balance of 1g accuracy
- Gauging Trowel
- Standard Weights

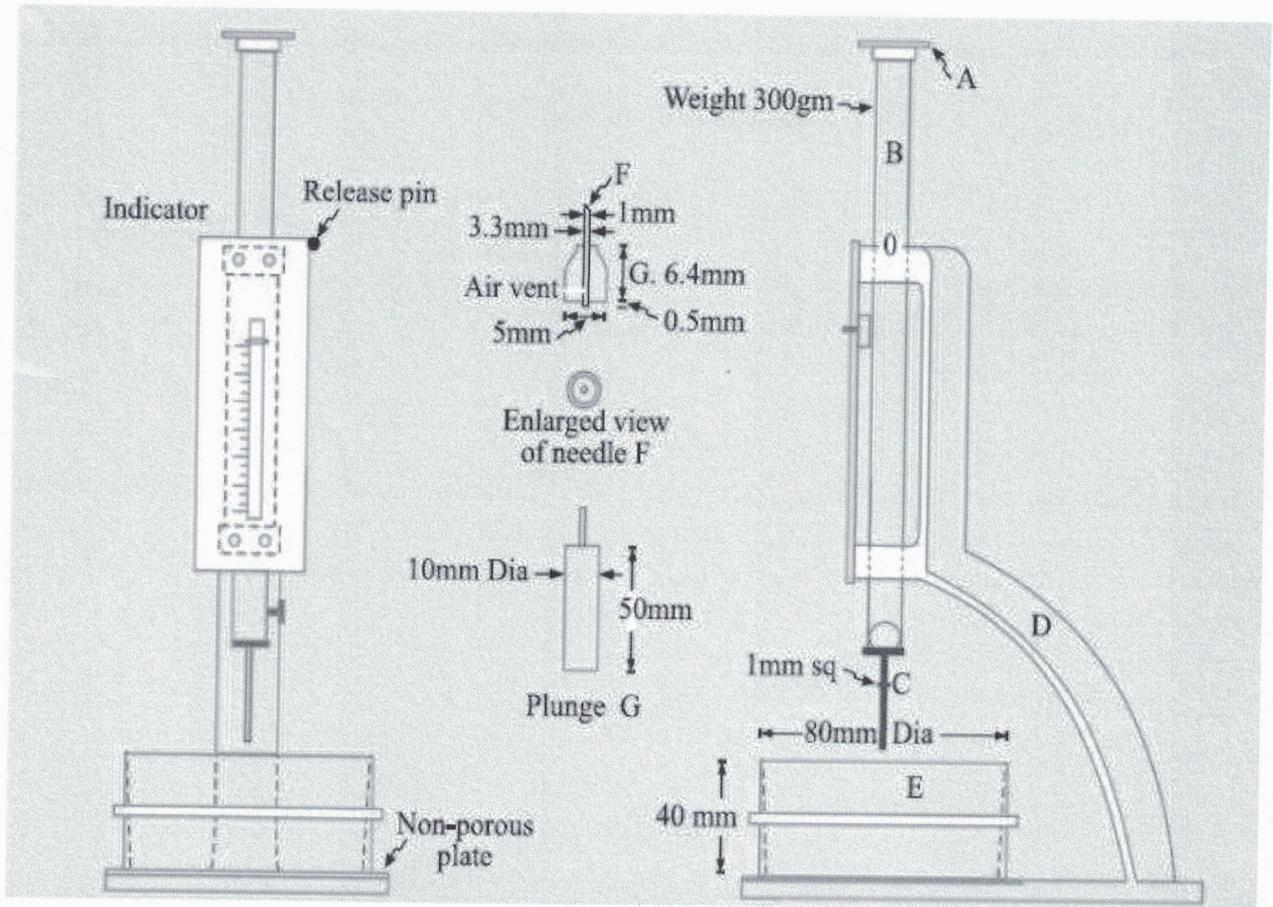


Figure 7: Vicat's Apparatus

~~XXXX~~

~~XXXX~~

~~XXXX~~

~~XXXX~~

~~XXXX~~

INTRODUCTION:

Cement, when used in construction, should set in a reasonable time. For any construction work dealing with cement, mortar or concrete certain time is required for mixing, transportation and placing. During this time cement paste, mortar or concrete should be in plastic condition. The time interval for which the cement paste remains in plastic condition is known as the setting time. For convenience, *initial setting time* is regarded as the time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity. The *final setting time* is the time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure. Cement should not set too early, so that it can be transported to the place where it is to be placed. Also it should not take too long for setting, so that formworks can be removed and further work can be started.

PROCEDURE:

1. Prepare a neat cement paste by mixing 300 gms of cement with 0.85 times the water required to give a paste of standard consistency, using potable or distilled water.
2. Start the stop watch at the instant when water is added to the cement.
3. Fill the Vicat mould with the cement paste, the mould resting on a non-porous plate. Gauging time should not be less than 3 minutes and not more than 5 minutes.
4. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould to give a test block.
5. Place the test block confined in the mould and resting on the non-porous plate, under the rod bearing the needle (C).
6. Lower the needle gently until it comes in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block.
7. In the beginning, the needle will completely pierce the test block. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block beyond 5.0 ± 0.5 mm measured from the bottom of the mould.
8. The period elapsing between the time when water is added to the cement and the time at which the needle fails to pierce the test block to a point 5.0 ± 0.5 mm measured from the bottom of the mould shall be the *initial setting time*.



15



ई. मणि राम गोलाल
सचिव

Determination of Final Setting Time:

1. Replace the needle of the Vicat apparatus by the needle with an annular attachment.
2. The cement shall be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression thereon, while the attachment fails to do so.
3. The period elapsing between the time when water is added to the cement and the time at which the needle makes an impression on the surface of test block while the attachment fails to do so shall be the *final setting time*.
4. In the event of a scum forming on the surface of the test block, use the underside of the block for the determination.

PRECAUTION:

- Clean appliances shall be used for gauging.
- All the apparatus shall be free from vibration during the test.
- The temperature of water and that of the test room should be $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$.
- Needle must be cleaned each time before use.
- Shift the position of the mould after recording the penetration reading so that the next penetration may not be at the same place.

OBSERVATION:

S. No.	Time at which water is first added (sec) T1	Time when initial setting time takes place (sec) T2	Time when final setting time takes place (sec) T3

CALCULATION:

$$\text{Initial Setting Time} = T1 - T2$$

$$\text{Final Setting Time} = T3 - T1$$

RESULT:

The results of initial and final setting time shall be reported to the nearest five minutes.

~~Handwritten marks~~

Handwritten marks and signature
ई. मणि राम गेलाल
सचिव

COMPRESSIVE STRENGTH OF CEMENT

IS: 4031 (Part 6) - 1988

OBJECTIVE:

This experiment is intended to determine the compressive strength of a given sample of cement through standard cement mortar cubes compacted by means of standard vibration machine.

APPARATUS:

- Compression Testing Machine
- Vibration Machine
- Standard Sand conforming to IS: 650-1966
- Poking Rod
- Cube Mould of 70.6 mm size
- Gauging Trowel
- Balance
- Graduated Glass Cylinders

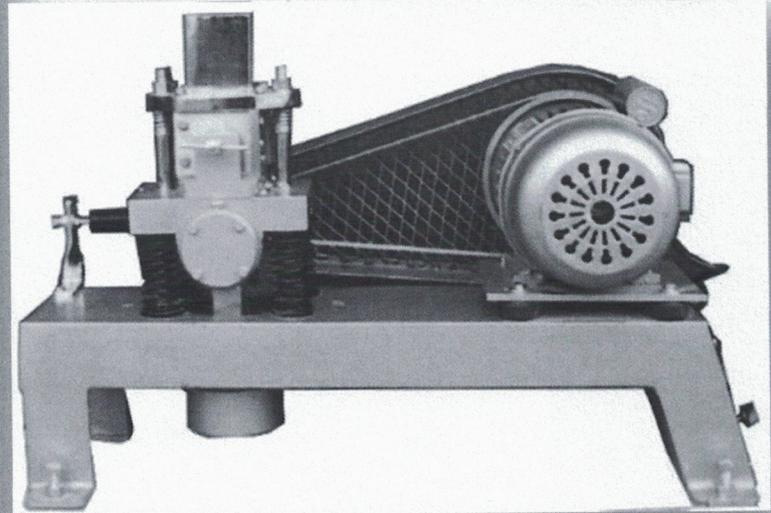
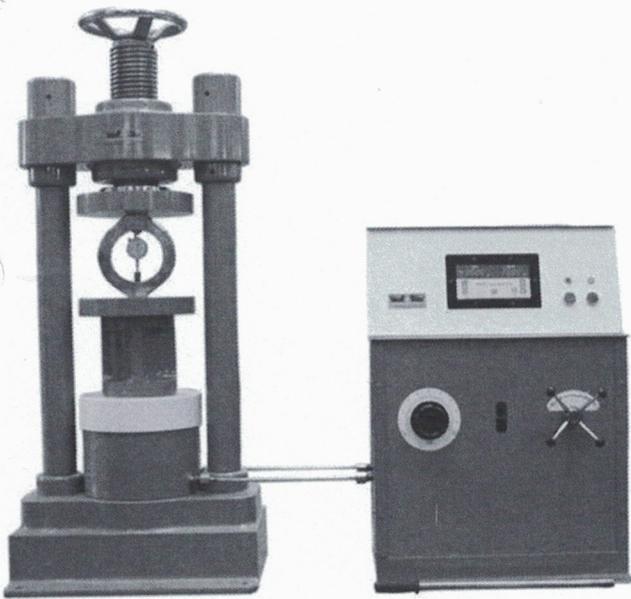


Figure 8: Compression Testing Machine

~~Handwritten marks~~

Handwritten marks

Handwritten signature
इ. मणि राम गेलाल
सचिव

INTRODUCTION:

Compressive strength of any material is defined as the resistance to failure under the action of compressive forces. It is the measure of compression force that the material can withstand without undergoing any cracks, breaking and fissure. The compressive strength of hardened cement is the most important property as it controls the mix design. Strength tests are not conducted on neat cement paste because of difficulties of excessive shrinkage and subsequent cracking. Strength of cement is therefore found indirectly, by testing cement mortar in a specific proportion.

PROCEDURE:

1. Take 200 g of Cement and 600 g of Standard Sand (conforming IS 650) in a non-porous enamel tray and mix them with a trowel for one minute, then add water equal to $(P/4 + 3.5)$ percent of combined weight of cement and sand, where P is the percentage of water required to produce a paste of standard consistency and mix the three ingredients thoroughly until the mixture is of uniform color.
2. Gauging time should not be less than 3 minutes and should not exceed 4 minutes. If it exceeds, mixture is rejected and operation is repeated.
3. Oil the interior faces of the mould and place the assembled mould on the top of the table of the vibration machine and hold it firmly in position by means of a suitable clamp.
4. Attach a hopper of suitable size and shape securely at the top of the mould to facilitate filling and this hopper shall not be removed until the completion of the vibration period.
5. Immediately after mixing the mortar, the mortar is placed in 9 cube mould of 7.06 cm; the area of each face being 50 sq.cm and prodded with the rod. The mortar shall be prodded 20 times in about 8s to ensure elimination of entrained air and honey-combing. The remaining quantity of mortar is placed in the hopper of the cube mould and prod again for the first layer and then compacted the mortar by vibration.
6. The period of vibration shall be two minutes at the specified speed of 12000 ± 400 vibration per minute.
7. At the end of vibration, remove the mould together with the base plate from the machine and finish the top surface of the cube in the mould by smoothing the surface with the blade of a trowel.
8. Keep the compacted cubes in the mould at a temperature of $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and at least 90 percent humidity for 24 h.
9. At the end of 24 h, remove the moulds and immediately submerge them in clean fresh water and keep them there until taken out just prior to testing.

18






ई. मणि राम गेलाल
सचिव

Testing:

1. Test three cubes each for compressive strength for each period of curing mentioned under the relevant specifications (i.e. 3 days, 7 days and 28 days).
2. The cubes shall be tested on their sides without any packing between the cube and the steel plattens of the testing machine.
3. Apply the load steadily and uniformly starting from zero at a rate of 35 N/mm²/min.

PRECAUTION:

- Inside of the cube moulds should be oiled to prevent the mortar from adhering to the sides of the mould.
- The cubes should be tested immediately after taking out of water and not allowed to dry until they fail under testing.
- Gauging time should be strictly observed (should not be less than 3 minutes and not more than 4 minutes).
- The water in which the cubes are submerged shall be renewed every 7 days and shall be maintained at a temperature of 27° C ± 2° C.
- In determining the compressive strength, do not consider specimens that are manifestly faulty, or that give strengths differing by more than 10% from the average value of all the test specimen.
- After discarding specimens or strength values, if less than two strength values are left for determining the compressive strength at any given period, a re-test shall be made.

OBSERVATION:

S. No.	Compressive Strength after 3 days/7 days				Compressive Strength after 28 days			
	Observation			Average Strength	Observation			Average Strength
	Plan Area (A) mm ²	Load at failure (W) N	Compressive Strength (N/mm ²)		Plan Area (A) mm ²	Load at failure (W) N	Compressive Strength (N/mm ²)	

19

ई. मणि राम गेलाल
सचिव

CALCULATION:

The compressive strength is calculated by dividing the maximum load applied to the cubes during the test divided by the cross-sectional area and reported to nearest 0.5 N/mm².

$$\text{Compressive Strength} = \frac{\text{Maximum load applied to the cube}}{\text{Cross-sectional area of the cube}}$$

~~XXXX~~ ~~DD~~ ~~DD~~

123

~~DD~~

~~DD~~

ई. मणि राम गेलाल
सचिव

TESTS ON CONCRETE

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

21

[Handwritten mark]

[Handwritten mark]

[Handwritten signature]

ई. मणि राम गेलाल
सचिव

WORKABILITY OF FRESH CONCRETE – SLUMP TEST

IS: 1199 (Part 2): 2018

OBJECTIVE:

This experiment is intended to determine the workability of concrete mix of given proportion by slump test.

