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# Cement Testing

 Website : [mattestlab.com](http://mattestlab.com)

 E-mail : [rvmattest@gmail.com](mailto:rvmattest@gmail.com)

**Vishal Raiyani**  
(M.Tech)

## CONTENTS

<b>CONSISTENCY TEST OF STANDARD CEMENT PASTE .....</b>	<b>3</b>
STANDARD: IS: 4031 (Part 4) – 1988 (RA 2014).....	3
DEFINITION.....	3
TEMPERATURE AND HUMIDITY .....	3
APPARATUS .....	3
PROCEDURE.....	3
CALCULATION .....	4
REPORT .....	4
PRECAUTION .....	4
<b>INITIAL AND FINAL SETTING TIMES TEST (CEMENT).....</b>	<b>5</b>
STANDARD: IS: 4031 (Part 5) – 1988 (RA 2014).....	5
TEMPERATURE AND HUMIDITY .....	5
APPARATUS:.....	5
PROCEDURE:.....	5
PREPARATION OF TEST BLOCK.....	5
DETERMINATION OF INITIAL SETTING TIME.....	6
DETERMINATION OF FINAL SETTING TIME .....	7
REPORTING OF RESULT .....	7
PRECAUTION .....	7
<b>COMPRESSIVE STRENGTH TEST (CEMENT).....</b>	<b>8</b>
STANDARD: IS: 4031 (Part 6) – 1988 (RA 2005).....	8
DEFINITION .....	8
TEMPERATURE AND HUMIDITY .....	8
APPARATUS:.....	8
PROCEDURE:.....	9
CALCULATION .....	11
REPORT .....	11
PRECAUTION .....	11
<b>SOUNDNESS TEST BY LE CHATELIER (CEMENT).....</b>	<b>12</b>
STANDARD: IS: 4031 (Part 3) – 1988 (RA 2014).....	12
TEMPERATURE AND HUMIDITY .....	12
APPARATUS .....	12
PROCEDURE.....	12

CALCULATION .....	13
REPORT .....	13
PRECAUTION .....	13
<b>SPECIFIC GRAVITY OF CEMENT .....</b>	<b>14</b>
STANDARD: IS: 4031 (Part 11) – 1988 (RA 2014).....	14
DEFINITION .....	14
APPARATUS .....	14
PROCEDURE.....	14
CALCULATIONS .....	14
REPORT .....	14
PRECAUTION .....	14
<b>FINENESS TEST BY DRY SIEVING (CEMENT).....</b>	<b>15</b>
STANDARD: IS: 4031 (Part 1) – 1996 (RA 2011).....	15
INTRODUCTION .....	15
APPARATUS .....	15
PROCEDURE.....	15
REPORT .....	16
PRECAUTIONS .....	16
<b>FINENESS BY BLAIN AIR PERMEABILITY METHOD (CEMENT).....</b>	<b>17</b>
STANDARD: IS: 4031 (Part 2) – 1996 (RA 2013).....	17
APPARATUS AND MATERIALS:.....	17
PROCEDURE:.....	17
TEST CONDITIONS: .....	17
COMPACTED CEMENT BED .....	18
PREPARATION OF THE SAMPLE .....	18
DETERMINATION OF DENSITY .....	18
FORMATION OF THE BED .....	18
DETERMINATION OF THE BED VOLUME .....	19
EXPRESSION OF RESULTS .....	20

## CONSISTENCY TEST OF STANDARD CEMENT PASTE

### **STANDARD: IS: 4031 (Part 4) – 1988 (RA 2014)**

- This standard (Part 4) covers the procedure for determining the quantity of water required to produce a cement paste of standard consistency.

### **DEFINITION**

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

### **TEMPERATURE AND HUMIDITY**

- The temperature of moldings room, dry materials and water shall be maintained at  $27 \pm 2^{\circ}\text{C}$ . The relative humidity of the laboratory shall be  $65 \pm 5$  percent.

