Types of Portland Cement

TYPE I : Ordinary Portland Cement

- ✓ *Is the cement most widely used (Common type), for use in general concrete construction.*
- ✓ *used when there is no exposure to sulfates in the soil or in groundwater.*
- ✓ *High 28-days compressive strength.*

Types of Portland Cement

TYPE II : Modified Portland Cement

- *Increase later strength, increase sulfate resistance.*
- *Reduce early strength, reduce heat of hydration.*
- *For use in general concrete construction exposed to moderate sulfate action or where moderate heat of hydration is required.*
- *Used in drainage structure, retaining walls abutment.*

Types of Portland Cement

TYPE III: High Early Strength Portland Cement (Rapid hardening)

- *Increase early strength, increase heat of hydration.*
- *Reduce later strength, reduce sulfate resistance.*
- *For use when high early strength is required.*
- *Early removal of formwork, or where sufficient strength for further construction is required quickly, cold weather concreting.*

Types of Portland Cement

TYPE IV: Low Heat Portland Cement

- *Increase later strength, increase sulfate resistance.*
- *Reduce early strength, reduce heat of hydration.*
- *For use when low heat of hydration is required.*
- *For use in massive concrete structures (large gravity dams), hot weather concreting.*

Types of Portland Cement

TYPE V: High sulfate resisting Portland Cement

- *Increase later strength, increase sulfate resistance.*
- *Reduce early strength, reduce heat of hydration.*
- *For use when high sulfate resisting is required.*
- *Concrete exposed to severe sulfate action, where soils have high sulfate content.*

***Other Types : Air Entraining Portland Cements** that improves the freeze –thaw resistance of concrete.*

Type IA

Type IIA

Type IIIA

Cement Tests

Number of tests are performed in the cement plant laboratory to ensure that the cement is of the desired quality and that it conforms to the requirements of the relevant national standards.

Normal consistency test (ASTM 187 - 86 Re approved 1991)

In the acceptance tests for cement, the water content is regulated by bringing the paste to a standard condition of wetness. This is called "Normal Consistency" measured using Vicat Apparatus.

Definition of terms

- Normal consistency: A standard measure of plasticity of a cement paste. A paste has normal consistency when a Vicat plunger (10 mm in diameter) penetrates 10 ± 1 mm in 30 sec under its own weight. The required water/cement ratio is determined by trial and error.

- Cement of normal consistency is required to measure setting time.

Normal consistency test

- *Procedures*

- place the mixing water in the bowl.

-Add cement and allow 30s for the absorption of the water.

- Mix at slow speed for 30s.

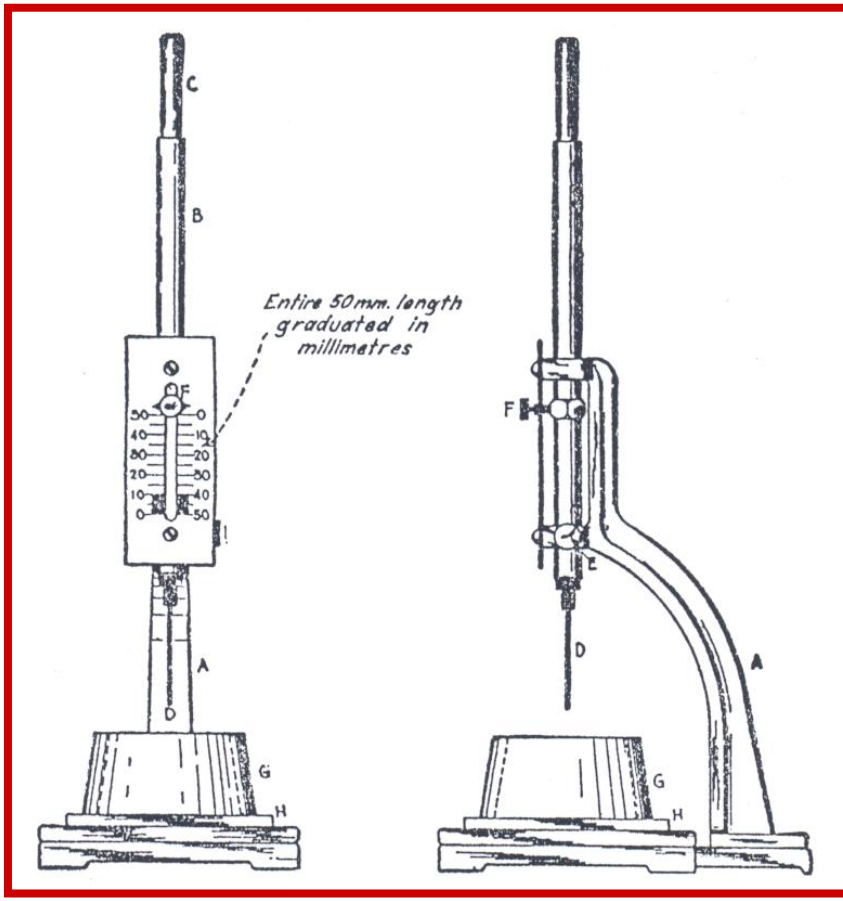
- Stop the mixer and wait for 15s, during this time scrape down into batch any paste that may have collected on sides of the bowl.

