QC Practicals

P SAI SARAN
Pesipati.saran@accconcrete.com
## Sieve Analysis

- **Purpose:-**
  Purpose of this test is to determine the particle size distribution of Fine & Coarse Aggregates

- **Reference Standard:-**
  IS: 2386 Part I

- **Apparatus:-**
  I.S. Sieve: Ranging from 25mm, 20mm, 16mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ, Sieve Shaker, Balance, and Tray.

- **Procedure:-**
  Weight of the test sample depends on the aggregates and will be as follows. Sample to be taken after completing the quartering procedure.

  - Sand = 1000 gm.
  - CA 1 = 5000 gm.
  - CA 2 = 5000 gm.

  The sample is sieved through set of I. S. sieves and weight of material retained on each sieve is noted.
Sieve Analysis
Induction – Overview of ACC Concrete Calculation With Example:-

<table>
<thead>
<tr>
<th>I.S.Sieve Size</th>
<th>Weight Retained (gm)</th>
<th>% Weight Retained</th>
<th>Cumulative percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Retained</td>
</tr>
<tr>
<td>25 mm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 mm</td>
<td>160</td>
<td>2.24</td>
<td>2.24</td>
</tr>
<tr>
<td>16 mm</td>
<td>5984</td>
<td>83.62</td>
<td>85.86</td>
</tr>
<tr>
<td>10 mm</td>
<td>742</td>
<td>10.37</td>
<td>96.23</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>196</td>
<td>2.74</td>
<td>98.97</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>0</td>
<td></td>
<td>98.97</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>0</td>
<td></td>
<td>98.97</td>
</tr>
<tr>
<td>600 -μ</td>
<td>0</td>
<td></td>
<td>98.97</td>
</tr>
<tr>
<td>300 -μ</td>
<td>0</td>
<td></td>
<td>98.97</td>
</tr>
<tr>
<td>150 - μ</td>
<td>0</td>
<td></td>
<td>98.97</td>
</tr>
<tr>
<td>PAN</td>
<td>74</td>
<td>0.1</td>
<td>100</td>
</tr>
<tr>
<td>TOTAL</td>
<td>7156</td>
<td></td>
<td>778.15</td>
</tr>
</tbody>
</table>

Fineness Modulus: (F.M.) = 7.78
$Fineness\ mod\ ulus\ (F.M.) = \frac{Total\ wt\ of\ cumulative\ %\ retained}{100}$

$\left(\frac{From\ 25\ mm\ to\ 150\ \mu}{100}\right) = \frac{778.15}{100}$

$Fineness\ Modulus:\ (F.M.) = 7.78$
Aggregates Impact Value Test
Aggregates Impact Value Test

- **Purpose**
  The purpose of this test is to determine the Impact value of coarse Aggregate.

- **Apparatus:**
  - Total weight not more than 60 kg and not less than 45 kg
  - A cylindrical steel cup of dia. = 102mm & depth = 50mm
  - A metal tup or hammer weighing 13.5 to 14.0 kg he lower part of which shall be cylindrical in shape, 100mm dia and 5 cm long.
  - Means for raising the hammer and allowing it to fall freely from a height of 380 +5.0mm
  - the IS sieve of sizes 12.5mm,10mm and 2.36mm
  - Cylindrical metal measures of dia. = 75mm and depth = 50mm.
  - Tamping rod 10mm in dia and 230mm long rounded at one end.
  - A balance of capacity not less than 500gm accuracy 0.1gm.
  - Oven, thermostatically controlled to maintain a temperature of 100 0c to 110 0c.
- **Reference Standard:**
  - IS 2386- Part IV

- **Test sample:**
  - The test sample consists of coarse aggregates passing IS sieve 12.5mm sieve and retains on 10mm. (Approx. 3kg taken)

- **Procedure:**
  - Take the sample and sieve it through IS sieve 12.5mm and 10mm.
  - Place the test sample in oven for a period of 4 hr. at a temperature of 100 0c to 110 0c.
Take out the sample cool it at room temperature and fill the cylindrical measures in three layer by giving 25 stroke per layer, struck of the excessive aggregates take the weight (Weight – A).

Assemble the impact-testing machine and fit the cylindrical measures at the bottom of machine fill the sample in it in standard manner.

Release the falling hammer and repeat the test until 15 blows are completed at an interval of not less than 1 sec.

The crushed sample is removed from the cup and whole sample is sieved through IS sieves 2.36mm till no significant amount of material passes through in one minute and weighed (weight B).

The fraction retained is also weighed (weight – C ) and if the total weight (B+C) is less than the initial weight – A by more than one gram the result shall be discard

**Calculation:-**

where

- \( B = \) Weight of fraction passing 2.36mm
- \( A = \) Weight of sample in Cylindrical Measures.
Aggregates Crushing Value Test
Aggregates Crushing Value Test
Aggregates Crushing Value Test

- **Purpose:**
  - Purpose of this test covers the procedure to determine the aggregates crushing value of coarse aggregates.