The slump test is applicable to a range of consistency of concrete that corresponds to slumps between 10 mm and 210mm.

APPARATUS:

- Mould in the form of a hollow frustum of a cone and shall have the following internal dimensions:
 - a) Diameter of a base : 200 ± 2 mm
 - b) Diameter of top : 100 ± 2 mm
 - c) Height : 300 ± 2 mm
- Scoop
- Funnel (Optional)
- Tamping rod made of steel, having a circular cross-section with a diameter of 16 ± 1 mm, 600 ± 5 mm in length and with rounded ends. The rod may be extended with a handle of plastic conduit, provided that the overall length does not exceed 1000mm.
- Rule- It shall be graduated from 0mm to 300mm, at intervals not exceeding 5 mm, with zero point being at extreme end of the rule.
- Base Plate/ Surface
- Shovel
- Remixing Tray
- Timer

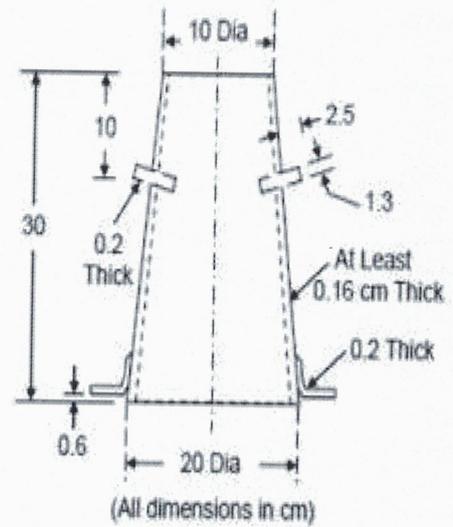
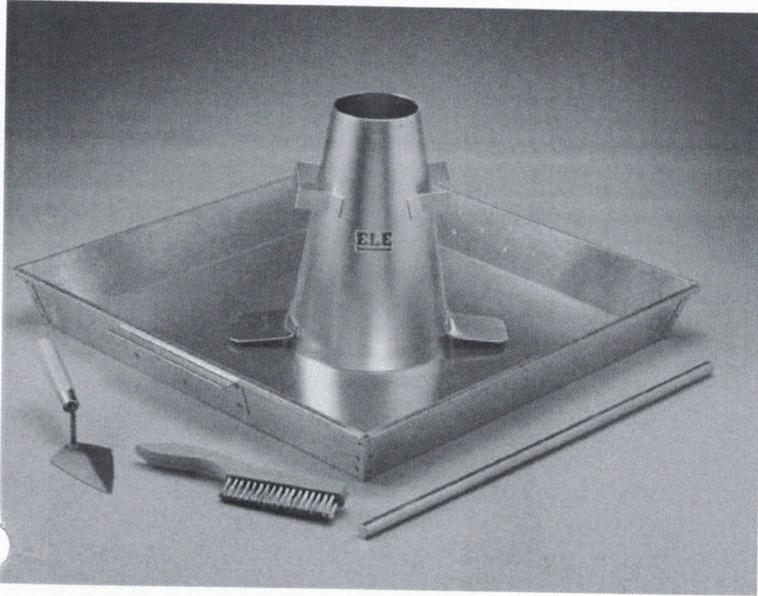


Figure 9: Slump Cone

INTRODUCTION:

Workability of concrete is the property of freshly mixed concrete which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished. It is the property of concrete which determines the amount of useful internal work necessary to produce full compaction without bleeding or segregation in the finished product. Workability is an important property of concrete and linked with compaction as well as the strength of the concrete.

The factors helping concrete to have more lubricating effect to reduce internal friction for helping easy compaction are given below:

- Water Content
- Mix Proportions
- Size of Aggregates
- Shape of Aggregates
- Surface Texture of Aggregates



ई. मणि राम गेलाल
सचिव

- Grading of Aggregate
- Use of Admixtures

PROCEDURE:

1. Dampen the mould and base plate with a moist cloth. Wipe any excessive water from the surfaces using an absorbent cloth. Place the mould on the surface of the rigid horizontal base plate free from extraneous vibration and shock.
2. Immediately after obtaining the sample, fill the mould in three layers, each approximately one-third of the height of the mould when compacted. During filling, clamp or hold the mould firmly in place by standing on the two foot pieces.
3. When filling the mould, ensure that the concrete is distributed symmetrically around the mould.
4. Tamp each layer with 25 strokes of the tamping rod.
5. The strokes shall be distributed in an 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.
6. Tamp the second layer and top layer each throughout its depth, so that the strokes just penetrate into the underlying layer.
7. In filling and tamping the top layer, heap the concrete above the mould before the tamping is started.
8. If the tamping operation of the top layer results in subsidence of the concrete below the top edge of the mould, add more concrete to keep an excess above the top of the mould at all times. Also ensure that the addition of concrete to the top layer does not provide extra compaction of the concrete.
9. After the top layer has been tamped, scrap off the surface of the concrete level with the top of the mould by means of a sawing and rolling motion of the tamping rod. Remove spilled concrete from the base plate/surface.
10. The entire operation from the start of the filling to the removal of the mould shall be carried out without interruption and shall be completed within 180 s.
11. Immediately after removal of the mould, determine the slump, h, by measuring the difference between the height of the mould and the highest point of the slumped concrete.
12. Measure slump to the nearest 5 mm.

[Handwritten marks]

[Handwritten mark]

[Handwritten mark]

[Handwritten signature]
 ई. मणि राम गेलाल
 सचिव

OBSERVATION:

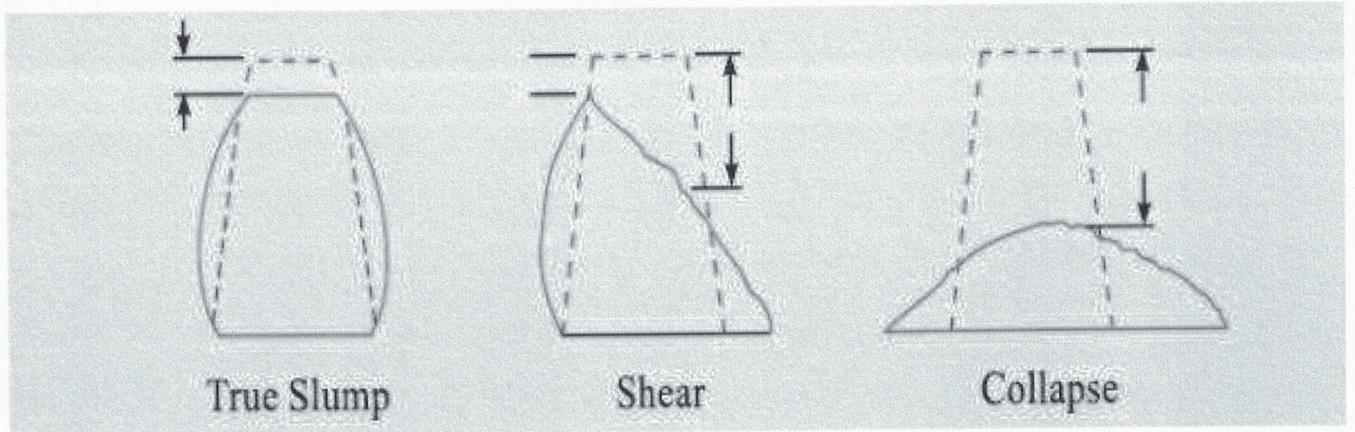


Figure 10: Types of Slump

The difference between the height of the mould and that of the highest point of the specimen being tested in mm is the slump of the concrete. The test is only valid if it yields a true slump, this being a slump in which the concrete remains substantially intact and symmetrical. If the slump collapses or shears off laterally, take another sample and repeat the test.

Record the true slump, to the nearest 5 mm.

If two consecutive test show portion of concrete shearing off from the mass of the test specimen or collapsing, report the test as being invalid as the concrete lacks the necessary plasticity and cohesiveness for the slump test to be suitable.

[Handwritten marks]

[Handwritten mark]

[Handwritten mark]

[Signature]
ई. मणि राम गेलाल
सचिव

WORKABILITY OF FRESH CONCRETE - COMPACTION FACTOR TEST
IS: 1199 (Part 2): 2018

OBJECTIVE:

This experiment is intended to determine the workability of concrete mix of given proportion by compaction factor test.

APPARATUS:

- A diagram of the apparatus is shown in Fig. 11. It shall consist of the two conical hoppers (A and B) mounted above a cylindrical mould (C). The essential dimensions of the hoppers and mould and distances between them shall be as shown in table below:

S. No.	Detail(see Fig. 11)	Dimension(mm)
i)	Upper hopper, A:	
	a) Top internal diameter	250
	b) Bottom internal diameter	125
	c) Internal height	280
ii)	Lower hopper, B:	
	a) Top internal diameter	230
	b) Bottom internal diameter	125
	c) Internal height	230
iii)	Cylinder, C:	
	a) Internal diameter	150
	b) Internal height	300
iv)	Distance between bottom of upper hopper and top of lower hopper	200
v)	Distance between bottom of lower hopper and top of cylinder	200

- Trowels
- Hand Scoop
- Tamping rod made of steel, having a circular cross-section with a diameter of 16 ± 1 mm, 600 ± 5 mm in length and with rounded ends
- Weighing Balance to weigh up to 50kg, with an accuracy to the nearest 10g.

(Handwritten marks)

(Handwritten marks)

(Handwritten signature)
ई. मणि राम गेलाल
सचिव

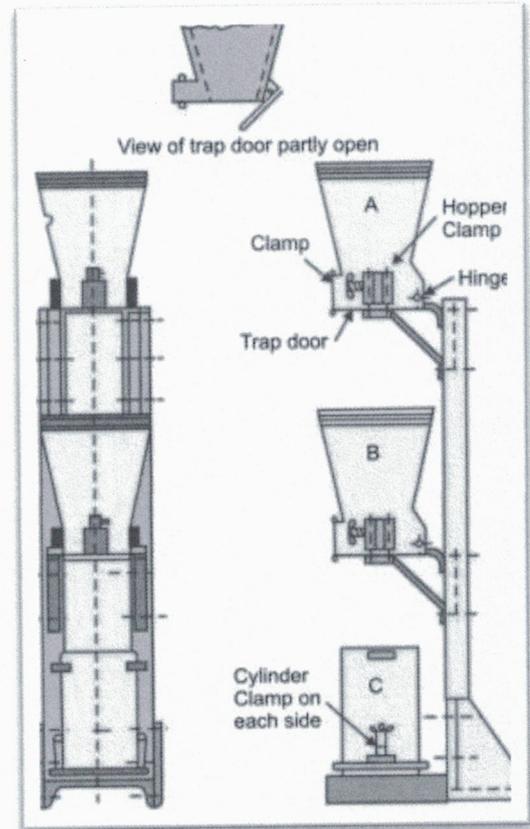


Figure 11: Compacting Factor Apparatus

INTRODUCTION:

Compaction factor test is used for determining the workability of concrete, where the nominal maximum size of the aggregate does not exceed 40 mm. It is used to calculate the degree of workability of fresh concrete with regard to the internal energy required for compacting the concrete perfectly. Compacting factor test works on a principle of determining the degree of compaction achieved by a standard amount of work by allowing the concrete to fall through a standard height. The degree of compaction, called compaction factor is the ratio of the weight of partially compacted concrete to the weight of fully compacted concrete. This test is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability and normally used when concrete is to be compacted by vibration.

PROCEDURE:

~~1~~

~~2~~

~~3~~

27

1/2

~~4~~

ई. मणि राम गेलाल
सचिव

1. Clean and dampen the inside of the hopper and cylinder thoroughly with a moist cloth before commencing the test.
2. Mix coarse and fine aggregates and cement dry until the mixture is uniform in color and then with water until concrete appears to be homogeneous.
3. Place the freshly mixed sample of concrete gently in the upper hopper with a hand scoop.
4. Fill up the upper hopper level with its brim and open the trap door so that the concrete falls into the lower hopper.
5. If the concrete sticks to the side of the hoppers, push it gently with the help of rod from top.
6. Immediately after the concrete comes to rest, uncover the cylinder, open the trap door of the lower hopper and allow the concrete to fall into the cylinder, bringing the concrete into standard compaction.
7. Remove the excess concrete from the top of the cylinder with the help of a trowel in each hand, with the plane of the blades horizontal, and moving them simultaneously one from each side across the top of the cylinder, at the same time keeping them pressed on the top edge of the cylinder. Wipe and clean the outside surface of the cylinder.
8. Determine the weight of the concrete in the cylinder to the nearest 50g. This weight is known as weight of **partially compacted concrete**.
9. Refill the cylinder with concrete from the same sample in layers approximately 5 cm deep, layers being heavily rammed or preferably vibrated (filling it in 3 layers and each layer compacted by giving 25 blows using the tamping rod) to obtain full compaction.
10. The top surface of fully compacted concrete is carefully struck off level with top of the cylinder.
11. Clean up the outside of the cylinder and determine the weight of concrete to the nearest 50 g. This is known as weight of **fully compacted concrete**.

PRECAUTION:

- The top hopper must be filled gently.
- The mix should not be pressed or compacted in the hopper.
- If the concrete in the hopper does not fall through when the trap door is released, it should be freed by passing a metal rod. A single steady penetration will usually affect release.
- To obtain strictly comparable results, the test should be carried out at a constant time interval after the mixing is completed. The convenient time for

releasing the concrete from the upper hopper has been found to be 2 minutes after the completion of mixing.