### **APPARATUS**

1. Vicat Apparatus
2. Gauging Trowel
3. Balance
4. Standard Weights



### **PROCEDURE**

- Unless otherwise specified this test shall be conducted at a temperature  $27 \pm 2^{\circ}\text{C}$  and the relative humidity of laboratory should be  $65 \pm 5\%$ .
- Prepare a paste of weighed quantity of cement with weighed quantity of potable or distilled water, taking care that the time of gauging is not less

than 3 minutes or not more than 5 minutes and the gauging is completed before any sign of setting occurs.

- The gauging is counted from the time of adding water to the dry cement until commencing to fill the mould.
- Fill the vicat mould with this paste resting upon a non-porous plate.
- Smoother the surface of the paste, making it level with the top of the mould.
- Slightly shake the mould to expel the air.
- In filling the mould operator's hands and the blade of the gauging trowel shall only be used.
- Immediately place the test block with the non-porous resting plate, under the rod bearing the plunger.
- Lower the plunger gently to touch the surface of the test block and quickly release, allowing it sink into the paste.
- Record the depth of penetration
- Prepare trial pastes with varying percentages of water and test as described above until the plunger is 5 mm to 7 mm from the bottom of the vicat mould.

### **CALCULATION**

$$\text{Standard consistency (\%)} = \frac{\text{Weight of water added}}{\text{Weight of cement}} \times 100$$

### **REPORT**

- Express the amount of water as a % by mass of the dry cement to the first place of decimal.

### **PRECAUTION**

- Care shall be taken to maintain the specified temperature, humidity and the time of mixing so as to avoid setting of cement paste

## **INITIAL AND FINAL SETTING TIMES TEST (CEMENT)**

**STANDARD: IS: 4031 (Part 5) – 1988 (RA 2014)**

- This standard (Part 5) covers the procedure for determining the Initial & Final Setting Times of cement.

### **TEMPERATURE AND HUMIDITY**

- The temperature of moulding room, dry materials and water shall be maintained at  $27 \pm 2$  °C. The relative humidity of the laboratory shall be  $65 \pm 5$  percent.
- The moist closet or moist room shall be maintained at  $27 \pm 2$  °C and at a relative humidity of not less than 90 percent.

### **APPARATUS:**

1. Vicat Apparatus
2. Gauging Trowel
3. Balance
4. Standard Weights



### **PROCEDURE:**

#### **PREPARATION OF TEST BLOCK**

- Take 500 gram of cement sample & prepare a neat cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency (0.85P).

- Potable or distilled water shall be used in preparing the paste.
- The paste shall be gauged in the manner and under the conditions prescribed in IS : 4031 (Part 4) – 1988
- Start a stopwatch at the instant water is added to the cement.
- Fill the Vicat mould E with a cement paste gauged in specified manner within 3-5 minutes.
- The mould resting on a nonporous plate.
- Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould.
- The cement block thus prepared in the mould is the test block.
- Immediately after moulding, place the test block in the moist closet or moist room and allow it to remain there except when determinations of time of setting are being made.

#### **DETERMINATION OF INITIAL SETTING TIME**

- Place the test block confined in the mould & resting on the non-porous plate, under the rod bearing the needle (C).
- Lower the needle gently until it comes in contact with the surface of the test block & quickly release, allowing it to penetrate into the test block.
- 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 & released as described above, fails to pierce the block for  $5 \pm 0.5\text{mm}$  measured from the bottom of the mould.
- The period elapsing between the times when water is added to the cement & the time at which the needle fails to pierce the test block to a point  $5.0 \pm 0.5\text{mm}$  measured from the bottom of the mould shall be the initial setting time.

**Initial Setting Time should not be less than 30 min for O.P.C.**

## **DETERMINATION OF FINAL SETTING TIME**

- Replace the needle (C) of the Vicat apparatus by the needle with an annular attachment.
- 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.
- 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.
- In the event of scum forming on the surface of the test block, use the underside of the block for the determination.

**Final Setting Time should not be more than 10 hrs for O.P.C.**

## **REPORTING OF RESULT**

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

## **PRECAUTION**

- The time of gauging in any case shall not be less than 3 minutes not more than 5minutes.