- **Apparatus:**
  - A 15 cm dia open ended steel cylinder, with a plunger and base plate.
  - Tamping rod, 16mm dia. And 45cm or 60cm long rounded at one end.
  - Balance of capacity more than 3 kg accurate to one gram.
  - IS sieve of sizes 12.5mm, 10mm and 2.36mm.
  - Compression testing machine of capacity 40 tones.
  - Well-ventilated oven can maintain a temperature of 100 0c to 110 0c.

- **Reference Standard:**
  - IS 2386 – Part IV
Aggregates Crushing Value Test

**Procedure:-**

- Coarse aggregates is passing I S Sieve 12.5mm and retained on 10mm. (Approx. 6.5 kg for two trials)
- The standard aggregates crushing test is made on aggregates passing I S 12.5 mm and retains on 10 mm.
- Place the sample in oven for a period of 4 hr. to make it surface dry and cool it at room temperature before testing.
- The aggregates sample is filled in standard cylinder measure in three layers approximately of equal depth and each layer is tamped 25 times.
- Weight of the sample contained in cylinder is measured (Wt – A)
- The surface of the cylinder is leveled and the plunger inserted so that it rests horizontally and it does not jam in the cylinder.
- A load of 40 tones shall be applied within 10 minute and whole of the material removed from the cylinder and sieved on 2.36mm I S sieve.
- The fraction passing the sieve shall be weighed (weight- B).
Aggregates Crushing Value Test

- The test is repeated.

- Calculation:

\[ \text{Aggregate crushing value} = \frac{B}{A} \times 100 \]

where,

- \( B \) = Weight of Fraction Passing 2.36mm IS Sieve
- \( A \) = Weight of Sample In Cylinder
Determination of Flakiness Index
**Purpose:-**

Purpose of The test is to determine the flakiness index of an aggregates i.e. percentage by weight of particle in it whose least dimension (thickness) is less than three fifth times of their mean dimension. the test is not applicable to sizes smaller than 6.3mm.

**Reference documents:-**

IS 2386- Part I

**Apparatus:-**

- The apparatus shall consist of :
  - Balance of sufficient capacity and have accuracy of ±0.1 percentage
  - Metal gauge.( thickness gauge )
  - IS sieve as shown in figure.

**Procedure:-**

- The quantity of material shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
### Dimension Of Thickness Gauge

<table>
<thead>
<tr>
<th>Size Of Aggregates</th>
<th>Thickness Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Passing Through IS Sieve</strong></td>
<td><strong>Retained On IS Sieve</strong></td>
</tr>
<tr>
<td>63 - mm</td>
<td>50 – mm</td>
</tr>
<tr>
<td>50 - mm</td>
<td>40 – mm</td>
</tr>
<tr>
<td>40 - mm</td>
<td>31.5 – mm</td>
</tr>
<tr>
<td>31.5 - mm</td>
<td>25 – mm</td>
</tr>
<tr>
<td>25 - mm</td>
<td>20 – mm</td>
</tr>
<tr>
<td>20 - mm</td>
<td>16 – mm</td>
</tr>
<tr>
<td>16 - mm</td>
<td>12.5 – mm</td>
</tr>
<tr>
<td>12.5 - mm</td>
<td>10 – mm</td>
</tr>
<tr>
<td>10 - mm</td>
<td>6.3 – mm</td>
</tr>
</tbody>
</table>
- Take approximately 8 – 10 kg of sample and sieve it through the I S sieve shown above table.
- Select at least 200 no. of pieces for each fraction to be tested.
- Pass each piece through the thickness gauge as given in above table.
- Weighed the pieces which pass through the thickness gauge.
- Calculate the % Passing by weight (A) as shown below
### Flakiness Index % = \sum \text{Values in Col. E}

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Passing Through</th>
<th>Retained On</th>
<th>Weight passing in gm</th>
<th>Total weight of sample gm</th>
<th>(X = (A/B)) (%)</th>
<th>(Y = (A/\text{Total weight of sample } W)) (%)</th>
<th>(X \times Y % \text{Flakiness (CxD)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I S Sieve</td>
<td>I S Sieve</td>
<td>A</td>
<td>B</td>
<td></td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>2</td>
<td>63 - mm</td>
<td>50 – mm</td>
<td>‘w1</td>
<td>W1</td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>3</td>
<td>50 - mm</td>
<td>40 – mm</td>
<td>‘w2</td>
<td>W2</td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>4</td>
<td>40 - mm</td>
<td>31.5 – mm</td>
<td>‘w3</td>
<td>W3</td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>5</td>
<td>31.5 - mm</td>
<td>25 – mm</td>
<td>‘w4</td>
<td>W4</td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>6</td>
<td>25 - mm</td>
<td>20 – mm</td>
<td>‘w5</td>
<td>W5</td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>7</td>
<td>20 - mm</td>
<td>16 – mm</td>
<td>‘w6</td>
<td>W6</td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>8</td>
<td>16 - mm</td>
<td>12.5 – mm</td>
<td>‘w7</td>
<td>W7</td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>9</td>
<td>12.5 - mm</td>
<td>10 – mm</td>
<td>‘w8</td>
<td>W8</td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>10</td>
<td>10 - mm</td>
<td>6.3 – mm</td>
<td>‘w9</td>
<td>W9</td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>Total</td>
<td>w</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>E</td>
</tr>
</tbody>
</table>
Determination of Elongation Index
Purpose:-
- The purpose of this test is to determine the Elongation Index of aggregates which is the percentage by weight of particle in it whose greatest dimension (length) is greater than 1.8 times their mean dimension. The test is not applicable to sizes smaller than 6.3mm.