-Mix at medium speed for 1 minute.

- Mould cement paste into shape of a ball. With gloved hands, toss ball six times through a free path of about 150 mm from one hand to another.

Normal consistency test

- *Press ball into larger end of Vicat ring and completely fill ring with paste.*
- *Remove excessive paste without compressing samples and locate ring under plunger of Vicat apparatus.*
- *Place plunger in contact with top of paste and lock. Set indicator on the scale to zero.*
- *Release plunger and record settlement of plunger in mm after 30 seconds.*
- *Repeat process with trial paste with varying percentages of water until normal consistency is observed.*



Set Time Test (ASTM C 191 - 92)

- *Setting time is the term used to describe the stiffening of the cement paste, and it refers to a change from a fluid state to a rigid state.*

- *Definition of terms:*

- Time of initial set: The time at which the concrete can no longer be properly mixed, finished or compacted. (Represented by a Vicat needle (1mm in diameter) penetration of 25 mm or less). ASTM C150 prescribes a minimum initial setting time of 60 minute for Portland cement.

- Time of final set: The time required for the cement to harden to a point where it can sustain some load. (Represented by no penetration of Vicat needle, the needle makes an impression and the cutting edge fails). ASTM C150 prescribes a maximum final setting time of 10-12 hours for Portland cement.

Set Time Test

Factors affecting setting time:

- *Temperature and humidity.*
- *Amount of water (w/c)*
- *Chemical composition of cement.*
- *Fineness of cement (finer cement → faster setting).*

Set Time Test

- *Procedures*

- Mix 650 g of cement with the percentage of water required for normal consistency as described above.

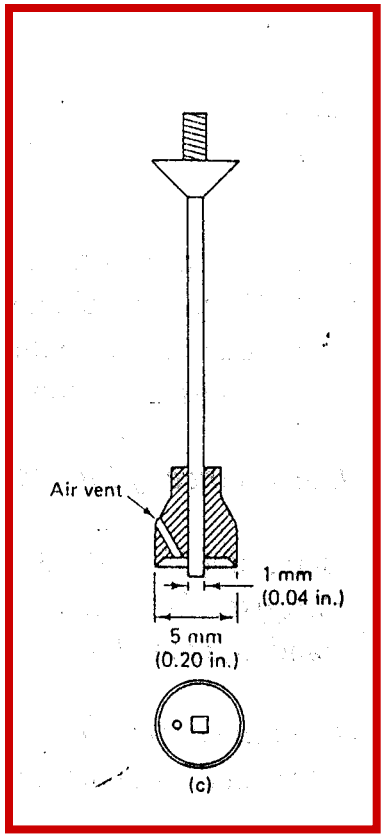
- After molding cement paste into the test ring, place specimen in moist room for 30 minutes.

- Place specimen ring under Vicat apparatus and lock needle on surface of paste. Set indicator scale to zero.

- Release weighted needles and record the penetration in mm after 30 seconds.

- Repeat process every fifteen minutes until initial set is achieved.

- Repeat processes every hour until final set is achieved.



Strength Tests

Usually mortar specimen made of standard sand having fixed water content (or fixed consistency), are molded and cured in standard way until age of testing.

- *Mortar Composition - The proportions of materials for the standard mortar shall be one part of cement to 2.75 parts of graded standard sand by weight. Use a water-cement ratio of 0.485 for all portland cements and 0.460 for all air-entraining portland cements. The water-cement ratio for other than portland and air-entraining portland cements shall be such as to produce a flow of 110 +/- 5.*
- *Specimen Mold Preparation - Apply a thin coating of mold release to the interior surfaces of the molds and base plates. Wipe surfaces with a cloth to remove any excess.*

Mortar Mixing Procedure (ASTM C305)

- Place dry paddle and dry bowl in the mixing position of the mixer. Introduce the materials into the bowl in the following manner:

1) Place all the mixing water in the bowl.

2) Add the cement to the water; then start the mixer and mix at slow speed (140 rpm) for 30 s.