## COMPRESSIVE STRENGTH TEST (CEMENT)

**STANDARD: IS: 4031 (Part 6) – 1988 (RA 2005)**

- This standard (Part 6) covers the procedure for determining the Strength of cement as represented by compressive strength tests on mortar cubes compacted by means of a standard vibration machine.

### **DEFINITION**

- Compressive strength is defined as the ratio of the load per unit area.

### **TEMPERATURE AND HUMIDITY**

- The temperature of moulding room, dry materials and water shall be maintained at  $27 \pm 2$  °C. The relative humidity of the laboratory shall be  $65 \pm 5$  percent.
- The moist closet or moist room shall be maintained at  $27 \pm 2$  °C and at a relative humidity of not less than 90 percent.

### **APPARATUS:**

- |                              |               |                   |
|------------------------------|---------------|-------------------|
| 1. Vibration Machine         | 4. Balance    | 7. Gauging Trowel |
| 2. Standard Weights          | 5. Poking Rod |                   |
| 3. Graduated Glass Cylinders | 6. Cube Mould |                   |



## PROCEDURE:

- Unless otherwise specified this test shall be conducted at a temperature  $27^{\circ} \pm 2^{\circ} \text{C}$ .
- Weigh the material required for each cube separately.
- The quantity of cement, standard sand and water required for each cube are as follows Cement = 200gms.

$$\text{Standard Sand} = 600\text{gm} \left( \begin{array}{l} 2\text{mm to } 1\text{mm} \quad - 200\text{gms} \\ 1\text{mm to } 500\text{mic} \quad - 200\text{gms} \\ 500\text{mic to } 90\text{mic} \quad - 200\text{gms} \end{array} \right) \text{Conforming to IS: 650 -1991.}$$

**Water =  $(P / 4 + 3)$**  Percentage of combined mass of cement and sand.

P is the consistency of cement as per IS: 4031 (Part 4) 1988.

- Place on a nonporous plate, a mixture cement and standard sand.
- Mix it dry with a trowel for one minute and then with water until the mixture is of uniform color.
- The time of mixing shall in any event be not less than 3 minutes and should be the time taken to obtain uniform colour exceeds 4 minutes.
- In assembling the moulds ready for use, cover the joints between the halves of the mould with a thin film of petroleum jelly and apply a similar coating of petroleum jelly between the contact surface of the bottom of the mould and base plate in order to ensure that no water escapes during vibration.
- Place the assembled mould on the table of the vibration machine & hold it firmly in position by means of suitable clamp, attach a hopper of suitable size & shape securely at the top of the mould to facilitate filling & hopper shall not be removed until the completion of vibration period.
- Immediately after fixing the mould in the vibrating machine, place the mortar in the cube mould and prod with the rod.

- Prod the mortar 20 times in about 8 seconds to ensure elimination of entrapped air and honey combing.
- Place the remaining mortar in the cube mould and prod again as specified for the first layer and then compact the mortar by vibration.
- The period of vibration shall be 2 minutes at the specified speed of  $12000 \pm 400$  vibrations per minute.
- Remove the mould from the vibrating machine and cut off the excess mortar with a straight edge.
- Store the test specimens in a place free from vibration, in moist air of at least 90 percent relative humidity and at a temperature of  $27 \pm 2^{\circ}\text{C}$  for  $24 \pm 1/2$  hours from the addition of water to the dry ingredients.
- After this period, mark the specimens and remove from the moulds and unless required for test within 24 hours.
- Immediately submerge the cubes in a clean, fresh water or saturated lime solution and keep there until taken out just prior to test.
- Renew the water or solution in which the specimens are submerged for every seven days, and the temperature of water is maintained with the specified limits.
- Conduct testing at recognized ages of the specimens, the most usual being 7 and 28 days.
- When it may be necessary to obtain the early strength, tests may be conducted at the age of  $72 \pm 2$  hours.
- Calculate the ages from the addition of water to the dry ingredients.
- Test at least three specimens preferably from different batches at each selected age.