Apparatus:
- The apparatus shall consist of:
  - Balance of sufficient capacity and have accuracy of 0.1 percentage
  - Metal gauge (Length gauge)
  - IS sieve as shown in figure.

Reference Standard:-
- IS 2386 – Part IV

Procedure:
- The quantity of material shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
**Dimension Of Length Gauge**

### Size Of Aggregates

<table>
<thead>
<tr>
<th>Size Of Aggregates</th>
<th>Passing Through I S Sieve</th>
<th>Retain On I S Sieve</th>
<th>Length Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>63 – mm</td>
<td>50 – mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 – mm</td>
<td>40 – mm</td>
<td></td>
<td>81.0 – mm</td>
</tr>
<tr>
<td>40 – mm</td>
<td>25 – mm</td>
<td></td>
<td>58.50 – mm</td>
</tr>
<tr>
<td>31.5 – mm</td>
<td>25 – mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 – mm</td>
<td>20 – mm</td>
<td></td>
<td>40.50 – mm</td>
</tr>
<tr>
<td>20 – mm</td>
<td>16 – mm</td>
<td></td>
<td>32.40 – mm</td>
</tr>
<tr>
<td>16 – mm</td>
<td>12.5 – mm</td>
<td></td>
<td>25.60 – mm</td>
</tr>
<tr>
<td>12.5 – mm</td>
<td>10 – mm</td>
<td></td>
<td>20.20 – mm</td>
</tr>
<tr>
<td>10.0 – mm</td>
<td>6.3mm</td>
<td></td>
<td>14.70mm</td>
</tr>
</tbody>
</table>
Take approximately 8 – 10 kg of sample and sieve it through the IS sieve shown above table.

Select at least 200 no. of pieces of any fraction to be tested.

Pass each piece through the thickness gauge as given in above table.

Weigh which are retained through the Length gauge.

Calculate the % Retained by weight (A) & % Retained by No. of pieces (B)
% Elongation (A) = \frac{w}{W} \times 100

<table>
<thead>
<tr>
<th>Gauge Length</th>
<th>Wight retained gm</th>
<th>Total weight of sample gm</th>
</tr>
</thead>
<tbody>
<tr>
<td>81.0 - mm</td>
<td>‘w1</td>
<td>W1</td>
</tr>
<tr>
<td>58.50 - mm</td>
<td>‘w2</td>
<td>W2</td>
</tr>
<tr>
<td>40.50 - mm</td>
<td>‘w3</td>
<td>W3</td>
</tr>
<tr>
<td>32.40 - mm</td>
<td>‘w4</td>
<td>W4</td>
</tr>
<tr>
<td>25.60 - mm</td>
<td>‘w5</td>
<td>W5</td>
</tr>
<tr>
<td>20.20 - mm</td>
<td>‘w6</td>
<td>W6</td>
</tr>
<tr>
<td>14.70 - mm</td>
<td>‘w7</td>
<td>W7</td>
</tr>
<tr>
<td>Total</td>
<td>w</td>
<td>W</td>
</tr>
</tbody>
</table>
Specific Gravity & Water Absorption of Coarse Aggregates

- **Purpose:-**
  - This test covers the procedure of determining specific gravity, apparent specific gravity and water absorption of aggregates.

- **Reference standard:-**
  - IS 2386 – Part III

- **Apparatus:-**
  - The apparatus shall consist of the following:
    - A balance of capacity not less than 3kg. & accurate to 0.5 gm.
    - Oven, thermostatically controlled, to maintain temperature of 100 0c to 110 0c.
    - A wire basket of not more then 6.3mm mesh or a perforated container of convenient size.
    - Two dry clothes each not less than 75 x 45 cm.
    - A shallow tray of area of not less than 650 cm2.
**Procedure:**

- The sample taken should not be less than 2-kg (A) and it should be taken by method of Conning and Quartering.
- The sample shall be screened & washed to remove finer particle.
- Place the sample in wire basket and immersed the assembly in distilled water at a temperature of 22 0c to 32 0c.
- While immersing in tank the care should be taken that it should not touch any side of tank, a cover of 5mm from all sides & top is left, and from bottom 25mm cover left.
- The wire basket is then dropped water 25 times at the rate of one drop per second.
- The whole assembly is left in distilled water for a period of 24 + ½ hr.
- On the next the wt. Of basket filled with aggregate is taken in water (W1).
The aggregates are then removed and the empty basket is returned into tank, dropped 25 times and weight of empty basket is taken in water (W2).