OBSERVATION:

S. No.	Description	Sample 1	Sample 2	Sample 3
1	Weight of Empty Cylinder (W1)			
2	Weight of Empty Cylinder + Free Fall Concrete(W2)			
3	Weight of Empty Cylinder + Hand Compacted Concrete (W3)			
4	Weight of Partially Compacted Concrete(WP = W2 - W1)			
5	Weight of Fully Compacted Concrete(WF = W3 - W1)			
6	Compaction Factor = WP/ WF			

CALCULATION:

The compacting factor, Fc can be calculated as follows:

The compacting factor = $\frac{\text{"weight of partially compacted concrete", } W_p}{\text{"weight of fully compacted concrete", } W_f}$

It shall normally be stated to the nearest second decimal place.

[Handwritten marks]

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

[Handwritten signature]
ई. मणि राम गेलाल
सचिव

WORKABILITY OF FRESH CONCRETE – FLOW TABLE TEST

IS: 1199 (Part 2): 2018

OBJECTIVE:

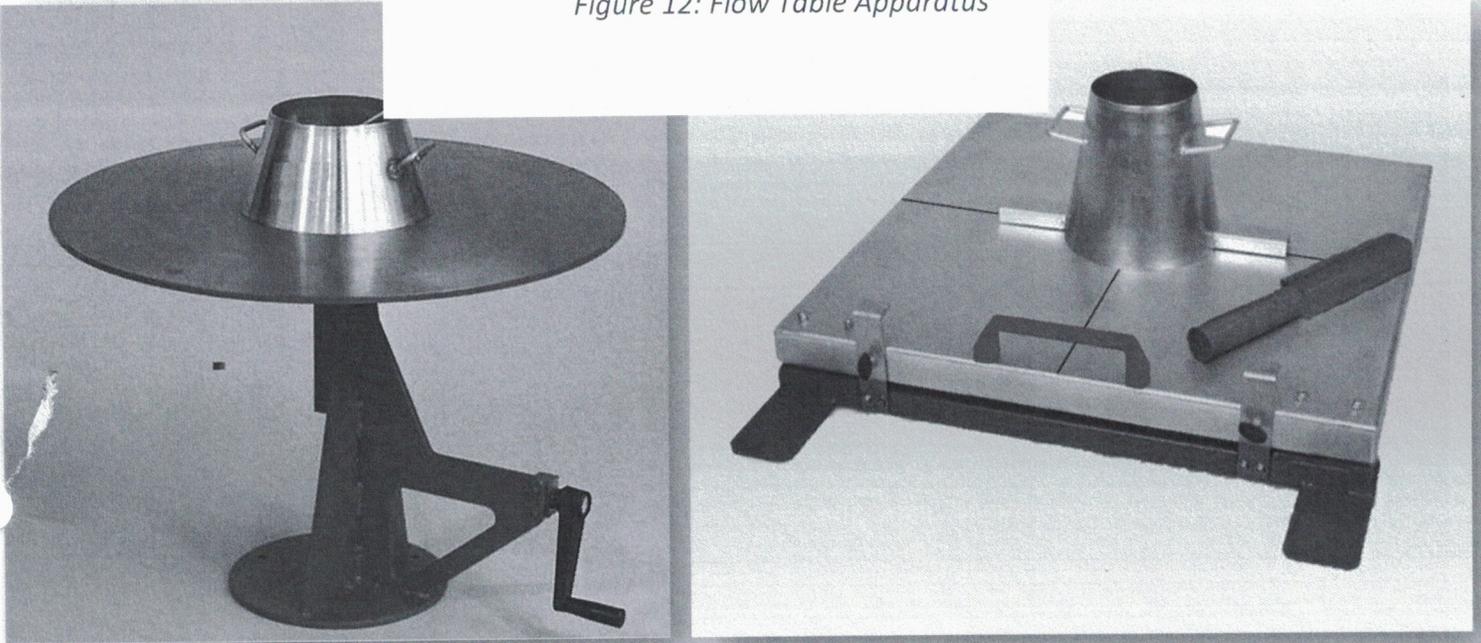
This experiment is intended to determine the consistency of fresh concrete by measuring the spread of concrete on a flat plate subject to jolting.

The flow test is applicable to a range of consistency of concrete that corresponds to flow values between 340 mm and 620 mm. Outside this range, the measurement of flow may be unsuitable and other methods of determining the consistency should be considered. If the concrete segregates during the test, this test is not suitable.

APPARATUS:

- Flow Table
The flow-table shall be constructed in accordance with Fig. 12. It shall consist of a flat plate with a plan area of 700 ± 2 mm \times 700 ± 2 mm, on which concrete can be placed, hinged to a rigid base onto which it can fall from a fixed height
- Mould in the form of a hollow frustum of a cone and shall have the following internal dimensions:
 - a) Diameter of a base: 200 ± 2 mm
 - b) Diameter of top: 130 ± 2 mm
 - c) Height: 200 ± 2 mm
- Tamping Bar made of hardwood or other non-absorbing hard material having a square section of 40 ± 1 mm and a length of at least 200 mm. A further 120 mm to 150 mm shall be extended to a circular section to form a handle to the bar
- Scoop, of adequate size
- Sampling tray, with minimum dimensions 900 mm \times 900 mm \times 50 mm deep, of rigid construction and made from non-absorbent material not readily attacked by cement paste.
- Shovel, with a square blade.
- Rule, with a minimum length of 700 mm, having at least 5 mm subdivisions along its entire length.
- Timer, with accuracy up to 1 s.

Figure 12: Flow Table Apparatus



INTRODUCTION:

The word “workability” or workable concrete signifies much wider and deeper meaning than the other terminology “consistency” often used loosely for workability. Consistency is a general term to indicate the degree of fluidity or the degree of mobility. Flow table test is used to determine the fluidity of concrete, where the nominal size of the aggregate does not exceed 40 mm. This test is appropriate for concrete of high and very high workability including flowing concrete which would exhibit a collapse slump. Flow table test of concrete also determines the quality of concrete concerning its consistency, cohesiveness and the proneness to segregation. It determines the consistency of fresh concrete by measuring the spread of concrete on a flat plate which is subjected to jolting.

[Handwritten marks]

[Handwritten signature]

[Handwritten initials]

[Handwritten signature]
ई. मणि राम गेलाल
सचिव

PROCEDURE:

1. Place the flow-table on a flat horizontal surface free from external vibration or shock. Ensure that the hinged top of the table can be lifted to the correct limit of its travel and is then free to fall to the lower stop. Check that the table is supported such that, when the top of the table falls to lower stop, there is a minimal tendency for the top to bounce.
2. Clean the table and mould and dampen immediately prior to testing, but keep them free from excessive moisture. Ensure that the contact blocks are clean.
3. Place the mould centrally on the tabletop and hold it in position by standing on the two foot pieces, or by the use of magnets.
4. Fill the mould with the concrete in two equal layers using scoop, and tamp each layer lightly 10 times with the tamping bar. If necessary, add more concrete to the second layer to maintain an excess above the top of the mould.
5. With the tamping bar, scrap off the concrete level with the upper edge of the mould and clean any excess concrete off the free area of the tabletop.
6. Wait 30 s after scraping of the concrete, then slowly raise the mould vertically by the handle over a period of 5 ± 2 s. While the operator stabilizes the flow-table by standing on the toe board at the front of the table, slowly raise the tabletop until it reaches to the upper stop in such a manner that the tabletop does not impact hard against the upper stop.
7. Then allow the tabletop to fall freely to the lower stop. Repeat this cycle to give a total of 15 drops, each cycle taking not less than 1 s nor more than 3 s.
8. Measure with the rule the maximum dimension of the concrete spread in the two perpendicular directions, **d1 and d2**, parallel to the table edges and record each measurement to the nearest 10 mm.
9. Check the concrete spread for segregation. The cement paste can segregate from the coarse aggregate to give a ring of paste extending several millimeters beyond the coarse aggregate. Report that segregation has occurred and the concrete was therefore unsatisfactory.



32



ई. मणि राम गोलाल
सचिव

PRECAUTION:

- The material for moulding each batch of test specimen shall be mixed separately.
- Tamping pressure must be sufficient to ensure uniform filling of the mould.
- The mould & flow table must be kept clean, dry & free from sticking concrete.
- The contact faces of the flow table top, supporting frame and the vertical shaft should be lubricated with light oil.

CALCULATION:

Determine the flow value $(d1 + d2)/2$ and record to the nearest 10 mm.

~~10~~ 10 10 10

✓

ई. मणि राम गेलाल
सचिव

SETTING TIME OF CONCRETE BY PENETRATION RESISTANCE

IS: 1199 (part 7): 2018

OBJECTIVE:

This experiment is intended to determine the setting time of concrete with slump greater than zero, by testing mortar sieved from the concrete mixture. The initial setting time and the final setting time are the time intervals required for the mortar sieved from the concrete mixture to reach the specified values of penetration resistance measured from the initial contact of cement and water.

PRINCIPLE:

The mortar sample is obtained by sieving a representative sample of fresh concrete. The mortar sample is placed in a container and stored at a specified ambient temperature. At regular time intervals, the resistance of the mortar to penetration by standard needles is measured. From a plot of penetration resistance versus elapsed time, the time of initial and final setting are determined.

APPARATUS:

- Containers for Mortar Specimens- cylindrical or rectangular in cross-section, with minimum lateral dimension 150 mm and height at least 150 mm. The container for the mortar from the concrete mixture shall provide enough mortar surfaces for ten undisturbed readings of penetration resistance in accordance with clear distance requirements.
- Penetration Resistance Apparatus- spring reaction type apparatus, graduated from 50 N to 600 N in increments of 10 N or less; or hydraulic reaction type apparatus with pressure gauge of 700 to 900 N capacity, graduated in increments of 10 N or less.

Indications of actual needle loads by these apparatus shall be accurate to 10 N. Removable needles of 645, 323, 161, 65, 32, and 16 mm² bearing areas shall be provided. Each needle shank shall be scribed peripherally at a distance of 25 mm above the bearing face. The length of the 16 mm² needle shall be not more than 90 mm to minimize bending. The apparatus shall be recalibrated periodically.

- Pipette
- Tamping rod- of circular cross-section, straight, made of steel, having a diameter of 16 ± 1 mm, a length of 600 ± 5 mm and having rounded ends.

- Thermometer, capable of measuring the temperature of the fresh mortar to an accuracy of 0.5°C. Glass thermometers having a temperature range from 0°C to 100°C or other thermometers of the required accuracy, including the metal immersion type, are acceptable.



Figure 13: Penetration Resistance Apparatus

~~Handwritten mark~~

~~Handwritten mark~~

Handwritten mark

Handwritten mark

BV

Handwritten signature

INTRODUCTION:

Concrete has a limited lifespan between batching/ mixing and curing meaning a certain time is required for mixing, transportation and placing for any construction work dealing with concrete. Setting of concrete is identified as the transition of fresh concrete from liquid phase to solid phase. So, it is important to identify this phase change to plan transporting and placing of concrete before the setting of concrete starts to hold plasticity and slump. Setting time can be defined as the time interval required for the mortar sieved from the concrete mixture to reach the prescribed penetration resistance after the initial contact of cement and water. For convenience, **initial setting time** is the time elapsed after initial contact of cement and water, required for the mortar (sieved from the concrete) acquires a penetration resistance of 3.5 MPa. Similarly, **final setting time** is the time elapsed after initial contact of cement and water, required for the mortar (sieved from the concrete) to reach a penetration resistance of 27.6 MPa.

PROCEDURE:

Preparation and Storage of Mortar Specimens:

- a) From the concrete mixture under test, select a representative sample of concrete of sufficient volume to provide enough mortar to fill the test container, or containers, to a depth of at least 140 mm. Remove all the mortar from the sample of concrete by sieving it through a 4.75mm IS sieve onto a non absorptive surface.

- b) Thoroughly mix the mortar manually on the non absorptive surface. Measure and record the temperature of the mortar. Place the mortar in the container, or containers, in a single layer. Compact the mortar to eliminate air pockets in the specimen and level the top surface. This may be accomplished by rocking the container back and forth on a solid surface, or by tapping the sides of the container. Sieved mortar is generally of fluid consistency and air pockets are readily removed by this method of compaction.

For stiffer mortars, alternative method as given below, by tamping with the tamping rod, shall be followed.

Place the mortar in the container(s) in layers of 50 mm each, and compact by tamping each layer. Tamp the mortar once for each 6.5 cm² of top surface area of the specimen and distribute the strokes uniformly over the cross-section of the specimen. After completion of the tamping, tap the sides of the containers lightly with the tamping rod to remove voids left by the tamping rod and to further level the surface of the specimen.



36



ई. मणि राम गेलाल
सचिव

Upon completion of specimen preparation, the mortar surface shall be at least 13 mm below the top edge of the container to provide space for the collection and removal of bleeding water and to avoid contact between the mortar surface and the protective covering.