## CALCULATION

- The measured compressive strength of the cubes shall be calculated by dividing the maximum load applied to the cubes during the test by the cross-sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest 0.5 N/mm<sup>2</sup>. In determining the compressive strength, do not consider specimens that are manifestly faulty, or that give strengths differing by more than 10 percent from the average value of all the test specimens. After discarding specimens or strength values, if less than two strength values are left for determining the compressive strength at any given period, a retest shall be made.

$$\text{Compressive strength} = \frac{\text{Load}}{\text{Cross sectional area of the specimen}} \quad \text{N / mm}^2$$

## REPORT

- Report the individual and the mean results to the second decimal and express in N/ mm<sup>2</sup>.

## PRECAUTION

- The time of mixing is very important and in no. case shall not be less than 3 minutes and not to exceed 4 minutes.

## SOUNDNESS TEST BY LE CHATELIER (CEMENT)

### **STANDARD: IS: 4031 (Part 3) – 1988 (RA 2014)**

- This standard (Part 3) covers the procedure for determining the soundness of cement.

### **TEMPERATURE AND HUMIDITY**

- The temperature of moulding room, dry materials and water shall be maintained at  $27 \pm 2$  °C. The relative humidity of the laboratory shall be  $65 \pm 5$  percent.
- The moist closet or moist room shall be maintained at  $27 \pm 2$  °C. And at a relative humidity of not less than 90 percent.

### **APPARATUS**

1. Le Chatelier
2. Balance
3. Weights
4. Water Bath



### **PROCEDURE**

- Take representative sample of cement and mix with 0.78 times the water required to give a paste of standard consistency as per IS: 4031 (Part 4) 1988.
- Place a lightly oiled mould on a lightly oiled glass and fill it with this cement paste.
- Prepare the paste in a manner and under the conditions all as per IS: 4031 (Part 4) 1988.
- Keep the edges of the mould gently together during this operation.
- Cover the mould with another piece of lightly oiled glass sheet and place a small weight.

- Immediately submerge the whole assembly in water bath maintained at a temperature of  $27 \pm 2^{\circ}\text{C}$  and keep there for 24 hours.
- After 24 hours remove the mould from the water bath and measure the distance separating the indicator points ( $E_1$ ).
- Again submerge the whole assembly in water bath at a temperature of  $27 \pm 2^{\circ}\text{C}$  and bring the water to boiling in  $27 \pm 3$  minutes and keep it for 3 hours.
- Remove the mould from the water bath, allow it to cool and measure the distance between the indicator points ( $E_2$ ).
- The distance between the two measurements indicates the expansion of the cement.
- Make at least two determinations for each test.

### **CALCULATION**

- Calculate the mean of two values to the nearest 0.5 mm to represent the expansion of cement.
- Calculate the Soundness of cement from the equation given below

$$\text{Soundness} = E_2 - E_1$$

$E_1$  = Initial distance between the indicator points.

$E_2$  = Final distance between the indicator points.

### **REPORT**

- Report the individual and the mean results to the nearest 0.5 mm.

### **PRECAUTION**

- Take care to maintain the temperature of the moulding room, dry material and water within  $27 \pm 2^{\circ}\text{C}$  and the humidity of the laboratory within  $65 \pm 5\%$ .

## SPECIFIC GRAVITY OF CEMENT

**STANDARD: IS: 4031 (Part 11) – 1988 (RA 2014)**

- This standard (Part 11) covers the procedure for determining the Specific Gravity.

### **DEFINITION**

- Specific Gravity is defined as the ratio of the mass of the cement to the mass of an equal volume of kerosene.

### **APPARATUS**

1. Standard Lee Chatlier flask 250ml capacity.
2. Balance of capacity 500gm and sensitivity to 0.01grams.

### **PROCEDURE**

- Clean and dry the Lee chattier flask.
- Fill the flask with kerosene exactly up to the zero graduation.
- Take approximately about 64 grams of cement and pour it in to the flask.
- Shake well until no air bubbles are visible in the flask.
- Allow the cement in the flask to settle down completely, preferably 24 hours.
- Note the volume of kerosene read from the flask.
- Make at least two determinations for each test.