The aggregates sample is brought to SSD condition and weight is taken (W3).

The aggregates are then placed in oven at a temperature of 100 °C to 110 °C and maintain at this temperature for 24 + ½ hr.

The aggregates sample is cooled in airtight container and weight is taken (C).

**Calculation:**

\[
\text{Specific Gravity (SSD)} = \frac{C}{(W3 - W)}
\]
**Water Absorption**

\[
\text{Water Absorption} = \frac{(W3 - C) \times 100}{C}
\]

- **W1** = weight of wire basket + aggregate in water
- **W2** = weight of wire basket in water
- **W1 - W2** = \( W \) = weight of saturated aggregate in water
- **W3** = weight of S S D aggregates in air
- **A** = weight of air dry aggregates in air
- **C** = weight of oven dry aggregate in air
**Induction – Overview of ACC Concrete**

- **Apparatus:-**
  - A balance capacity not less than 3kg. & accurate to 0.5 gm.
  - Oven, thermostatically controlled, to maintain temperature of 100 0c to 110 0c
  - Pycnometer about one liter capacity.
  - A mean of supplying a current of warm air such as hair drier.
  - A tray of area not less than 325 cm2
  - Filter paper and funnel.

- **Procedure:-**
  - Take about 1-kg sample for 10mm to 4.75mm or 500 gm for finer than 4.75mm.
  - Place the sample in tray and cover it with distilled water and remain immersed for 24 + ½ hr.
  - Take out the sample and drain the water carefully. Care should be taken that sample is not drained off. If required use filter paper and the rained being returned to the sample.
  - Make the sample saturated surface dry by exposing it to gentle current of warm air or heat the sample in oven and take the weight (A).
  - Place the sample in Pycnometer and fill the distilled water in it.
  - Rotate the Pycnometer to remove air bubble. The Pycnometer shall be topped up with distilled water to remove any froth from the surface and so that the surface of water in hole is flat.
Specific Gravity & Water Absorption of fine Aggregates

- Dry the Pycnometer from outside and take the weight. (B).
- Empty the sample into tray, care being taken that all the aggregates is transferred.
- Refill the Pycnometer with distilled water to the same level and take the weight (C).
- The sample is then placed in oven at temperature of 100°C to 110°C for a period of 24 + ½ hr. Cool it in airtight container and take weight (D).

**Observation:**

\[
\begin{align*}
\text{Wt Of Pycnometer Full Of Water} & = C \text{ gm} \\
\text{Wt Of SSD Agg} & = A \text{ gm} \\
\text{Wt Of Pycnometer + SSD Agg.+ Water} & = B \text{ gm} \\
\text{Weight of saturated aggregate in water} & = (B-C) = C1\text{gm} \\
\text{Weight of oven Dry aggregate} & = D \text{ gm}
\end{align*}
\]

**Calculation:**

\[
\begin{align*}
\text{Specific Gravity SSD} & = \frac{D}{(A - C1)} \\
\text{Water Absorption} & = \frac{(A - D) \times 100}{D}
\end{align*}
\]
IS 1199  Slump Cone Test
Slump cone test (workability of concrete)

- **Purpose**: Purpose of this test covers the procedure for determining the slump of concrete.

- **Apparatus**: Slump Cone, Scoop, Tamping bar, Trowel with straight edge, Foot rule / measuring tape

- **Reference Documents**: IS 1199
• **Procedure:-**

  The inside of the mould shall be cleaned of any set concrete and moisture and placed on a level, clean flat, rigid and non-absorbent surface like a metal plate. **Concrete shall be filled in approximately in four equal layers, each layer rodded 25 times with the tamping rod, through the depth.** The top shall be filled and excess concrete removed with a straight edge. The mould shall be removed immediately, in a slow vertical motion. Wait till concrete flow become stationary Then slump shall be measured immediately as the difference in height between the top of the mould and the highest point of the specimen. This height in millimeter shall be recorded as the slump. If the specimen collapses, the test shall be repeated. Then also if the result is same, the same shall be recorded with the fact.
Compaction Factor Test (workability)
**APPARATUS:**

<table>
<thead>
<tr>
<th>DETAILS</th>
<th>DIMENSION (CM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPPER HOPPER, A</td>
<td></td>
</tr>
<tr>
<td>Top internal diameter</td>
<td>25.4</td>
</tr>
<tr>
<td>Bottom internal diameter</td>
<td>12.7</td>
</tr>
<tr>
<td>Internal height</td>
<td>27.9</td>
</tr>
<tr>
<td>LOWER HOPPER, B</td>
<td></td>
</tr>
<tr>
<td>Top internal diameter</td>
<td>22.9</td>
</tr>
<tr>
<td>Bottom internal diameter</td>
<td>12.7</td>
</tr>
<tr>
<td>Internal height</td>
<td>22.9</td>
</tr>
<tr>
<td>CYLINDER, C</td>
<td></td>
</tr>
<tr>
<td>Internal diameter</td>
<td>15.2</td>
</tr>
<tr>
<td>Internal height</td>
<td>30.5</td>
</tr>
<tr>
<td>Distance between bottom of upper hopper &amp; top of lower hopper</td>
<td>20.3</td>
</tr>
<tr>
<td>Distance between bottom of lower hopper &amp; top of cylinder</td>
<td>20.3</td>
</tr>
</tbody>
</table>
PROCEDURE:

- The sample of concrete to be tested shall be placed gently in the upper hopper.
- The hopper shall be filled level with its brim & the trap door shall be opened so that the concrete falls into the lower hopper.
- Immediately after the concrete has come to rest the cylinder shall be uncovered, the trap door of the lower hopper opened, & the concrete allowed to fall into the cylinder.
The excess concrete should be striked off & this shall be carried without any shock or vibration to the concrete.

The weight of the concrete in the cylinder shall be determined to the nearest 10g. This shall be recorded as weight of partially compacted concrete (W1).

The cylinder shall be refilled with concrete from the same sample in layers approximately 5 cm deep, the layers being heavily rammed or preferably vibrated so as to achieve full compaction. The top surface of the fully compacted concrete shall be carefully struck off & its weight taken. This is the weight of fully compacted concrete (W2).

**CALCULATION:**

The compacting factor shall be calculated as follows:

C.F = W1/ W2

Where,

W1  = Weight of partially compacted concrete.
W2  = Weight of fully compacted concrete.
Vee – Bee Consistometer (workability test)
Vee – Bee Consistometer (workability test)

APPARATUS:
- a) Vibrator table resting upon elastic supports.
- b) A metal pot.
- c) A sheet metal cone, open at the both ends, and
- d) A standard iron rod.

STEPS:
- A slump test shall be performed as above in the sheet metal cylindrical pot of the consistometer.
- The glass disc attached to the swivel arm shall be moved & placed just on the top of the slump cone in the pot & before the cone is lifted up, the position of the concrete cone shall be noted by adjusting the glass disc attached to the swivel arm.
- The cone shall be then lifted up & the slump noted on the graduated rod by lowering the glass disc on top of the concrete cone.
- The electrical vibrator shall then be switched on & the concrete shall be allowed to spread out in the pot.
- The vibration shall then be continued until the whole concrete surface uniformly adheres to the glass disc & time taken for this to be attained shall be recorded in seconds.
Measurement of Air Content of Freshly Mixed Concrete (Pressure Method)
Measurement of Air Content of Freshly Mixed Concrete (Pressure Method)
Measurement of Air Content of Freshly Mixed Concrete (Pressure Method)

APPARATUS:

- Measuring bowl: A flanged metallic bowl having a dia. 1 to 1.25 times the height. The container size should be 0.005m³.
- Conical cover Assembly: The flanged metallic cover, not readily attached by the cement paste, as interior surfaces inclined 300C from the horizontal. The cover is fitted with a stand pipe which has graduations for the range of 0 – 10% of air content.
- Calibration cylinder: It consists of a cylindrical metallic measure with slots at lower end.
- Other accessories: Rubber Mallet, measure, strike of bar, trowel, & tamping rod.

CALIBRATION OF APPARATUS: Steps

- Place a representative sample of the concrete in the measuring bowl in three equal layers, consolidating each layer by rodding the bowl. Vibration may be substituted for rodding & by tapping the sample when the air content of concrete placed by vibration is to be determined. When the concrete is to be placed by rodding, consolidate each layer of concrete by about 25 strokes of the tamping rod evenly distributed over the cross section. Follow the rodding of each layer by tamping the sides of the bowl 10 to 15 times with the mallet until the cavities left by rodding are leveled out & no large bubbles of the air appear over the surface of the rodded layer. In rodding the first layer, the rod shall not forcibly strike the bottom of the bowl. In rodding the second & final layer, only enough force shall be used to caused the rod to penetrate the surface of the previous layer. Slightly overfill the bowl with the third layer & after rodding or vibration remove the excess concrete by sliding the strike-off bar across the top flange with a sawing motion until the bowl is just full to the flange level.
Thoroughly clean the flanges of the bowl & of the conical cover so that a pressure tight seal is obtained while the cover is clamped in place.

Assemble the apparatus & add water over the concrete by means of the tube until it rises to about half way mark in the standpipe.

Incline the apparatus assembly about 30° from vertical end using the bottom of the bowl as a pivot, describe several complete circles, with the upper end of the column simultaneously tapping the conical cover lightly to remove any entrapped air bubbles above the concrete sample.

Replace the apparatus assembly to its vertical position & fill the water column slightly above the zero mark, while lightly tapping the sides of the bowl. Foam on the surface of the water column may be removed with a syringe or with a spray of alcohol to provide a clear meniscus.

Bring the water level to the zero mark of the stand pipe closing the vent at the top of the water column.

Apply slightly more than the desired test pressure P (0.02 kg/cm² or more) to the concrete by means of hand pump.