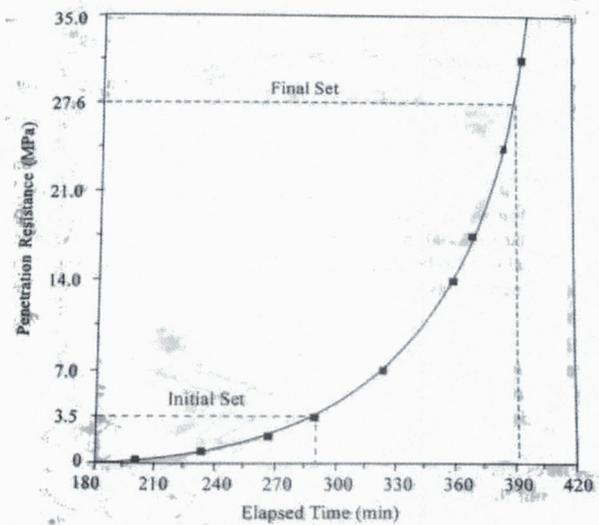
Testing Procedure:

- a) Remove bleed water from the surface of the mortar specimens just prior to making a penetration test by means of a pipette or a suitable instrument. To facilitate the collection of bleeding water, tilt the specimen carefully to an angle of about 10° from the horizontal by placing a block under one side 2 min prior to removal of the water.
- b) Insert a needle of appropriate size, depending upon the state of hardening of the mortar, in the penetration resistance apparatus and bring the bearing surface of the needle into contact with the mortar surface. Gradually and uniformly apply a vertical force downward on the apparatus until the needle penetrates the mortar to a depth of 25 mm as indicated by the scribe mark. The time required to penetrate to the 25 mm depth shall be approximately 10 s. Record the force required and the time of application, measured as elapsed time after initial contact of cement and water. In subsequent penetration tests take care to avoid areas where the mortar has been disturbed by previous tests. The clear distance between two needle impressions shall be at least two diameters of the needle being used, but not less than 13 mm. The clear distance between any needle impression and the side of the container shall be not less than 25 mm.
- c) Make penetration tests at hourly intervals for normal mixtures and normal temperatures, the initial test being made after an elapsed time of 2 to 3 h. For accelerated mixtures or high temperatures, it may be advisable to make the initial test after an elapsed time of 1 or 2 h and subsequent tests at 30 min intervals. For low temperature conditions or retarded concrete mixtures, the initial penetration test may be deferred for an elapsed time of 4 to 6 h and perhaps longer. Subsequent tests may be made at intervals of 1 h, unless the rate of increase in penetration resistance indicates that shorter intervals are desirable.
- d) Not less than six penetrations shall be made in each rate of hardening test and the time intervals between penetration resistance determinations shall be such as to give a satisfactory rate of hardening curve, as indicated by equally spaced points. Continue the tests until a penetration resistance of at least 27.5 MPa is reached.

इ. मणि राम गेलाल
सचिव

Plotting of Graph:

- Plot a graph of penetration resistance (MPa) as ordinate and elapsed time (hours and minutes) as abscissa using a scale such that 3.5 MPa (N/mm²) and 1 hour are represented by not less than 15 mm.
- Plot the penetration resistance values on the graph and connect various points by a smooth curve.



Determination of Initial and Final Setting Time from the Graph:

- From the penetration resistance equal to 3.5 MPa, draw a horizontal line. The point of intersection of this with the smooth curve is read on the x-axis which gives *initial setting time*.
- Similarly, a horizontal line is drawn from the penetration resistance of 27.5 MPa and point it cuts the smooth curve is read on the x-axis which gives the *final setting time*.
- Time of setting shall be reported in hours and minutes to the nearest minutes.

CALCULATION:

Calculate the penetration resistance in MPa, as the force required to cause a 25 mm depth of penetration of the needle divided by the area of the bearing face of the needle.

[Handwritten marks]

[Handwritten mark]

[Handwritten mark]

ई. मणि राम गेलाल
सचिव

COMPRESSIVE STRENGTH OF CEMENT CONCRETE IS: 516 - 1959

OBJECTIVE:

This experiment is intended to determine the compressive strength of cubic concrete specimens.

APPARATUS:

- Compression Testing Machine
- 150 mm Cube Moulds
- Trowel
- Tamping rod- The tamping bar shall be a steel bar 16 mm in diameter, 0.6 m long and bullet pointed at the lower end.
- Weighing Balance

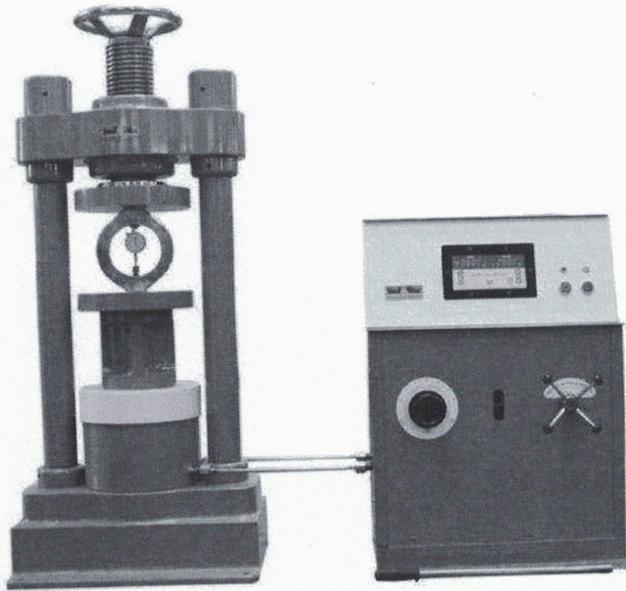


Figure 14: Compression Testing Machine



Figure 15: Cube Mould

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

INTRODUCTION:

Compressive strength of concrete is defined as the resistance to failure under the action of compressive forces. It is the measure of compression force that the material can withstand without undergoing any cracks, breaking and fissure. The compressive strength of hardened concrete is the most crucial property as it controls the mix design and is an important parameter to determine the performance of the material during service conditions. It depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during the production of concrete, etc.

The compressive strength of concrete is given in terms of the characteristic compressive strength of 150 mm size cubes tested at 28 days (fck). The characteristic strength is defined as the strength of the concrete below which not more than 5% of the test results are expected to fall.

PROCEDURE:

1. Sampling of Materials:

Samples of aggregates for each batch of concrete should be of the desired grading and shall be in an air-dried condition. The cement samples, on arrival at the laboratory, should be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material. Maximum nominal size of aggregate does not exceed 38mm.

2. Proportioning:

The proportions of the materials, including water, in concrete mixes used for determining the suitability of the materials available, should be similar in all respects to those to be employed in the work.

3. Weighing:

Weigh the quantities of cement, each size of aggregate, and water for each batch to an accuracy of 0.1 percent of the total weight of the batch.

4. Mixing Concrete:

Mix the concrete either by hand or in a laboratory batch mixer in such a manner as to avoid loss of water or other materials and each batch of concrete

40

ई. मणि राम गेलाल
सचिव

should be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.

● **Machine Mixing:**

- a) Wet the inner surfaces of the drum of concrete mixer with water.
- b) When the mixing drum is charged by a power loader, all the mixing water shall be introduced into the drum before the solid materials; the skip shall be loaded with about one-half of the coarse aggregate, then with the fine aggregate, then with the cement and finally with the remaining coarse aggregate on top. (If all-in-aggregate is used, the skip shall be loaded first with about one-half of the aggregate then with the cement and finally with the remaining aggregate on top.)

Where the mixing drum is hand-loaded it shall be charged with the dry materials in a similar manner, and the water shall be added immediately before the rotation of the drum is started.

- c) The period of mixing shall be not less than 2 minutes after all the materials are in the drum, and shall continue till the resulting concrete is uniform in appearance.

● **Hand Mixing:**

- a) Mix the cement and fine aggregate on a watertight none-absorbent platform until the mixture is thoroughly blended and is of uniform color.
- b) Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.
- c) Add water and mix it until the concrete appears to be homogeneous and of the desired consistency.

5. Clean the moulds properly and oil the interior faces of the mould so that concrete will not stick into the mould and make latter cleaning difficult. Fill the concrete into the mould in layers approximately 5 cm deep by moving the scoop around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete within the mould.



41



ई. मणि राम गेलाल
सचिव

6. Compaction:

If compaction is done by hand, tamp the concrete with the standard rod, strokes being uniformly distributed over the cross-section of the mould. For 15 cm cube, number of strokes should not be less than 35 per layer and 25 strokes for 10 cm cubes. Strokes should penetrate into the underlying layer. Tamp the sides of the mould to close the voids left by tamping bars.

If compaction is done by vibration, then each layer is compacted by means of suitable vibrating hammer or vibrator or vibrating table. Mode and quantum of vibration of laboratory specimen shall be as nearly the same as those adopted in actual operations.

7. Curing:

Store the test specimen in a place, free from vibration, in moist air of at least 90 percent relative humidity and at a temperature of $27^{\circ} \pm 2^{\circ}$ C for 24 hours \pm 1/2 hour from the time of addition of water to the dry ingredients. Mark and remove the specimen from the mould and keep it immediately submerged in clean, fresh water and keep there until taken out just prior to test. Water in which specimen is submerged shall be renewed every seven days.

8. Test for Compressive Strength:

- a) *Age at test:* Usually testing is done after 7 days and 28 days, the days being measured from the time the water is added to the dry ingredients.
- b) Test at least three specimens at a time.
- c) Test specimens stored in water immediately after removal from the water while they are still in the wet condition. If the specimens are received dry, keep them in water for 24 hours before testing.
- d) Note down the dimensions of the specimens nearest to 0.2 mm and also note down their weight.







ई. मणि राम गोलाल
सचिव



9. Placing Specimen in the Testing Machine:

- a) Wipe clean the bearing surfaces of the testing machine and remove any loose sand or other materials from the surfaces of the specimen which are to be in contact with the compression platens.
- b) Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast i.e. not to the top and bottom.
- c) Align the specimen centrally on the base plate of the machine.
- d) Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
- e) Apply the load gradually without shock and continuously at the rate of 140 kg/cm²/minute till the cube specimen breaks.
- f) Note down the maximum load and appearance of the concrete and any unusual features in the type of failure i.e. whether aggregate has broken or cement paste has separated from the aggregate, etc.

PRECAUTION:

- See that the load is applied in the center. Even a small eccentricity can cause serious deviations.
- Inside of the cube moulds should be oiled to prevent the mortar from adhering to the sides of the mould.
- The water used for curing should be tested every 7 days and the temperature of water must be at 27°C ± 2°C.
- Note down the dimensions of the specimens nearest to 0.2 mm and also note down their weight.

OBSERVATION:

S. No	Age of Cube	Cross Sectional Area(mm ²)	Load (N)	Compressive Strength (N/mm ²)	Avg. Compressive Strength (Mpa)
1	3 days				
2					
3					
4	7 days				
5					
6					
7	28 days				
8					
9					

CALCULATION:

The compressive strength is calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area and reported to nearest kg/cm². The average of three values is taken as the representative of the batch provided the individual variation is not more than ± 15 percent of the average

$$\text{Compressive Strength} = \frac{\text{Maximum load applied to the cube}}{\text{Cross-sectional area of the cube}}$$








ई. मणि राम गेलाल
सचिव



TESTS ON AGGREGATES


ई. मणि राम गेलाल
सचिव

SAMPLING TECHNIQUE OF AGGREGATES

Sampling is perhaps the most important step in assuring that good quality aggregates are being used. Since a sample is just a small portion of the total material, the importance that the sample be representative of the material being delivered cannot be overemphasized. Any test performed on the sample, regardless of how carefully and accurately performed, is worthless unless the sample is truly representative of the material offered for use on the project.

Safety

The sampling of materials can expose the technician to machinery, moving belts, large stockpiles, and other potential dangers. Proper safety practices are always the first concern. When not sure of safety the technician should stop and seek the supervisor's instructions.

Sampling References

A representative sample can be obtained by following the standard procedures detailed in the latest edition of AASHTO T2 and ITM 207, "Method of Sampling Stockpile Aggregate."

Size of Original Sample

The key to any sample program is to obtain a representative sample. A standard sampling method must be followed to obtain uniform samples.

Sample Type

The technician should realize there are different types of samples. The most common sample is a stockpile sample. Some samples need to be taken by the Producer in the processing operation to assure that the final product will be within control limits. These samples are referred to as production samples. The gradation at this point may not be the same as the stockpile sample at some facilities. Occasionally, an investigative sample should be obtained by the Producer when looking for a very specific feature, such as a certain sieve, oversized material, etc. These tests may consist of many shortcuts and should only be used as a quick comfort level check. Every source can have other types of samples which are unique to their operation.

ई. मणि राम गेलाल
सचिव

Method of Sampling

Due to the various sampling locations and the availability of equipment, there are several methods of taking aggregate samples. Uniformity of obtaining the sample cannot be emphasized enough, since it eliminates one variable in test results. The technician must remember that safety comes first.

BIN SAMPLE

Sampling the top of the bin is extremely dangerous as well as a difficult, if not impossible, method to obtain a representative sample. For this reason, this method of sampling is undesirable.

Discharge Sampling of Bins or Belts

Bin samples can be taken at the discharge chute. In these cases a number of small samples should be taken at short intervals and combined to make the total sample. Each of these samples must include the entire cross section of the flow of material from the chute or belt. Continuity of operation normally will not allow the technician to control the rate of flow from the discharge chute to allow these samples to be taken easier. A mechanical diversion or slide chute system is the quickest, safest, and most accurate system for taking a belt sample; unfortunately very few mechanical systems exist.

Belt Sampling

Belt sampling consists of taking samples of materials directly from conveyor belts. The proper procedure is to:

1. Make sure that the belt is carrying a normal load of material that is not segregated.
2. Have the plant operator stop the belt, and use proper lock out procedures;
3. Take a complete cross section of the material, being careful to include all the material on the belt and only the material in the section. A template is recommended, especially on steeply inclined belts. Remove most of the sample with a scoop or shovel and the remainder with a brush; and
4. Take as many complete cross sections as necessary to obtain a sample that meets the minimum sample size.

ई. मणि राम गेलाल
सचिव

STOCKPILE SAMPLING

a) Coarse Aggregate Stockpiles

Coarse aggregates are recommended to be sampled using ITM 207. A summary of the procedure includes the following:

- i. Locate the area of the stockpile from which hauling will begin.
- ii. Using a front-end loader, dig into the stockpile and set aside a small pile of 10 to 15 t of material. This should be done in the same manner as if a truck is being loaded for shipment (Figs. 16). When forming the small pile, the loader bucket should be as low as possible, and the operator should roll the material from the bucket rather than dumping the material. Reducing the distance the material is allowed to free-fall will reduce the amount of segregation that may occur in the small pile. Each additional bucket load of material should be taken and dumped in the same manner as set out above, and should be placed uniformly over the preceding one. (Fig. 16).
- iii. Thoroughly mix the small pile. Using the loader bucket, go to the end of the oblong pile and roll the material over. Keeping the loader bucket as low as possible, push the bucket into the material until the front of the bucket passes the midpoint of the original pile. The loader bucket should then be slowly raised and rolled forward thus producing a smooth mixing of the material. (Fig. 16). Go to the opposite end of the pile, and repeat this mixing procedure. If the pile does not appear to be reasonably uniform, additional mixing should be done.
- iv. The pile is now ready for sampling. Do not strike off the top (Fig. 20). The sample will be taken at the center of the volume which is approximately one-third of the height of the pile. The sample shall consist of not less than 6 full shovels of material taken at equal increments around the pile (Fig. 17). The shovel shall be inserted full-depth horizontally into the material and raised vertically. Care should be taken to retain as much of the material as possible on the blade of the shovel (Fig. 17).