### **CALCULATIONS**

- Specific Gravity = 
$$\frac{\text{Weight of cement}}{\text{Volume of kerosene read from the flask}}$$

### **REPORT**

- Report the individual and the mean results to the nearest second decimal.

### **PRECAUTION**

- Care shall be taken to avoid loss while pouring the cement in to the flask.

## FINENESS TEST BY DRY SIEVING (CEMENT)

### STANDARD: IS: 4031 (Part 1) – 1996 (RA 2011)

- This standard (Part 1) covers the procedure for determining the Fineness of cement by dry sieving as represented by the mass of the residue left on a standard 90-micron I.S. Sieve.

### INTRODUCTION

- 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 of hydration and hence the faster and greater the development of strength. Increase in fineness of cement is also found to increase the drying shrinkage of concrete. Specific surface is the total surface area of all the particles in one gram of cement.

### APPARATUS

1. 90-micron I.S. Sieve
2. Balance
3. Brush



### PROCEDURE

- Weight accurately 10 g of cement and place it on a standard 90 μm IS sieve (Wt. A).
- Break down any air-set lumps in the cement sample if any with fingers.
- Continuously sieve the sample giving circular and vertical motion for a period of 2 minutes. Mechanical sieving devices may also be used.
- Weigh the residue left on the sieve (Wt. B).
- This weight shall not exceed 10% for ordinary cement.

Percentage of fineness (C) of sample shall be calculated as follows & the average of 3 tests shall be reported.

$$\% \text{ of fineness (C)} = \frac{B \times 100}{A}$$

**The value of C, to the nearest 0.1 percent, as the residue on the 90 μm sieve for the cement tested**



## **REPORT**

- Report the individual and the mean results the nearest 0.1percent
- When the results differ by more than one percent absolute, carry out a third sieving and calculate the mean of the results.

## **PRECAUTIONS**

- Care shall be taken while sieving to avoid spilling of cement from the sieve.
- Sieving shall be carried out manually by a skilled and experienced labour

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## **FINENESS BY BLAIN AIR PERMEABILITY METHOD (CEMENT)**

**STANDARD: IS: 4031 (Part 2) – 1996 (RA 2013)**

- This standard (Part 2) covers the procedure for determining by Blaine air permeability apparatus, the fineness of cement as represented by specific surface expressed as total surface area in  $\text{cm}^2/\text{g}$ .

### **APPARATUS AND MATERIALS:**

1. Variable Flow Type Air Permeability Apparatus
2. Timer
3. Balances
4. Standard Weights
5. Pycnometer
6. Manometer Liquid
7. Mercury
8. Reference Cement
9. Light oil
10. Light Grease



### **PROCEDURE:**

### **TEST CONDITIONS:**

- The laboratory in which the air permeability test is carried out shall be maintained at a temperature of  $27 \pm 2^\circ\text{C}$  and a relative humidity not exceeding 65 percent. All materials for test and calibration shall be at the

laboratory temperature when used and shall be protected from absorption of atmospheric moisture during storage. A laboratory temperature of  $20 \pm 2^\circ\text{C}$  may be maintained, if desired by the purchaser.

### COMPACTED CEMENT BED

- The compacted cement bed comprises a reproducible arrangement of cement particles with a specified volume of air included between the particles. This air volume is defined as a fraction of the total volume of the bed and is termed the porosity,  $e$ .
- It follows that the volume fraction occupied by the cement particles is  $(1-e)$ . If  $V$  is the total volume of the bed, the absolute volume of cement is  $V(1-e)$  ( $\text{cm}^3$ ), and the mass of cement  $m$  is  $pV(1-e)$  (g) where  $p$  is the solid density of the cement particles  $p$  ( $\text{g}/\text{cm}^3$ ).
- Thus, knowing  $p$ , a mass of cement can be weighed to produce a desired porosity,  $e$ , in the compacted bed of total volume  $V$ .

### PREPARATION OF THE SAMPLE

- Agitate the sample of cement to be tested by shaking for 2 min in a stoppered jar to disperse agglomerates. Wait for 2 min. stir the resulting powder gently using a clean dry rod in order to distribute the fines throughout the cement.