To relieve local restraints, tap the sides of the measures & when the pressure guage indicates the exact test pressure p (determined in accordance with the calibration test) read the level h₁ & record to the nearest division or half division (0.10 to 0.05% air content) on the graduated standpipe. Gradually release the air pressure through the vent at the top of the water column & tap the sides of the bowl lightly for about one minute.
- Record the water level $h_2$ to the nearest division or half division.
- The apparent air content $A_1$ is equal to $h_1 - h_2$.
- Repeat the step specified as above (Without adding water to re-establish the water level at the zero mark). The two consecutive determinations of apparent air content should check within 0.2% of air & shall averaged to give the value of $A_1$, to be used in calculating the air content, $A$ as given below:

**CALCULATIONS:**
The air content, $A$ can be calculated as

$$A = h_1 - h_2$$

Where
- $A = \text{air content, percentage by volume of concrete.}$
- $A_1 = \text{apparent air content, percentage by volume of concrete.}$
  
$$A_1 = h_1 - h_2$$
Determination of Bleeding

APPARATUS:

- **a)** Measures: A cylindrical container of approximately 0.01 m³ capacity, having an inside diameter of 250 mm and inside height of 280 mm. The container shall be made of metal of minimum thickness of 4 mm and shall be externally reinforced around the top with metal band 38 mm wide and 4 mm thick. The inside shall be smooth and free from corrosion. Coating, or lubricants. Suitable handles should be provided, properly welded on the outer surface of the container, on the opposite side in center, so as to enable lifting/handling of the container with concrete.

- **b)** Tamping Bar: The tamping bar shall be a rounded-ended steel bar of 16 mm diameter and 600 mm length.

- **c)** Pipette: A pipette for drawing off free water from the surface of the test specimens.

- **d)** Graduated Jar: A graduated jar of 100 ml capacity.
TEST PROCEDURE:

1. The concrete shall be filled into the measure in layers approximately 50mm deep and each layer shall be compacted by hand or by vibration. When compacting by hand, tamping with the tamping bar shall be distributed in a uniform manner over the cross-section of the measure. The number of strokes per layer in no case shall the concrete be subjected to less than 60 strokes per layer for the 0.01 m³ measure. Then, the top surface of the concrete shall be leveled to a reasonably smooth surface by means of trowel.

2. The test specimen shall be kept at a temperature of 27 ± 20°C. Immediately after trowelling the surface of test specimens, the time as well as the mass, of the cylinder and its contents shall be recorded. The container shall be kept on a level surface free from vibration and covered with a lid. Water accumulated at the top shall be drawn off by means of a pipette, at 10 minutes intervals during the first 40 minutes and at 30 minutes intervals subsequently till bleeding ceases. To facilitate collection of bleeding water, the specimen may be tilted by placing a 50-mm block under one side of the measure during collection of water. The total water shall be recorded after each transfer.
**CALCULATION:**

Accumulated bleeding water expressed as a percentage of the net mixing water shall be calculated as follows:

Bleeding water percentage = \( \frac{V_w}{W} \times \frac{w}{W} \times s \) \times 100

Where

- \( V_w = \text{total mass of the bleeding water, kg;} \)
- \( w = \text{net mass of water in the batch, kg;} \)
- \( W = \text{total mass of the batch, kg; and} \)
- \( S = \text{the mass of sample, kg.} \)
Measurement of workability by Flow Table:

APPARATUS:
- Mould: Having dimensions
  - Base 25 cm in dia.
  - Upper surface 17 cm in dia.
  - Height 12 cm.
  - Flow table confirming to requirements of IS: 5512 - 1969

STEPS:
- Clean the flow table from all gritty materials & Keep the mould centered on the table,
- Fill the mould in two layers, each approximately one–half the volume of the mould. Each layer shall be rodded 25 times with a rod 1.6 cm in dia. & 61 cms long.
- Remove the excess concrete that has overflowed
- Raise & drop the table for a height of 12.5mm, 15 times in about 15 seconds.

- Note down the diameter of spread concrete along six symmetrically distributed directions with the help of caliper and determine average Dia of spread of concrete nearest to 5mm

**CALCULATIONS:**

- The % flow is calculated as

\[
\text{Flow, } \% = \frac{\text{Average spread diameter in cm} - 25}{25} \times 100
\]

\[25\]
Determination of Setting time of Concrete

- For the purpose of this procedure, the following definitions shall apply.
- Initial setting time: The elapsed time, after initial contact of cement and water, required for the mortar (sieved from the concrete) to reach a penetration resistance of 3.43 N/mm² (35kgf / cm²).
- Final setting time: The elapsed time, after initial contact of cement and water, required for the mortar (sieved from the concrete) to reach a penetration resistance of 26.97 N/mm² (275kgf / cm²)

**APPARATUS:**

- Containers for Mortar specimens: Rigid, Watertight, non-absorptive, non-oiled containers, cube, with minimum lateral dimension 150mm and height at least 150mm.
- Penetration Resistance Apparatus: Spring reaction-type apparatus, graduated from 5 kgf to 60 kgf in increments of 1 kgf. Indications of actual needle loads by these apparatus shall be accurate to 1 kgf. Removal needles of 645, 323, 161, 100, 65, 32 and 16 mm² bearing areas shall be provided. Each needle shank shall be scribbled 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. Schematic diagram of the equipment is shown in figure.