ई. मणि राम गेलाल
सचिव



Figure 16: Stockpile of Sample by Wheel Loader and Truck

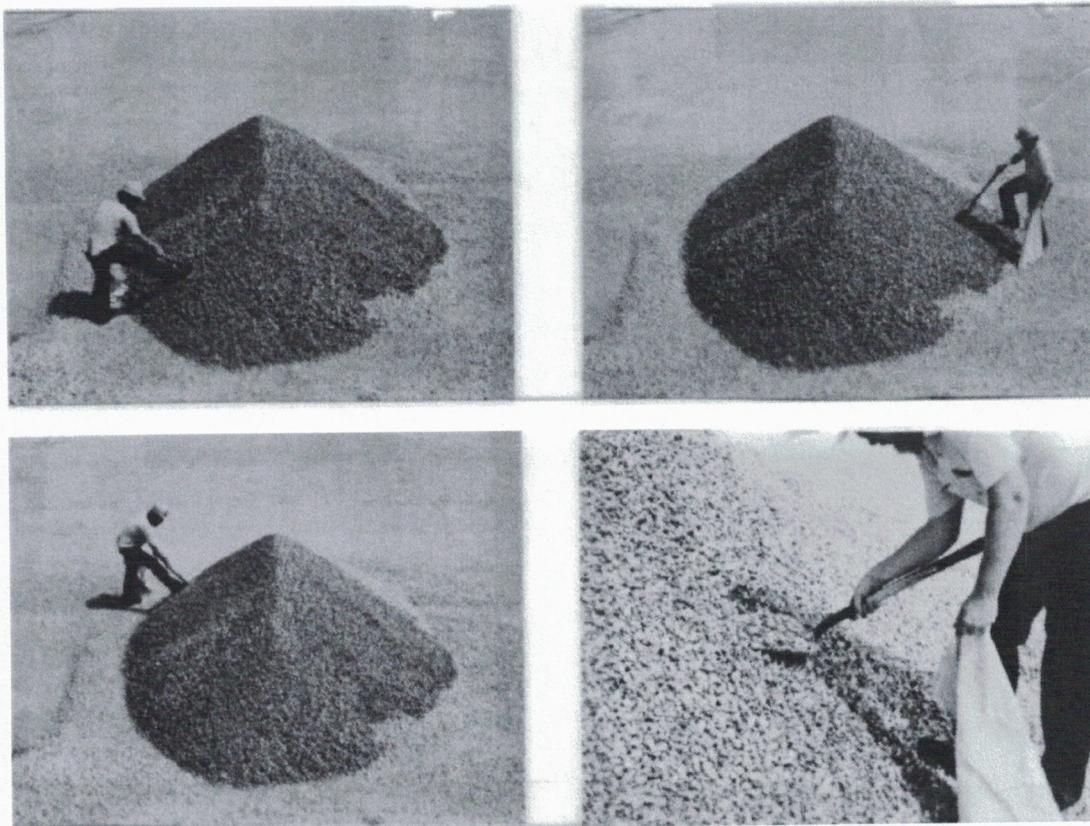


Figure 17: Aggregate Sampling from the Stockpiles

[Handwritten signatures]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

ई. मणि राम गेलाल
सचिव

b) Fine Aggregate Stockpiles

Fine aggregate samples normally are obtained in the same method as coarse aggregate samples, except a fire shovel or sampling tube is used to collect the material.

Sampling Directly from Trucks

Direct sampling from the truck is not recommended. There are a number of factors that may influence the gradation of the material, such as segregation or particle breakdown during loading, transporting, and unloading. Therefore, material being shipped by trucks should be sampled at the point of delivery.



GRADATION ANALYSIS OF AGGREGATES

IS: 2386 (Part I) – 1963

OBJECTIVE:

This experiment is intended to determine the particle size distribution in a sample of aggregates.

APPARATUS:

- IS sieves:
 - Types: Square hole, perforated plate
 - Seive Designations: 80mm, 63mm, 50mm, 40mm, 31.5mm, 25mm, 20mm, 16mm, 12.5mm, 6.3mm, 4.75mm
 - Types: Fine mesh, wire cloth
 - Seive Designations: 3.35mm, 2.36mm, 1.18mm, 600micron, 300micron, 150micron, 75micron
- Weighing Balance: The balance or scale shall be such that it is readable and accurate to 0.1 percent of the weight of the test sample.
- Sieve shaker
- Metal trays
- Scoop
- Brush



Figure 18: Sieve Pans

(Handwritten marks)

(Handwritten mark)

(Handwritten mark)

(Handwritten mark)

(Handwritten signature)
ई. मणि राम गेल
सचिव

INTRODUCTION:

In the making of concrete, the coarse aggregates used are of varying sizes. This distribution of particle sizes of the coarse aggregates is termed as gradation of aggregates. The sieve analysis of these particles is done in order to determine their corresponding particle sizes.

SAMPLE:*

The minimum weight of the sample that should be taken in order to conduct this sieve analysis is provided below:

Maximum size of aggregate present in substantial proportions(mm)	Minimum weight of sample taken for testing(kg)
63	100
50	100
40	50
25	50
20	25
16	25
12.5	12
10	6
6.3	3

PROCEDURE:

1. Take the minimum sample and dry the sample at a temperature of 100°C to 110°C.
2. The air-dry sample shall be weighed.
3. All the sieves shall be cleaned thoroughly.
4. The sieves shall be arranged in such a way that the sieve the largest size is kept at the top followed by sieves having lesser sizes and the sample is passed through this setup.
5. If sieving is carried out by hand, the shaking shall be done separately over a clean tray for a period of not less than two minutes. The shaking shall be done with a varied motion, backwards and forwards, left to right, circular clockwise and anti-clockwise, and with frequent jarring so that the material is kept moving over the sieve surface in frequently changing directions. Material smaller than 20 mm should not be helped through the sieve by hand or by brushing. Lumps of fine materials, if present, may be broken by gentle pressure with fingers against the side of the sieve.

6. If the sieving is carried out in a nest of sieves on a machine, then the sieving shall be done for a period of not less than ten minutes for each test.
7. On completion of sieving, the material retained on each sieve, together with any material cleaned from the mesh, shall be weighed.
8. The percentage by weight retained on each sieve shall be calculated and the results shall be given to the nearest 0.1 percent. From these results the cumulative percentage by weight of the total sample passing each of the sieves will be calculated and recorded to the nearest whole number, the results of sieving tests shall be recorded graphically on the chart for recording sieve analysis.
9. The fineness modulus is obtained by adding the cumulative percentage of aggregates retained on each of the dividing standard sieves and dividing by 100. The larger figure of fineness modulus shows that the material is coarser.

OBSERVATION:

IS Sieve (mm)	Wt. of Sample retained (g)	Percentage of wt. retained (%)	Cumulative percentage of wt. retained (%)	Percentage of wt. passing (%)	Remarks

[Handwritten marks and scribbles]

[Handwritten mark]

[Handwritten signature]

DETERMINATION OF SILT CONTENT IN FINE AGGREGATES
IS: 2386 (PART II) - 1963

OBJECTIVE:

This experiment provides the method to determine the silt content present in fine aggregates.

APPARATUS REQUIRED:

- A watertight screw-topped glass jar of dimensions similar to a 1 kg fruit preserving jar
- A device for rotating the jar about its long axis, with this axis horizontal, at a speed of 80 ± 20 rev/min.
- A sedimentation pipette of the Anderson type of approximately 25 ml capacity
- A 1000 ml measuring cylinder
- A scale or balance of capacity not less than 10 kg, readable and accurate to one gram
- A scale or balance of capacity not less than 250 g, readable and accurate to 0.001 g
- A well-ventilated oven, thermostatically controlled, to maintain a temperature of 100°C to 110°C .

INTRODUCTION:

This is a gravimetric method for determining the clay, fine silt and fine dust, which includes particles up to 20 micron. Differences in the nature and density of materials or in the temperature at the time of testing may vary the separation point.

CHEMICALS REQUIRED:

A solution containing 8 g of sodium oxalate per liter of distilled water shall be taken. For use, this stock solution is diluted with distilled water to one tenth (that is 100 ml diluted with distilled water to one liter).







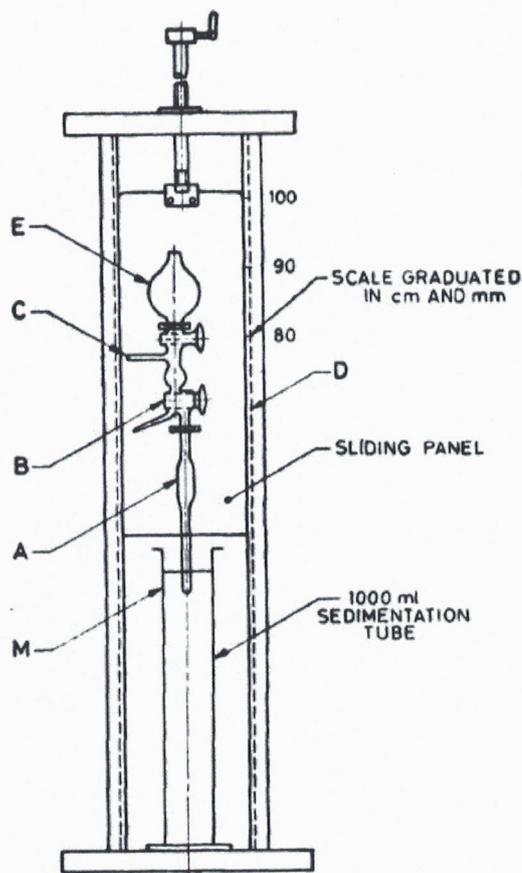


Figure 19: Measuring Cylinder with Scale

PROCEDURE:

1. Approximately 300 g of the sample in the air-dry condition, passing the 4.75-mm IS Sieve, shall be weighed and placed in the screw-topped glass jar, together with 300 ml of the diluted sodium oxalate solution. The rubber washer and cap shall be fixed, care being taken to ensure water tightness.
2. The jar shall then be rotated about its long axis, with this axis horizontal, at a speed of 80 ± 20 rev/min for a period of 15 minutes.
3. At the end of 15 minutes, the suspension shall be poured into the 1000-ml measuring cylinder and the residue washed by gentle swirling and decantation of successive 150-ml portions of sodium oxalate solution, the washings being added to the cylinder until the volume is made up to 1000 ml.
4. The suspension in the measuring cylinder shall be thoroughly mixed by inversion and the tube and contents immediately placed in position under the pipette.

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

5. The pipette A shall then be gently lowered until the tip touches the surface of the liquid, and then lowered a further 10 cm into the liquid.
6. Three minutes after placing the tube in position, the pipette A and the bore of tap B shall be filled by opening B and applying gentle suction at C.
7. A small surplus may be drawn up into the bulb between tap B and tube C, but this shall be allowed to run away and any solid matter shall be washed out with distilled water from E.
8. The pipette shall then be removed from the measuring cylinder and its contents run into a weighed container, any adherent solids being washed into the container by distilled water from E through the tap B.
9. The contents of the container shall be dried at 100°C to 110°C to constant weight, cooled and weighed.

CALCULATION:

The proportion of fine silt and clay or fine dust shall then be calculated from the following formula:

$$\text{Percentage of clay and fine silt or fine dust} = \frac{100}{W_1} \left(\frac{1000W_2}{V} - 0.8 \right)$$

W_1 = weight in g of the original sample,

W_2 = weight in g of the dried residue,

V = volume in ml of the pipette, and

0.8 = weight in g of sodium oxalate in one litre of the diluted solution

DETERMINATION OF BULKING OF SAND IS 2386 (PART III) – 1963

OBJECTIVE:

This experiment provides the method to determine the bulking of the sand.

APPARATUS:

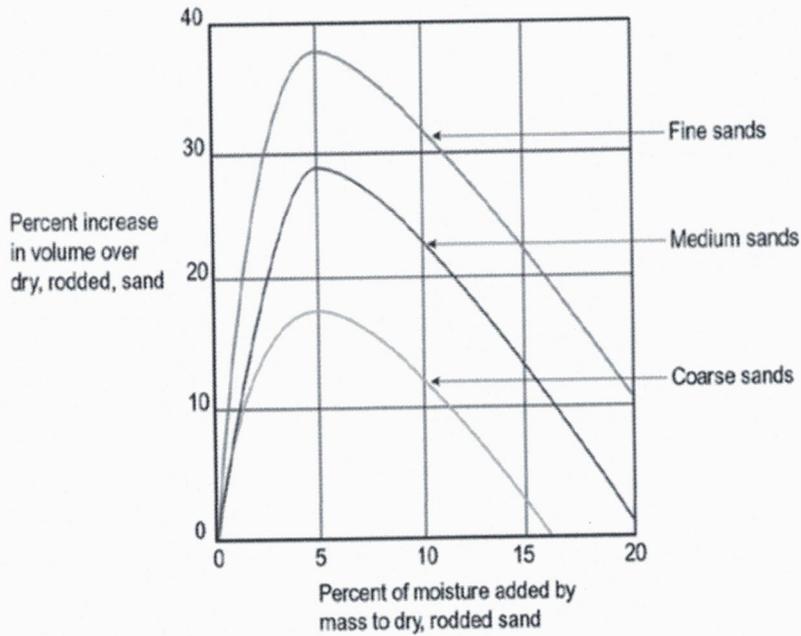
- A measuring jar or any straight sided container
- A ruler
- A steel rod for tamping
- A second container

INTRODUCTION:

Free moisture forms a film around each particle. This film of moisture exerts what is known as surface tension which keeps the neighboring particles away from it. Similarly, the force exerted by surface tension keeps every particle away from each other. Therefore, no point contact is possible between the particles. This causes bulking of the volume. It is interesting to note that the bulking increases with the increase in moisture content up to a certain limit and beyond that the further increase in the moisture content results in the decrease in the volume and at a moisture content representing saturation point, the fine aggregate shows no bulking.



