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## Cement Testing

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## DETERMINATION OF CONSISTENCY OF STANDARD CEMENT PASTE

### STANDARD: IS: 4031 (Part 4) 1988: -

- ❖ 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 7 mm 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 not less than 65 percent.

### APPARATUS: -

1. Vicat Apparatus
2. Gauging Trowel
3.  $1000 \pm 1.0\text{gms}$  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 shall not less than 65 percent.
- ❖ Prepare a paste of weighted quantity of cement with weighted quantity of potable or distilled water, taking care that the time of gauging is less than neither 3 minutes nor 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 an on-porous plate.
- ❖ Smoothen 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 in to 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.

**PRECAUTION: -**

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

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**-- End of SOP --**



## DETERMINATION OF INITIAL & FINAL SETTING TIMES

### STANDARD: IS: 4031 (Part 5) – 1988

- ❖ 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 not less than 65 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 400 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  $5.0 \pm 0.5\text{mm}$  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.

**Note: - 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.

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

#### **PRECAUTION**

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

**-- End of SOP --**

## DETERMINATION OF COMPRESSIVE STRENGTH TEST

### STANDARD: IS: 4031 (Part 6) – 1988

- ❖ 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

1. The temperature of moulding room, dry materials and water shall be maintained at  $27 \pm 2$  °C. The relative humidity of the laboratory shall not less than 65 percent.
2. 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
2. Balance
3. Gauging Trowel
4. Standard Weights
5. Poking Rod
6. Graduated Glass Cylinders
7. Cube Mould



### PROCEDURE:

- ❖ Unless otherwise specified this test shall be conducted at a temperature  $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ .
- ❖ 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.

Standard Sand=600gm

( 2 mm to 1mm - 200gms  
1mm to 500mic - 200gms  
500 mic to 90mic - 200gms )

Conforming to IS:650-1991

- ❖ Water=(P/4+3) Percentage of combined mass of cement and sand. The consistency of

cement as per IS: 4031(Part4)1988.

- ❖ Place on an on porous plate, 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 3minutes and should be the time taken to obtain uniform color exceeds 4minutes.
- ❖ 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 & shapes curly at the top of the mould to facilitate filling & hoppers shall not be removed until the completion of vibration period.
- ❖ Prod the mortar 20 times in about 8seconds to ensure lamination 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.
- ❖ 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  $24 \pm 1$  after completion of vibration.
- ❖ After this period remove them from mould & immediately submerge the cubes in a clean, fresh water or saturated lime solution and keep the 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.

- ❖ The cube shall be tested on their sides without any packing and apply load at uniform rate of  $35 \text{ N/mm}^2$  per min.

**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.

**-- End of SOP --**

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## DETERMINATION OF SOUNDNESS TEST BY LE CHATELIER

### STANDARD: IS: 4031 (Part 3) – 1988

- ❖ 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  $27 \pm 2^\circ\text{C}$ .  
The relative humidity of the laboratory shall not less than 65 percent.
- ❖ The moist closet or moist room shall be maintained at  $27 \pm 2^\circ\text{C}$ . 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 condition 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 oil glass sheet and place a small weight.
- ❖ Immediately submerge the whole assembly in water bath maintain data temperature of  $27 \pm 2^\circ\text{C}$  and keep therefor 24 hours.
- ❖ After 24hours remove the mould from the water bath and measure the distances pirating the indicator points ( $E_1$ ).
- ❖ Again, submerge the whole assembly in water bath at a temperature of  $27 \pm 2^\circ\text{C}$  can 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.

**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 shall not less than 65 percent.

**-- End of SOP --**

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## DETERMINATION OF FINENESS BY BLAINE AIR PERMEABILITY METHOD

### STANDARD: IS: 4031 (Part 2) – 1999

- ❖ 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. Manometer Liquid
3. Timer
4. Mercury
5. Balances
6. Reference Cement
7. Standard Weights
8. Light oil
9. Pycnometer
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.

#### 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  $pV(1-e)$  ( $\text{g}$ ) 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 g/cm<sup>3</sup>. Verify this accuracy by a repeat determination and record the mean of the two determinations to the nearest 0.01 g/cm<sup>3</sup> as the density.

#### **FORMATION OF THE BED**

- ❖ To give a cement bed of porosity  $e = 0.500$  weigh a quantity of cement,  $m$ , calculated from

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

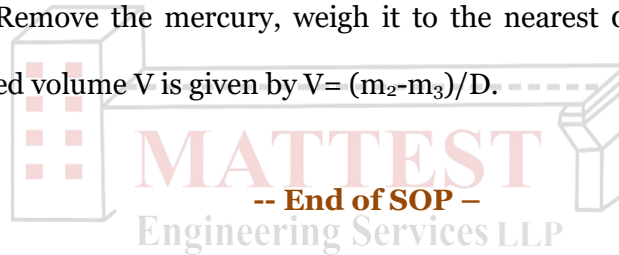
Where,  $P$  is the density of the cement (g/cm<sup>3</sup>), and

$V$  is the volume of the cement bed (cm<sup>3</sup>).

- ❖ 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,  $m$ , in the cell taking care to avoid loss.
- ❖ 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° 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**

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



## DETERMINATION OF FINENESS TEST BY DRY SIEVING (CEMENT)

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

- ❖ 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

- ❖ Weigh 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 with 2 min. stirring.
- ❖ Continuously sieve the sample giving circular motion for a period of 2 minutes. Mechanical sieving devices may also be used.
- ❖ Weigh the residue left on the sieve (Wt. B).
- ❖ Percentage of fineness (C) of sample shall be calculated as follows & the average of 3 tests shall be reported.

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

A

**Note:** % of fineness shall not exceed 10% for ordinary cement.

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

**-- End of SOP --**

## DETERMINATION OF DENSITY

### STANDARD: IS: 4031 (Part 11) – 1988

- ❖ This standard (Part 11) covers the procedure for determining the Density.

### DEFINITION

- ❖ Density is defined as the ratio of the mass of the cement to the mass of an equal volume of kerosene.

### APPARATUS

1. Standard Le-Chatelier flask
2. Balance



### PROCEDURE

- ❖ Clean and dry the Le-Chatelier flask.
- ❖ Fill the flask with kerosene exactly up to the zero to one mark.
- ❖ 1<sup>st</sup> reading shall be recorded after the flask has been immersed in water bath with constant temperature.
- ❖ 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 few hours.
- ❖ Final reading shall be recorded after the flask has been immersed in water bath with constant temperature. Note the volume of kerosene read from the flask.
- ❖ Make at least two determinations for each test.

**Calculation:** Density = Mass of Cement (g) / Displaced Volume (cm<sup>3</sup>)

\*Displace Vol. = Final Reading – Initial Reading

**-- End of SOP --**