3) Add sand slowly over a 30 s period, while continued mixing at slow speed.

4) Stop the mixer, change to medium speed (285 rpm), and mix for an additional 30 s.

5) Stop the mixer and let the mortar stand for 1.5 minutes. During the first 15 s, quickly scrape down into the batch any mortar that may have collected on the side of the bowl; then for remainder of the interval, cover with the lid.

6) Finish mixing for 1 minute at medium speed (285 rpm).

7) Determine flow of mortar as follows: Reading

a) Wipe table clean and dry and place flow mold at center

b) Place a layer of mortar about 25 mm thickness in the mold and tamp 20 times.

c) Then fill the mold and tamp this second layer 20 times.

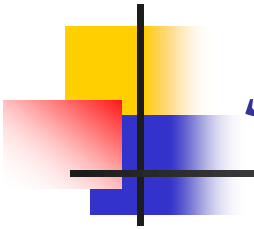
d) Cut mortar flush with top of mold with a trowel, held perpendicular to the mold, using a sawing motion.

e) Wipe table around mold clean of all mortar and dry; then remove mold.

f) Drop table through 12.5 mm height 25 times in 15 s.

g) Use calipers to measure the diameters along the 4 inscribed lines on the table. The sum of the four readings is the flow (the percent increase in the original diameter). Record this flow value.

8) Following flow test, return all mortar to the mixing bowl. Scrape down the sides and remix for 15 s at medium speed (285 rpm).



Strength Tests

Molding Test Specimens - Start molding within 2 minute and 30 s after completion of the original mixing of the mortar.

Compressive Test

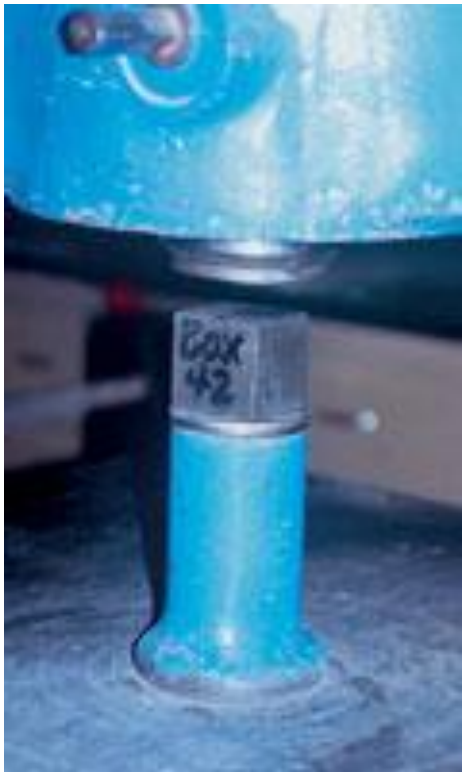
- *Fill the mold in two layers, compact each layer 32 times. in about 10 s in four (4) rounds .*

- *Place molded specimens in a moist room for 24 hours. Keep specimens in their molds for this initial curing period. After 24 hours remove specimens from the molds and immerse in a curing tank.*

- *Compressive Strength Determination - Test all specimens according to the specified testing schedule. 3, 7, and 28 day strengths will be obtained to ascertain the strength gain as a function of time.*

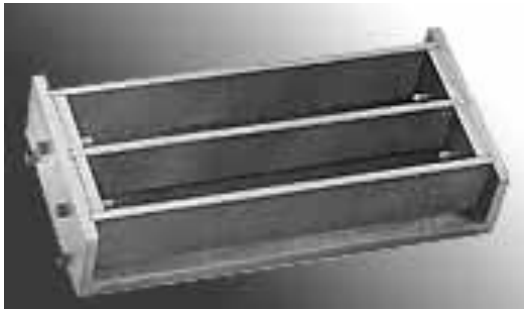
Compression Test

- *Apply the load to specimen faces that were in contact with the true plane surfaces of the mold*
- *Place specimen below the center of the upper bearing block of the testing machine.*
- *Compressive strength (σ_c) = P/A (where A = 50*50 mm^2)*



Flexural Test

- *Using Prisms (40*40*160) mm*
- *Fill the mold in two layers, compact each layer 12 times.*
- *The flexural test uses simply-supported mortar prisms loaded at mid span.*
- *Flexural strength* $(\sigma_f) = \frac{MC}{I}$



Flexural Assembly

Direct Tensile Test

- *Using briquette Specimen*
- *Fill the mold in two layers, press each layer 12 times by thumb.*
- *Tensile strength (σ_t) = P/A (where A = 25*25 mm2)*