श. मणि राम गेलाल
सचिव



PROCEDURE:

1. Put sufficient quantity of the sand loosely into a container until it is about two-thirds full. Level off the top of the sand and pushing a steel rule vertically down through the sand at the middle to the bottom, measure the height. Suppose this is h cm.
2. Empty the sand out of the container into another container where none of it will be lost. Half fill the first container with water. Put back about half the sand and rod it with a steel rod, about 6 mm in diameter, so that its volume is reduced to a minimum. Then add the remainder of the sand and rod it in the same way. Smooth and level the top surface of the inundated sand and measure its depth at the middle with the steel rule. Suppose this is h_1 cm.

CALCULATION:

The percentage of bulking of the sand due to moisture shall be calculated from the formula:

$$\text{Percentage Bulking} = \left(\frac{h}{h_1} - 1 \right) \times 100$$

[Handwritten marks]

[Handwritten signature]

[Handwritten mark]

[Handwritten mark]

[Handwritten signature]

**DETERMINATION OF SPECIFIC GRAVITY AND WATER
ABSORPTION OF COARSE AGGREGATES
IS 2386 (PART III) – 1963**

OBJECTIVE:

The purpose of this experiment is to determine the specific gravity and the water absorption value of coarse aggregates.

Method I: Aggregate larger than 10mm

APPARATUS:

- Balance having capacity of not less than 3 kg, accurate to 0.5 gm and of such type and shape that it should permit the basket containing the sample to be suspended from the beam and weighed in water
- An oven to maintain a temperature of 100°C to 110°C
- A wire basket of not more than 6.3 mm mesh or perforated container of convenient size preferably chromium plated and polished, with wire hangers not thicker than one millimeter for suspending it from the balance.
- A stout watertight container in which the basket may be freely suspended
- Two dry soft absorbent clothes not each not less than 75*45cm
- A shallow tray of area not less than 650 cm²
- An airtight container of capacity similar to that of basket

PREPARATION OF SAMPLE:

A sample of not less than 2000 gm of the aggregate shall be prepared for testing purpose. Aggregate which have been artificially heated shall not normally be used, if such material is used the fact shall be stated in the report. Two tests shall be made, and it is recommended that the two samples should not be tested concurrently.

A

Q

132

15 ✓
ई. मणि राम गेलाल
सचिव

PROCEDURE:

1. The sample shall be washed properly in order to remove fine particles and dust.
2. Drain the sample and then place in the wire basket to and immerse in distilled water at a temperature between 22°C and 32°C with a cover of at least 5 cm of water above the top of the basket.
3. The entrapped air shall be removed immediately after immersion of the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second. The basket and aggregate shall remain completely immersed during the operation and for a period of 24±1/2 hours afterwards.
4. The basket and the sample shall then be jolted and weighed in water at a temperature of 22°C to 32°C. If necessary for them to be transferred to a different tank for weighing, they shall be jolted 25 times as described above in the new tank before weighing (Weight A1).
5. The basket and the aggregate shall then be removed from the water and allowed to drain for a few minutes, after which the aggregate shall be gently emptied from the basket on to one of the dry cloths and the empty basket shall be returned to the water, jolted 25 times and weighed in water (Weight A2).
6. The aggregate placed on the dry cloth shall be gently surface dried with the cloth, transferring it to the second dry cloth when the first will remove no further moisture. It shall be spread out not more than one stone deep on the second cloth, and left exposed to the atmosphere away from direct sunlight or any other source of heat for not less than 10 minutes or until it appears to be completely surface dry (which with some aggregate may take an hour or more) the aggregate shall be turned over at least once during this period and a gentle current of unheated air may be used after the first ten minutes to accelerate the drying of difficult aggregate. The aggregate shall then be weighed (Weight B).
7. The aggregate shall then be placed in the oven in the shallow tray, at a temperature of 100°C to 110°C and maintained at this temperature for 24±1/2 hours. It shall then be removed from the oven, cooled in the air-tight container and weighed (weighed C).

60

ई. मणि राम गेलाल
सचिव

CALCULATIONS:

The calculation of specific gravity, apparent specific gravity and water absorption shall be done as follow:

$$\text{Specific gravity} = \frac{C}{B-A}$$

$$\text{Apparent specific gravity} = \frac{C}{C-A}$$

$$\text{Water absorption} = \frac{B-C}{C} * 100 \text{ (percent of dry weight)}$$

Where,

A = weight of saturated aggregate in water ($A_1 - A_2$) (g)

A_1 = weight of sample + basket in water (g)

A_2 = weight of basket in water (g)

B = weight of saturated surface dry aggregate in air (g)

C = weight of oven-dried aggregate in air (g)

REPORTING OF RESULTS:

The size of aggregate tested shall be mentioned and whether it has been artificially heated before testing shall be reported.

The observations are reported as below:

S.N.	Specimen No.	Wt. of basket in air (g) A_2	Wt. of sample + basket in water (g) A_1	Wt. of SSD sample in water (g) ($A_1 - A_2$)	Wt. of SSD sample in air (g) B	Wt. of oven dry sample (g) C	Water absorption

Where, SSD = Saturated Surface Dry



Method II: Aggregate between 40mm and 10mm

APPARATUS:

- Balance having capacity of not less than 3 kg, accurate to 0.5 gm and of such type and shape that it should permit the basket containing the sample to be suspended from the beam and weighed in water
- An oven to maintain a temperature of 100°C to 110°C
- Glass vessel or jar – A wide-mouthed glass vessel such as a jar of about 1.5 litres capacity, with a flat ground lip and a plane ground disc of plate glass to cover it, giving a virtually watertight fit.
- Cloths- Two dry soft absorbent cloths, each not less than 75 x 45 cm.
- Tray- A shallow tray of area not less than 650 cm²
- Container- An airtight container of capacity similar to that of basket.

PREPARATION OF SAMPLE:

A sample of not less than one kilogram of the aggregate shall be prepared for testing purpose. Aggregate which have been artificially heated shall not normally be used, if such material is used the fact shall be stated in the report. Two tests shall be made, and it is recommended that the two samples should not be tested concurrently.

PROCEDURE:

1. The sample shall be screened on a 10-mm IS sieve, thoroughly washed to remove fine particles of dust, and immersed in distilled water in the glass vessel; it shall remain immersed at a temperature of 22 to 32°C for 24 ± 1/2 hours. Soon after immersion and again at the end of the soaking period, air entrapped in or bubbles on the surface of the aggregate shall be removed by gentle agitation. This may be achieved by rapid clockwise and anti-clockwise rotation of the vessel between the operator's hands.
2. The vessel shall be overfilled by adding distilled water and the plane ground-glass disc slid over the mouth so as to ensure that no air is trapped in the vessel. The vessel shall be dried on the outside and weighed (weight A).
3. The vessel shall be emptied and the aggregate allowed to drain. Refill the vessel with distilled water. Slide the glass disc in position as before. The vessel shall be dried on the outside and weighed (weight B).

62

ई. मणि राम गोलाल
सचिव

4. The difference in the temperature of water in the vessel during the first and second weighing shall not exceed 2°C.
5. The aggregate shall be placed on a dry cloth and gently surface dried with the cloth, transferring it to a second dry cloth when the first will remove no further moisture. It shall then be spread out not more than one stone deep on the second cloth, and left exposed to the atmosphere away from direct sunlight or any other source of heat for not less than 10 minutes or until it appears to be completely surface dry (which with some aggregates may take an hour or more) The aggregate shall be turned over at least once during this period and a gentle current of unheated air may be used after the first ten minutes to accelerate the drying of difficult aggregates. The aggregate shall then be weighed (weight C).
NOTE-If the apparent specific gravity only is required, the operations described in this step may be omitted.
6. The aggregate shall be placed in the oven in the shallow tray, at a temperature of 100 to 110°C for 24 ± 1/2 hours. It shall then be cooled in airtight container and weighed (weight D).

CALCULATIONS:

The calculation of specific gravity, apparent specific gravity and water absorption shall be done as follow:

$$\text{Specific gravity} = \frac{D}{C - (A - B)}$$

$$\text{Apparent specific gravity} = \frac{D}{D - (A - B)}$$

$$\text{Water absorption} = \frac{C - D}{D} * 100 \text{ (percent of dry weight)}$$

Where,

A = weight in g of vessel containing sample and filled with distilled water,

B = weight in g of vessel filled with distilled water only,

C = weight in g of saturated surface-dry sample, and

D = weight in g of oven-dry sample.


 ई. मणि राम गेलाल
 सचिव

REPORTING OF RESULTS:

The individual and mean results shall be reported. The grading of aggregate tested shall be stated, and whether it has been artificially heated.



ई. मणि राम गेलाल
सचिव

DETERMINATION OF ELONGATION INDEX
IS 2386 (Part I) – 1963

OBJECTIVE:

This experiment is intended to determine the elongation index of the coarse aggregates i.e. the particle shape of the particle.

APPARATUS:

- IS sieves of 63mm, 50mm, 40mm, 31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm
- Weighing balance of having an accuracy of 0.1% of weight of the test sample
- Metal Gauge

The metal gauge shall be of the pattern as shown in figure 20 below with elongated slots. The opening sizes of metal gauge is given in the table below:

Size of aggregates		Thickness gauge size, (0.6 times mean sieve) (mm)	Length gauge size, (1.8 times mean sieve) (mm)
Passing through IS sieve(mm)	Retained on IS sieve(mm)		
63	50	33.90	-
50	40	27.00	81.0
40	25	19.50	58.5
31.5	25	16.95	-
25	20	13.50	40.5
20	16	10.80	32.4
16	12.5	8.55	25.6
12.5	10	6.75	20.2
10	6.3	4.89	14.7

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

[Handwritten signature]
ई. मणि राम गोलाल
सचिव

INTRODUCTION:

Elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four-fifth times (1.8 times or 9/5 times) their mean dimension. This test is not applicable to the particles having the size less than 6.3mm. It is used to determine the shape of the particles. The elongated particles have high surface area to volume ratio, which results in the decrement of workability of the concrete mixes.

PROCEDURE:

1. The sample quantity of aggregate taken shall be minimum of 200 pieces of each fraction to be tested. The sample shall be weighed then.
2. Pass the sample through the IS sieves of 63, 50, 40, 31.5, 25, 20, 16, 12.5, and 10mm.
3. The elongated aggregates are then separated by using the standard length gauge.
4. The weight of the elongated materials retained on the standard length gauge shall be weighed.

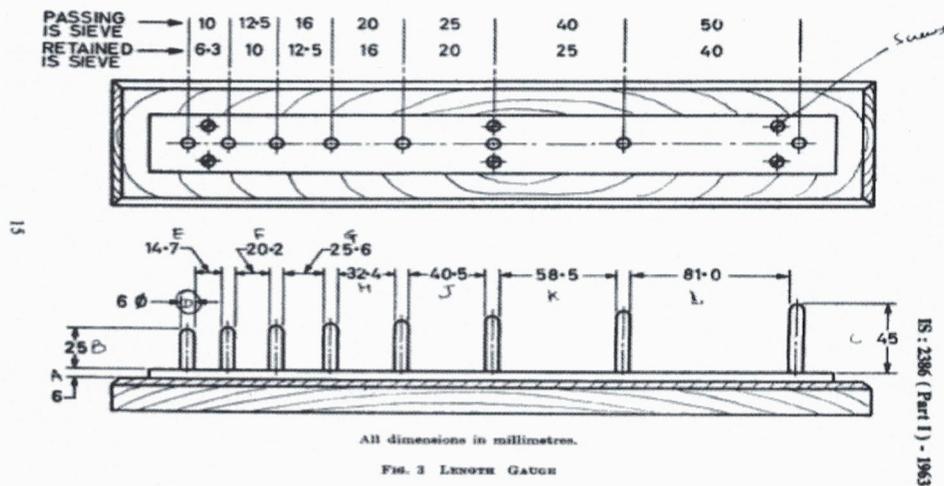


Figure 20: Elongation Apparatus

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]
श. मणि राम गोलाल
सचिव

CALCULATION:

The elongation index (E.I.) is calculated by the formula given below:

$$E.I. = \frac{\text{Weight of aggregate retained on the gauge}}{\text{Total weight of the sample}} * 100$$

REPORTING:

The observations are reported as below:

Size of aggregates		Wt. of fraction containing minimum of 200 pieces (g)	Wt. of aggregate of each fraction retained on length gauge (g)
Passing through IS sieve(mm)	Retained on IS sieve(mm)		
63	50		
50	40		
40	25		
31.5	25		
25	20		
20	16		
16	12.5		
12.5	10		
10	6.3		
Total		$\Sigma W =$	$\Sigma M =$

$$\text{Elongation Index} = \frac{\Sigma M}{\Sigma W} * 100 (\%)$$



ई. मणि राम गेलाल
सचिव

DETERMINATION OF FLAKINESS INDEX
IS 2386 (Part I) – 1963

OBJECTIVE:

This experiment is intended to determine the flakiness index of the coarse aggregates i.e. the particle shape of the particle.