- Pipette: Pipette or suitable instrument for drawing off free water from the surface of the test specimens.

- Tampering Rod: Round, straight, steel rod 16 mm in diameter and approximately 600 mm in length, having the tamping end rounded to a hemispherical tip, of 16 mm diameter.
STEPS:

1.0) PREPARATION OF MORTAR SPECIMENS:

- 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 140mm.

- All of the mortar from the sample of concrete by sieving it through a 4.75mm IS sieve onto a non-absorptive surface is to be removed.

- Thoroughly remix the mortar by hand on the non-absorptive surface and place it in the container, or containers in layers of 50mm each, and compact by rodding each layer. Rod the specimen by the means of the tamping rod held so as to penetrate the mortar with the round end. Rod the mortar once for each 6.5cm² of top surface area of the specimen and distribute the strokes uniformly over the cross-section of the specimen. After completion of the rodding, tap the sides of the containers lightly with the surface of the specimen. The mortar surface shall be at least 13mm below the top edge of the container to provide space for the collection and removal of bleeding water.

  Minimum one specimen shall be taken for each concrete mix proportions
2.0) STORAGE OF MORTAR SPECIMENS:

- Store and maintain the specimens at the temperature selected for testing the specimens. To prevent excessive evaporation of moisture, keep the specimen covered and protected with a suitable tight fitting, water-impermeable cover for the duration of the test, except when bleeding water is being removed or penetration tests are being made. The specimens shall be shielded from the sun.

DETERMINATION OF SETTING TIME

- Remove bleeding water from the surface of the mortar specimens just prior to making a penetration test by means of pipette or suitable instrument. To facilitate collection of bleeding water, till the specimen carefully to an angle of about 12° from the horizontal by placing a block under one side 2 minutes prior to removal of the bleeding water.
Insert the needle of requisite, recommended 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 25mm depth in approximately 10 seconds. Record the force required and the time of application and convert it to the pressure in kg/cm², based on the area of the needle and time at which the reading is taken. In subsequent penetration tests take care to avoid areas where the mortar has been distributed by previous tests. The clear distance between the two needle impressions shall be at least two diameters of the needle being used, but not less than 13mm. The clear distance between any needle impression and the side of the container shall be not less than 25mm.

Make penetration tests at hourly intervals for normal mixtures and normal temperature, the initial test being made after an elapsed time of 3 to 4h. For accelerated mixtures or high temperatures, it may be advisable to make the initial test after an elapsed time of 1 or 2h and subsequent tests at 1/2h intervals. For low temperature conditions or related concrete mixtures, the initial penetration test may be deferred for an elapsed time of 4 to 6h, and perhaps longer. Subsequent test may be made at intervals of 1h, unless the rate of increase in penetration resistance indicates that shorter intervals are desirable.
CALCULATION:

INITIAL SETTING TIME:
- Initial setting time = Time elapsed between initial mixing of cement and water to the time at which penetration resistance is 35kg/cm²

FINAL SETTING TIME:
- Final setting time = Time elapsed between initial mixing of cement and water to the time at which penetration resistance is 275kgf/cm²
Determination of Flexural Strength: IS: 516
Testing Machine:

- The testing machine shall be of reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified in 4 KN/minute. The permissible errors shall be not greater than +2.0 percent. The bed of the testing machine shall be provided with two steel rollers, 38mm in diameter, on which the specimen is to be supported. These rollers shall be so mounted that the distance from center to center is 600mm for 150mm specimens. The load shall be applied through two similar rollers mounted at the third points of the supporting span, that is spaced at 200mm center to center. The load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to any torsional stresses or restraints.
PROCEDURE:

Test specimen:

- The specimen shall be 15cm x 15cm x 70 cm concrete beam. Specimen shall be cured by submerging in clean water up to the time of testing.

Placing the specimen in the testing machine:

- The bearing surfaces of the supporting & loading rollers shall be wiped clean, & any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers. The specimen shall then be placed in the machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould, along two lines spaced 20.0 or 13.3 cm apart. The axis of the specimen shall be carefully aligned with the axis of the loading device. No packing shall be used between the bearing surfaces of the specimen & the rollers. The load shall be applied without shock & increasing continuously at a rate such that the extreme fibre stress increases at approximately 7 kg/sq cm/min, that is, at a rate of loading of 400 kg/min for the 10.0cm specimens. The load shall increased until the specimen fails, & the maximum load applied to the specimen during the test shall be recorded. The appearance of the fractured faces of concrete & any unusual features in the type of failure shall be noted.
CALCULATION:

The flexural strength of the specimen shall be expressed as the modulus of rupture \( f_b \) shall be calculated to the nearest 0.05 N/mm² as follows:

\[
f_b = \frac{p \times l}{b \times d^2}
\]

Where

- \( b \) – measured width in mm of the specimen,
- \( d \) – measured depth in mm of the specimen at the point of failure,
- \( l \) – length in mm of the span on which the specimen was supported, and
- \( p \) – maximum load in N applied to the specimen.
Determination of Indirect Tensile Strength (Split Cylinder Test)

**APPARATUS:**
- a) Compressive testing machine
- b) Two packing strips of plywood conforming to IS: 303-1960 & 12mm wide & 3mm thick shall be provided for specimen & shall be used only once.