### DETERMINATION OF DENSITY

- Determine the density of the cement using a device such as a pycnometer or Le-chatelier flask. Use a non-reactive liquid in the determination. The quantity of cement used will depend on the nature of the apparatus but shall be such that the value of  $p$  determined is accurate to  $0.01 \text{ g}/\text{cm}^3$ . Verify this accuracy by a repeat determination and record the mean of the two determinations to the nearest  $0.01 \text{ g}/\text{cm}^3$  as the density.

### FORMATION OF THE BED

1. To give a cement bed of porosity  $e = 0.500$  weigh a quantity of cement,  $m_1$ , calculated from

$$M_1 = 0.500 pV \text{ (g)}$$

Where,  $p$  is the density of the cement ( $\text{g}/\text{cm}^3$ ), and

$V$  is the volume of the cement bed ( $\text{cm}^3$ ).

2. This mass, correctly compacted, will produce a bed of porosity 0.500. Place the perforated disc on the ledge at the bottom of the cell and place on it a new filter paper disc. Ensure that the filter paper disc fully covers the perforated disc and is flat by pressing with a clean dry rod. Place the weighed quantity of cement,  $m_1$ , in the cell taking care to avoid loss.
3. Tap the cell to level the cement. Place a second new filter paper disc on the levelled cement. Insert the plunger to make contact with the filter paper disc. Press the plunger gently but firmly until the lower face of the cap is in contact with the cell. Slowly withdraw the plunger about 5 mm, rotate it through  $90^\circ$  and gently but firmly press the bed once again until the plunger cap is in contact with the cell. The bed is now compacted and ready for the permeability test. Slowly withdraw the plunger.

#### **DETERMINATION OF THE BED VOLUME**

1. Owing to the need for clearance between the cell and the plunger, the volume of the compacted cement bed varies for each cell-plunger combination. The volume of the compacted cement bed shall be established for a given cell-plunger clearance, this volume is to be determined as follows.
2. Apply a very thin film of light mineral oil to the cell interior. Place the perforated disc on the ledge in the cell. Place two new filter paper discs on the perforated disc and ensure that each covered the base of the cell whilst lying flat by pressing with a rod.
3. Fill the cell with mercury. Remove any air bubbles with a clear dry rod. Ensure that the cell is full by pressing a glass plate on the mercury surface until it is flush with the cell top. Empty the cell, weigh the mercury to the nearest 0.01 g,  $m_2$ , and record the temperature. Remove one filter paper disc. Form a compacted cement bed by the method described in and places on it a new filter paper disc. Refill the cell with mercury, removing air bubbles and leveling the top as before. Remove the mercury, weigh it to the nearest 0.01 g,  $m_3$  and check the temperature.

The bed volume  $V$  is given by

$$V = (m_2 - m_3) / D$$

### **EXPRESSION OF RESULTS**

- Where the porosity is  $e = 0.500$ , the four times and temperatures resulting from the procedure shall be examined to check that the temperatures all fall within the specified range of  $27 \pm 2^\circ\text{C}$  or  $27 \pm 2^\circ\text{C}$ .
- The resulting value of  $S$ , to the nearest  $10 \text{ cm}^2/\text{g}$ , shall be reported as the specific surface of the cement.
- A difference of 1 percent between the means of the fineness measurements carried out on two different powder beds from one and the same sample is acceptable.
- The standard deviation of the repeatability is and of the reproducibility is about  $100 \text{ cm}^2/\text{g}$ . Where the porosity  $e$  is not  $= 0.500$ , equation 5 shall be used and the result to the nearest  $10 \text{ cm}^2/\text{g}$  reported as the specific surface of the cement. If, owing to a breakdown in control or for other reasons, the four temperatures do not lie within the specified range of  $27 \pm 2^\circ\text{C}$  or  $27 \pm 2^\circ\text{C}$  a value of  $S$  shall be reported, to the nearest  $10 \text{ cm}^2/\text{g}$ , as specific surface of the cement.