APPARATUS:

- IS sieves of 63mm, 50mm, 40mm, 31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm
- Weighing balance of having an accuracy of 0.1% of weight of the test sample
- Metal Gauge

The metal gauge shall be of the pattern as shown in figure 21 below with elongated slots. The opening sizes of metal gauge is given in the table below:

Size of aggregates		Thickness gauge opening, Width (0.6 times mean width) (mm)	Thickness gauge opening, Length (mm)
Passing through IS sieve(mm)	Retained on IS sieve(mm)		
63	50	33.90	-
50	40	27.00	81.0
40	25	19.50	58.5
31.5	25	16.95	-
25	20	13.50	40.5
20	16	10.80	32.4
16	12.5	8.55	25.6
12.5	10	6.75	20.2
10	6.3	4.89	14.7

[Handwritten initials]

[Handwritten initials]

[Handwritten initials]

[Handwritten initials]

ई. मणि राम गेलाल
सचिव

INTRODUCTION:

Flakiness index is the percentage by weight of particles in it, whose least dimension (i.e. thickness) is less than three-fifths of its mean dimension. This test is not applicable to the particles having the size less than 6.3mm. It is used to determine the shape of the particles. The flaky particles have high surface area to volume ratio, which results in the decrement of workability of the concrete mixes.

PROCEDURE:

1. The sample quantity of aggregate taken shall be minimum of 200 pieces of each fraction to be tested. The sample shall be weighed then.
2. Pass the sample through the IS sieves of 63, 50, 40, 31.5, 25, 20, 16, 12.5, and 10mm.
3. The flaky aggregates are then separated by using the standard flakiness gauge.
4. The weight of the flaky materials passing through the standard flakiness gauge shall be weighed.

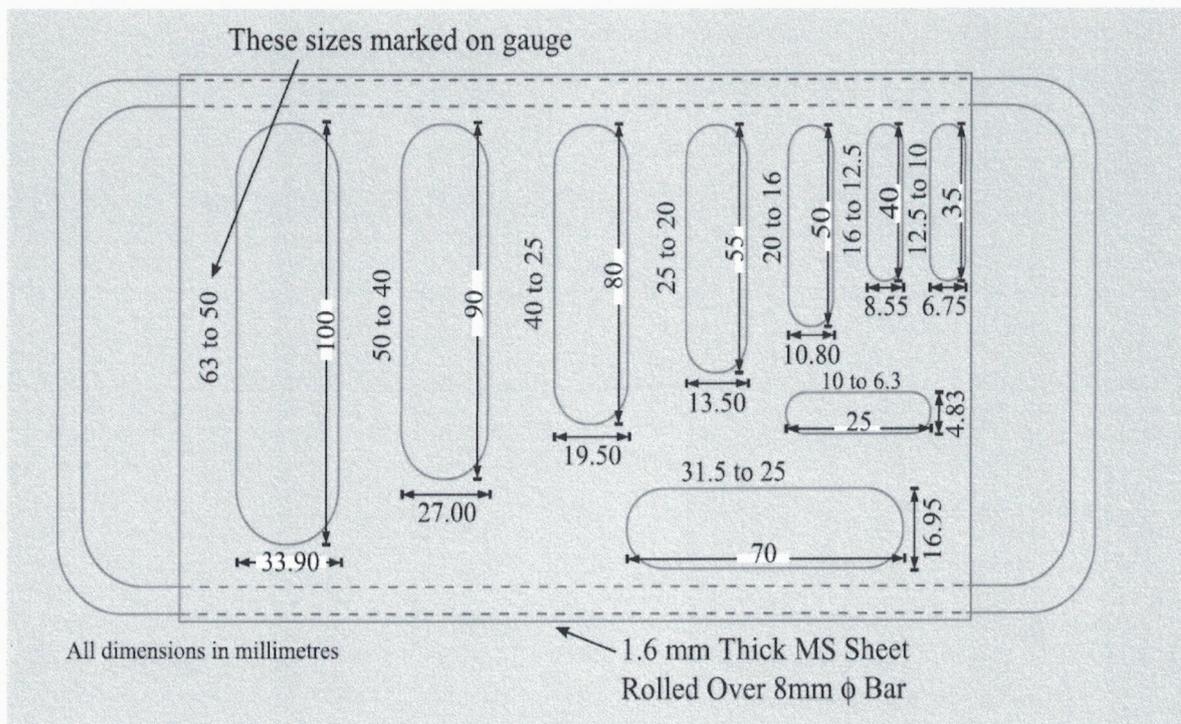


Figure 21: Gauging Trowel

A

Q

M

Q

ई. मणि राय गेलार
सचिव

CALCULATION:

The flakiness index (F.I.) is calculated by the formula given below:

$$F.I. = \frac{\text{Total weight of aggregate passing through flakiness gauge}}{\text{Total weight of the sample}} * 100$$

REPORTING:

The observations are reported as below:

Size of aggregates		Wt. of fraction containing minimum of 200 pieces (g)	Wt. of aggregate of each fraction passing thickness gauge (g)
Passing through IS sieve(mm)	Retained on IS sieve(mm)		
63	50		
50	40		
40	25		
31.5	25		
25	20		
20	16		
16	12.5		
12.5	10		
10	6.3		
Total		$\Sigma W =$	$\Sigma M =$

$$\text{Flakiness Index} = \frac{\Sigma M}{\Sigma W} * 100 (\%)$$



ई. मणि राम गेला
सचिव

DETERMINATION OF AGGREGATE CRUSHING VALUE
IS: 2386 (PART IV) - 1963

OBJECTIVE:

This experiment provides the method to determine the crushing value of the coarse aggregates.

APPARATUS:

- IS sieves of 12.5mm, 10mm and 2.36mm
- A 15cm diameter open ended steel cylinder with plunger and base plate. The surfaces of the cylinder in contact with the aggregates shall be machined and case hardened.
- For measuring the sample, the cylinder with sufficient rigidity to retain its form under rough usage and of the following internal dimensions: diameter = 11.5cm and height = 18cm
- A balance having the capacity of 3 kg having the accuracy up to 1gm.
- A straight metal tamping rod of circular cross-section 16 mm in diameter and 45 to 60 cm long, rounded at one end.
- A compression testing machine capable of applying a load of 40 tons and which can be operated to give a uniform rate of loading so that the maximum load is reached in 10 min.

INTRODUCTION:

The crushing value of the aggregate gives the relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. When the aggregates are subjected to a specified load under the standard conditions, then the percentage by weight of the crushed aggregates obtained is termed as the crushing value of the aggregates. It indicates the strength of the aggregate.

[Handwritten signatures and initials]

[Handwritten signature]
ई. मणि राम गोलाल
सचिव

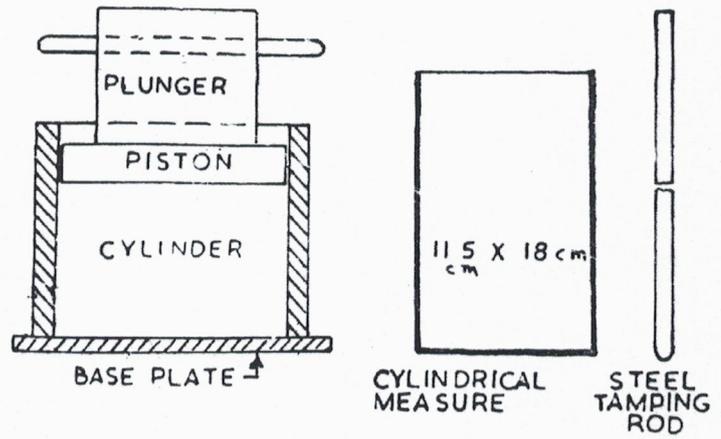


Figure 22: Open Ended Steel Cylinder with Plunger and Base Plate

PREPARATION OF TEST SAMPLE:

1. Prepare the sample such that they pass through 12.5mm IS sieve and are retained on 10mm IS sieve.
2. Test the aggregates on surface dry conditions. If dried by heating, the period of drying shall not exceed 4 hours at the temperature of 100°C to 110°C, and the sample should be cooled to room temperature before testing.
3. The quantity of aggregate shall be such that the depth of material in the cylinder shall be 10cm after tamping.
4. Fill the cylinder in three layers with each layer being tamped 25 times with the rounded end of the tamping rod.
5. Determine the weight of the sample and take the same weight for the repeated testing. (Weight A)

PROCEDURE:

1. Put the cylinder of the test apparatus in position on the base plate.
2. Add the test sample in thirds with each third subjected to 25 strokes of tamping rod.
3. Level the surface of the aggregates such that the plunger inserted rests horizontally on the surface. The plunger shall not jam in the cylinder.
4. Place the apparatus with the test sample and the plunger in position between the platens of the testing machine.

Handwritten signatures and initials.

Handwritten initials and a checkmark.

ई. मणि राम गेलाल
सचिव

5. Apply the total load of 40 tons in a uniform rate such that the total load is reached in 10 minutes.
6. Release the load and remove whole of the material from the cylinder.
7. Sieve the whole removed crushed material on 2.36mm IS sieve for the standard test.
8. Weigh the fraction passing through 2.36mm sieve (Weight B).
9. The surface of the aggregate shall be levelled carefully such that the plunger rests horizontally on the surface when inserted.

CALCULATION:

Calculate the ratio of the weight of fines formed to the total sample weight in each test and express in percentage recorded to the first decimal place.

$$\text{Aggregate Crushing Value} = \frac{B}{A} * 100$$

Where,

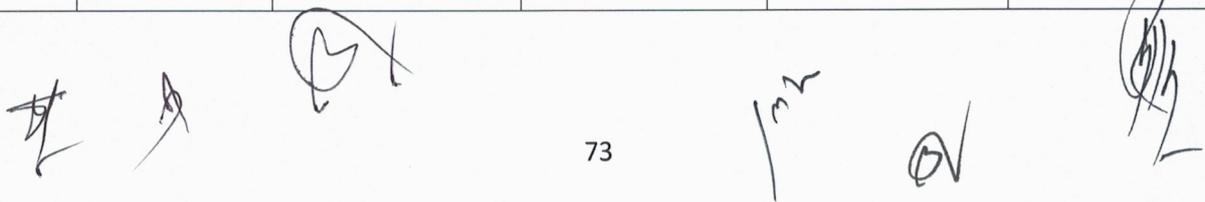
B = weight of fraction passing through appropriate sieve

A = weight of surface-dry sample

REPORTING:

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

S.N.	Wt. of container (g), C	Wt. of surface dry specimen + container (g), A	Wt. of fines passing 2.36mm IS sieve + container (g), B	Crushing strength = $[(B-C)/(A-C)] * 100$	Average Crushing Strength (%)



CONCLUSION:

Aggregate Crushing Value: %

The aggregate crushing value should not be more than 45% for aggregates used for concrete other than for wearing courses, and 30% for concrete used for wearing surfaces such as runways, roads and air field pavements.

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

ई. मणि राम गोलाल
सचिव

Handwritten mark

DETERMINATION OF AGGREGATE IMPACT VALUE
IS: 2386 (PART IV) - 1963

OBJECTIVE:

This experiment is intended to determine the impact value of coarse aggregates in dry condition.

APPARATUS:

- An impact testing machine of the general form and complying with the following:
 - 1) Total weight not more than 60 kg nor less than 45 kg.
 - 2) The machine shall have a metal base weighing between 22 and 30 kg with a plane lower surface of not less than 30 cm diameter, and shall be supported on a level and plane concrete or stone block or floor at least 45 cm thick. The machine shall be prevented from rocking either by fixing it to the block or floor or by supporting it on a level and plane metal plate cast into the surface of the block or floor.
 - 3) A cylindrical steel cup of internal dimensions:
Diameter 102 mm
Depth 50 mm
and not less than 6.3 mm thick with its inner surface casehardened, that can be rigidly fastened at the centre of the base and easily removed for emptying.
 - 4) A metal tup or hammer weighing 13.5 to 14.0 kg, the lower end of which shall be cylindrical in shape, 100.0 mm in diameter and 5 cm long, with a 2-mm chamfer at the lower edge, and case-hardened. The hammer shall slide freely between vertical guides so arranged that the lower (cylindrical) part of the hammer is above and concentric with the cup.
 - 5) Means for raising the hammer and allowing it to fall freely between the vertical guides from a height of 380 ± 5.0 mm on to the test sample in the cup, and means for adjusting the height of fall within 5 mm.
 - 6) Means for supporting the hammer whilst fastening or removing the cup.
- Tamping rod of circular cross-section 10mm in diameter and 230mm long, rounded at one end
- IS sieves of 12.5mm, 10mm and 2.36mm
- Weighing Balance of capacity not less than 500g, accurate to 0.1g

- Oven

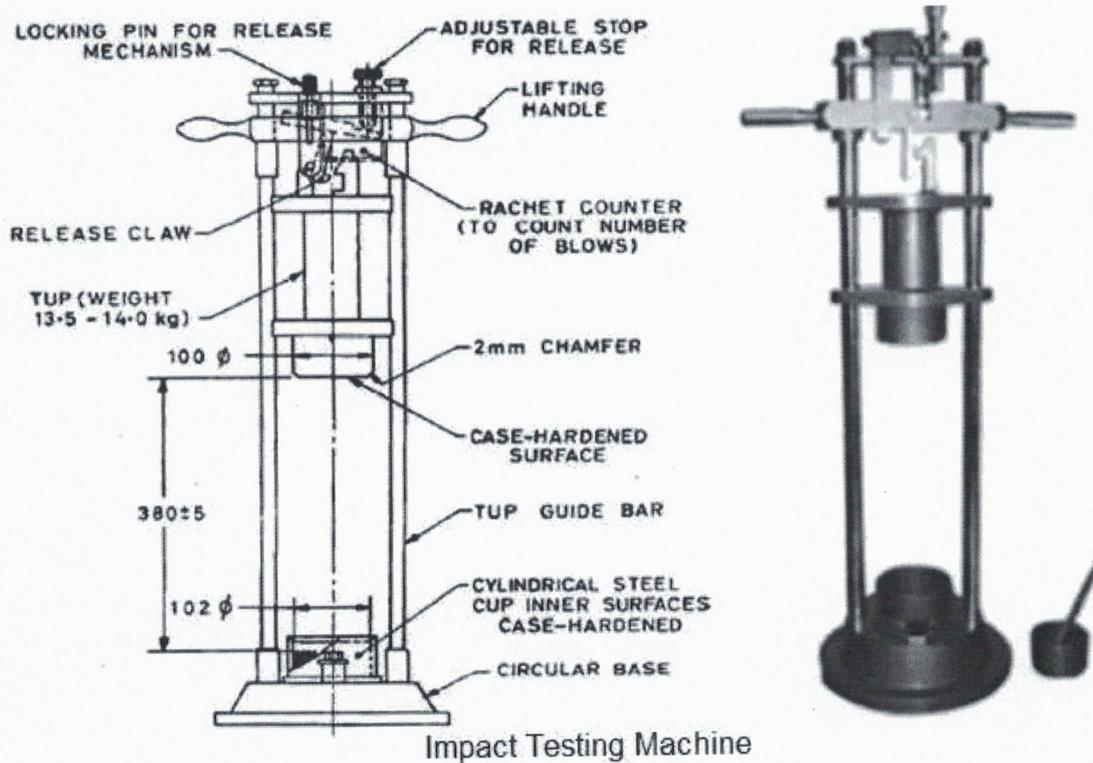


Figure 23: Impact Testing Machine

INTRODUCTION:

The impact value of the aggregates is the relative measure of its resistance to sudden impact or shock. This value may differ to from its resistance to gradually applied compressive load. It is used to assess the resistance of aggregates to disintegration against impact loading.