**PROCEDURE:**
- a) Cast 150x300mm cylinder of the mix proposed. Specimens shall be tested immediately on removal from the water whilst they are still wet.
- b) Diametrical lines shall be drawn on the two ends of the specimen that will ensure that they are in the same axial plane. The diameter & the dimensions of the specimen shall be noted before testing. The diameters of the specimen lying in the plane of the premarked lines shall be ensured near the ends & the middle of the specimen & the average taken to the nearest 0.2mm. The length of the specimen shall be taken to the nearest 0.2m by averaging the two lengths measured in the plane containing the premarked lines shall be ensured near the ends & at the middle of the specimen.
c) The bearing surfaces of the testing machine & of the packing strips shall be wiped clean. The specimen shall be placed on the plywood strip & aligned so that lines marked on the ends of the specimen are vertical & centered over the plywood strip. The second plywood strip shall be placed lengthwise on the cylinders, centered on the lines marked on the ends of the cylinder.

d) The rate of loading will be 1.4 to 2.1 N/mm² for 150x300mm cylinders.

**CALCULATIONS:**

The split tensile strength shall be calculated from the following formula:

\[
\sigma_{sp} = \frac{2P}{Dl}
\]

where,

\( \sigma_{sp} \) = measured splitting tensile strength calculated to 0.05N/mm²

\( P \) = max. load in N.

\( D \) = diameter in mm of the specimen.

\( l \) = measured length of the specimen in mm.
Determination of Permeability of Concrete

- DIN 1048 part V
Determination of Permeability of Concrete

APPARATUS:

- a) Moulds: Cube moulds of size 150x150mm shall be used.
- b) Compressive testing machine
- c) Permeability apparatus.

PROCEDURE:

- a) The cubes should be cast with in 3 layers with 35 blows to each layer or if vibration is given to the concrete moulds it should be ensured that there is no segregation.
- b) The test should be carried out at 28 days.
- c) The concrete cube should be made watertight from all sides except either from above or below which shall be subjected to a water pressure.
- d) The cube specimen shall be subjected to a water pressure of 0.5N/mm² acting normal to the mould filling direction for a period of three days.
- e) This pressure shall be kept constant throughout the test.
f) Immediately after the pressure has been released after three days the cube specimen shall be removed & split down the center with the face which was exposed to water facing down.

g) When the split faces shows sign of drying (after about 5 to 10 minutes), the maximum depth of penetration in the direction of cube thickness shall be measured in mm & the extent of water permeation established.

h) The mean of the maximum depth of penetration obtained from three specimens shall be taken as the test result.

CALCULATION:

- The maximum depth of penetration in the direction of cube thickness shall be measured in mm.
Rapid Chloride Penetration Test ASTM C 1202-94
Rapid Chloride Penetration Test ASTM C 1202-94

**Purpose:-**

- The purpose of the test is to measure the chloride ion penetration resistance of concrete specimens.

**Scope:-**

- This test method covers the determination of the electrical conductance of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. This test method is applicable to types of concrete where correlations have been established between this test procedure and long term chloride ponding procedures such as those described in AASHTO T 259
- **Apparatus:-**
  - Vacuum saturation apparatus, separatory funnel, beaker, vacuum desiccator, vacuum pump, coating apparatus & materials, balance or scale, specimen sizing equipment, sodium chloride solution, sodium hydroxide solution, constant voltage power supply, cable.

- **Principle:-**
  - The technique was based on principle that charged chloride ions would accelerate in an electric field towards the pole of opposite direction.
**Procedure:-**

This test was used to rapidly assess the diffusivity of different types of concretes to chloride ions. The test setup was shown in Fig. 1. For this test 100 ø x 50 mm long specimens were used. After 28 days of water curing, the specimens were allowed for conditioning as per the procedure laid down in ASTM C 1202 and the specimens were applied around the periphery with two coats of epoxy compound. The second coat was applied after an interval of about 6 hours allowing for the drying of the first coat. After that a very thin layer of M-seal was applied around the edges to avoid leakages due to surface undulations. After completion of the specimen preparation, the specimen was soaked in normal water for a period of about 1-day for complete saturation before test. The specimens were then fixed in the cells, which were designed and fabricated earlier in this laboratory according to the test suggested by Whiting (1984). These cells are first checked with water for leakages, which are controlled by either tightening the cell or by further grinding of the M seal, if necessary.