PROCEDURE:

1. Take the test sample which passes through 12.5m IS sieve and is retained on 10mm IS sieve.
2. Dry the sample in an oven for a period of four hours or till such time that its weight becomes constant at a temperature of 105°C to 110°C. Then, cool the sample.
3. Fill the cylindrical measure by the test sample in three layers by tamping each layer by 25 blows. Determine the net weight of the aggregate in the measure (W_1).

4. Transfer the sample from the measure to the cup of the aggregate impact testing machine and compact it by tamping 25 times.
5. Raise the hammer to the height of 38cm above the upper surface of the aggregate in the cup and allow it to fall freely on the sample.
6. Subject the sample to 15 blows each being delivered at an interval not less than one second and sieve the crushed aggregate on 2.36mm IS sieve.
7. Weigh the fraction passing through the 2.36mm IS sieve (W_2). The fraction passing the sieve shall be weighed to an accuracy of 0.1 g. The fraction retained on the sieve shall also be weighed (Weight W_3) and, if the total weight ($W_2 + W_3$) is less than the initial weight (Weight W_1) by more than one gram, the result shall be discarded and a fresh test made. Two tests shall be made.

CALCULATION:

Aggregate Impact Value (AIV) is given by:

$$AIV = \frac{W_2}{W_1} * 100$$

Where,

W_1 = initial weight of sample

W_2 = weight of crushed sample passing through 2.36mm IS sieve

REPORTING:

Aggregate Impact Value is reported in the table below:

Observation	Test No.			Average
	1	2	3	
Wt. of sample filling in the cylinder = W_1 (g)				
Wt. of aggregate passing through 2.36mm IS sieve after the test = W_2 (g)				
$AIV = (W_2/W_1)*100$				

[Handwritten marks]

[Handwritten mark]

[Handwritten mark]

[Handwritten signature]
 इ. मणि राम गेलाल
 सचिव

CONCLUSION:

Aggregate Impact Value: %

The aggregate impact value should not be more than 45% for aggregates used for concrete other than for wearing surfaces, and 30% for concrete used for wearing surfaces such as runways, roads, and air field pavements.

ई. मणि राम गेलार
सचिव

DETERMINATION OF LOS ANGELES ABRASION VALUE
IS: 2386 (Part IV) - 1963

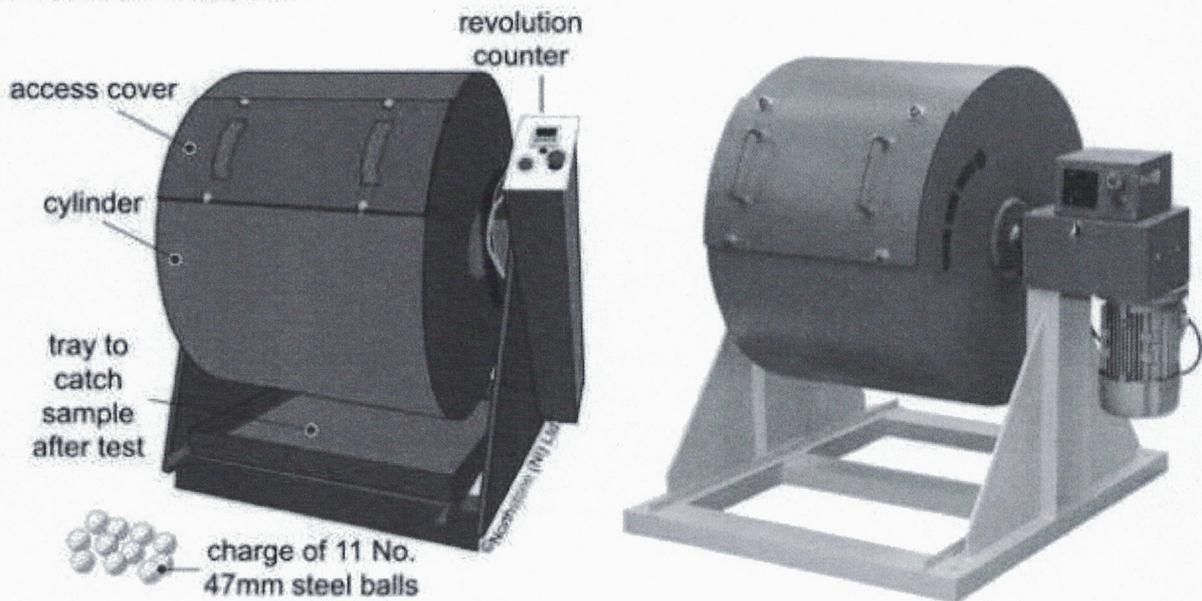
OBJECTIVE:

This experiment provides the method to determine the abrasion value of the coarse aggregates.

APPARATUS:

- Los Angeles Abrasion testing machine
- Steel Balls (approximately 48mm in diameter and each weighing between 390 and 445g)
- IS sieves as required depending upon the size of aggregates to be tested and 1.70mm IS sieve
- Balance accurate to 1g

Los Angeles machine



Los Angeles abrasion test setup

Figure 24: Los Angeles Abrasion Test Setup

ABRASIVE CHARGE: The abrasive charge shall consist of cast iron spheres or steel spheres approximately 48 mm diameter and each weighing between 390 and

[Handwritten marks]

[Handwritten mark]

[Handwritten marks]

[Handwritten signature]
ई. मणि राम गेलाल
सचिव

445 grams. The abrasive charge depending upon the grading of the test sample shall be as in given table:

Grading	No. of spheres	Weight of charges (g)
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 20
D	6	2500 ± 15
E	12	5000 ± 25
F	12	5000 ± 25
G	12	5000 ± 25

TEST SAMPLE:

1. The field sample shall be reduced to give test sample approximately 20 Kg for aggregates larger than 20 mm and 10 Kg for aggregates smaller than 20 mm.
2. The test sample shall then be washed and dried in an oven at 105° to 110°C to substantially constant weight.
3. The test sample shall conform to one of the grading shown in Table as given below. The grading used shall be those most nearly representing the aggregate furnished for the work.

Sieve size (mm)		Weight of test sample for grade (g)							Remarks
Passing	Retained on	A	B	C	D	E	F	G	
80	63	-	-	-	-	2500*			
63	50	-	-	-	-	2500*			
50	40	-	-	-	-	5000*	5000*		
40	25	1250					5000*	5000*	
25	20	1250						5000*	
20	12.5	1250	2500						
12.5	10	1250	2500						
10	6.5			2500					
6.5	4.75			2500					
4.75	2.36				5000				

*Tolerance of ±2% permitted

[Handwritten marks]

[Handwritten mark]

[Handwritten mark]

[Handwritten signature]

PROCEDURE:

1. Place the test sample and abrasive charge in Los Angeles Abrasion testing machine.
2. Set the revolution counter to zero and switch on the machine.
3. Rotate the machine at a speed of 20 to 33 rev/min. For grading A, B, C and D, rotate the machine for 500 revolutions and for grading E, F and G, rotate the machine for 1000 revolutions.
4. After completion of the revolutions, discharge the material onto a tray.
5. Make the preliminary separation of the sample on a sieve coarser than 1.70mm IS sieve. Then, sieve the finer portion on a 1.70mm IS sieve.
6. Wash the material coarser than 1.70mm and dry in an oven at a temperature of 105°C to 110°C and weigh accurately to the nearest gram.

CALCULATION:

The difference between the original weight of the sample taken and the final weight of the sample retained on 1.70mm IS sieve shall be expressed as a percentage of the original weight of the test sample.

$$\text{Abrasion value} = \frac{W_1 - W_2}{W_1} * 100$$

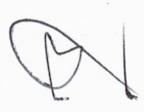
Where,

W_1 = weight of initial dry sample taken

W_2 = weight of material retained on 1.70mm IS sieve

$W_1 - W_2$ = weight of material passing 1.70mm IS sieve











REPORTING:

Report the Los Angeles value in the table below:

S.N.	Wt. of sample taken (g), W_1	Wt. of material retained on 1.70mm sieve (g), W_2	Wt. of material passing 1.70mm sieve(g), $W_1 - W_2$	% passing (Abrasion value) = $[(W_1 - W_2)/W_1]*100$	Average LAA value
1					
2					
3					

CONCLUSION:

Aggregate Abrasion Value: %

The aggregate abrasion value shall not exceed the following values:

- a) For aggregate to be used in concrete for wearing surfaces, (such as runways, roads, pavements, spillways, tunnel lining carrying water and stilling basins): 30 percent
- b) For aggregates to be used in concrete other than for wearing surfaces: 50 percent

[Handwritten marks]

[Handwritten mark]

[Handwritten mark]

[Handwritten signature]

ई. मणि राम गोलाल
सचिव

[Handwritten mark]

TESTS ON BRICKS



DETERMINATION OF WATER ABSORPTION OF BRICK
IS: 3495 (PART 2):2019

OBJECTIVE:

To determine water absorption of brick.

APPARATUS:

- Ventilated Oven
- Weighing machine capable of weighing within 0.1 percent of the mass of the specimen
- Water tank

PROCEDURE: (24-hr Water Absorption Test)

1. Sample bricks are taken randomly from a stack as a specimen.
2. Dry the brick specimens in a ventilated oven at a temperature of 105 °C to 115°C for not less than 24 h until two successive weighings at intervals of 2 h show an increment of loss not greater than 0.2 percent of the last previously determined mass of the specimen.
3. Cool the specimen to room temperature.
4. Specimen is weighed in a digital weighing machine and is record as W1
5. The specimen is immersed in clean distilled water at 15 to 30°C for 24 h.
6. After 24 hours immersion, the specimen is taken out of water and wiped with a damp cloth for any traces of water.
7. The specimen is weighed again which has been removed from water within 3mins and recorded as W2.
8. Calculate water absorption of brick.

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

[Handwritten mark]

[Handwritten signature]

ई. मणि राम गेलार
सचिव

OBSERVATION:

S.N.	Wt. of sample taken (Kg), W ₁	Wt. of brick immersed in water (Kg), W ₂	weight of water absorbed by a brick, W ₂ - W ₁	Water Absorption % = [(W ₂ -W ₁)/W ₁]*100	Average Water Absorption %
1					
2					
3					
4					
5					

CALCULATION:

The difference between the original weight of the sample taken and the final weight of the sample shall be expressed as a percentage of the original weight of the test sample.

$$\text{Water Absorption} = \frac{W_2 - W_1}{W_1} * 100$$

Where,

W₁ = weight of bricks kept in an oven at a temperature of 105°C

W₂ = weight of brick immersed in water at room temperature for 24 hours

W₁ - W₂ = weight of water absorbed by a brick

CONCLUSION:

Water Absorption in %: %



ई. मणि राम गेलाल
सचिव

DETERMINATION OF COMPRESSIVE STRENGTH OF BRICK
IS: 3495 (PART 1):2019

OBJECTIVE:

To determine the compressive strength of bricks.

APPARATUS:

- Compressive Strength Testing Machine

PROCEDURE:

1. Sample bricks (As per IS 5454-1978 Table 2) are taken for the compressive strength testing.
2. The bricks are then immersed in water at room temperature of $27 \pm 2^\circ\text{C}$ for 24 hours.
3. Remove the specimen from water and drain out any surplus water at room temperature.
4. The frog of the bricks is flushed level with cement mortar (1:3).
5. The bricks are stored under damp jute bags for 24 hours followed by its immersion in water at room temperature for three days and remove and wipe out any traces of moisture.
6. The bricks are placed in the compression testing machine with flat faces horizontal and mortar filled face being upwards.
7. Load is applied at a uniform rate of $7 \pm 1 \text{ N/mm}^2$ per minute till failure.

OBSERVATION:

S.N.	Average Area of bed faces, mm^2	Load at Failure (N)	Compressive Strength (N/mm^2)	Average Strength (N/mm^2)
1				
2				
3				
4				
5				

CALCULATION:

The compressive strength is calculated by dividing the maximum load applied to the bricks during the test divided by the cross-sectional area.

$$\text{Compressive Strength} = \frac{\text{Breaking Strength of the brick}}{\text{Average area of bed faces}}$$

CONCLUSION:

Compressive Strength: N/mm²

[Handwritten signatures and scribbles]

ई. मणि राम गेलाल
सचिव