PROPERTIES OF CEMENT

Physical properties Mechanical properties Chemical properties

Physical properties of cement

- Depend upon its chemical composition, thoroughness of burning ad fineness of grinding
- Gives strength to the masonry
- An excellent binding material
- Easily workable
- Offers good resistance to the moisture
- Possesses a good plasticity
- Stiffens or hardens early
- A t thin paste of cement with water should feel sticky between the fingers.
- A cement thrown in water should sink and should not float on the surface

Mechanical properties of cement

- The compressive strength at the end of 3 days should not be less than 11.5 N/mm^2 and that at the end of 7 day should not be less than 17.5N/mm^2.
- The tensile strength at the end of 3 days should not be less than 2N/mm2 and that at the end of 7 days should not be less than 2.50N/mm^2.

Chemical properties of cement

- The ratio of percentage of alumina to iron oxide should not be less than 0.66
- The ratio of percentage of lime to alumina, iron oxide and silica, known as Lime Saturation Factor (LSF) should not be less than 0.66 and should not be more than 1.02.
- Total loss of ignition should not be more than 4 per cent.
- Total sulphur content should not be more than 4 per cent.
- Weight of insoluble residue should not be more than 1.50 per cent.
- Weight of magnesia should not exceed 5%

MORTAR

Paste prepared by adding required quantity of water to a mixture of binding material like cement or lime and fine aggregate like sand.

Classification of mortars

Based on Bulk density

Kind of binding material

Nature of application special

mortars

PROPERTIES OF CEMENT MORTARS

- Capable of developing good adhesion with the building units such as bricks, stones
- Capable of developing the designed stresses
- Capable of resisting penetration of rain water
- should be cheap
- Should be durable
- Should be easily workable
- Should not affect the durability of materials with which it comes into contact
- Should set quickly so that speed in construction may be achieved
- Joints formed by mortar should not develop cracks and they should be able to Maintain their appearance for a sufficiently long period.

HYDRATION

- The reaction of cement with water is exothermic
- The reaction liberates a considerable quantity of heat.
- This liberation of heat is called Heat of Hydration.
- Study and control of the heat of hydration becomes important in the construction of concrete dams and other mass concrete constructions.
- Different compounds hydrate at different rates and liberate different quantities of heat.

Heat of Hydration at the given age (cal/g)			
Compound	**3 Days**	**90 Days**	**13 Years**
C35	58	104	122
C25	12	42	59
C3A	212	311	324
C4AF	69	98	102

Heat of hydration of cement is an additive property (H) H=

aA + bB+ cC + dD

Where, A, B, C, and D are the percentage contents of C3S, C2S, C3A and C4AF.

And a, b, c and d are coefficients representing the contribution of 1 % of the corresponding compound to the heat of hydration

COMPRESSIVE STRENGTH (CEMENT MORTAR)

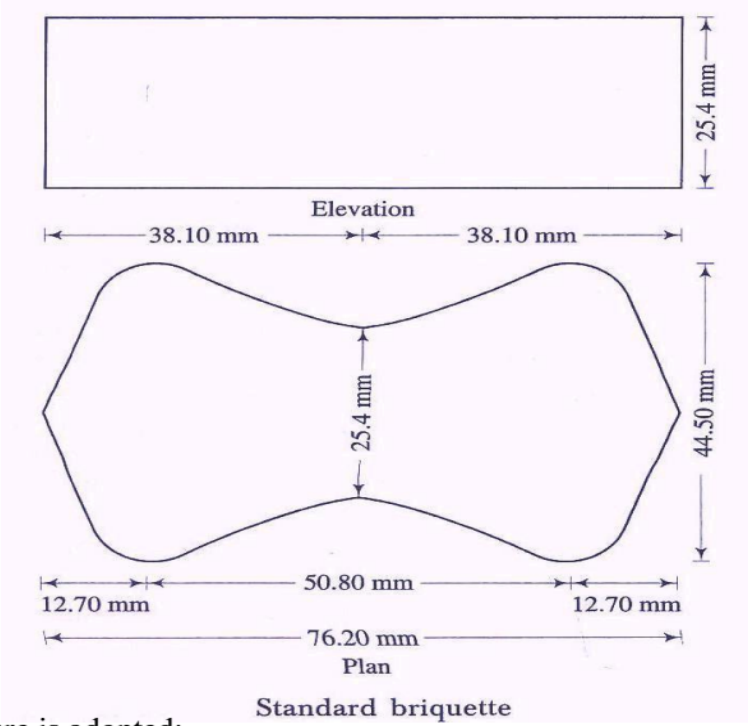
- Compressive strength is the basic data required for mix design.
- By this test, the quality and the quantity of concrete can be controlled and the degree of adulteration can be checked.
- The test specimens are 70.6 mm cubes having face area of about 5000 sq. mm.
- Large size specimen cubes cannot be made since cement shrinks and cracks may develop.
- The temperature of water and test room should be 27°± 2°C.
- A mixture of cement and standard sand in the proportion 1:3 by weight is mixed dry with a trowel for one minute and then with water until the mixture is of uniform colour.
- Three specimen cubes are prepared. The material for each cube is mixed separately.
- The quantities of cement, standard sand and water are 185 g, 555 g and (P/4) + 3.5, respectively where P = percentage of water required to produce a paste of standard consistency.
- The mould is filled completely with the cement paste and is placed on the vibration table. Vibrations are imparted for about 2 minutes at a speed of 12000±400 per minute.
- The cubes are then removed from the moulds and submerged in clean fresh water and are taken out just prior to testing in a compression testing machine.
- Compressive strength is taken to be the average of the results of the three cubes.
- The load is applied starting from zero at a rate of 35 N/sq mm/minute.
- The compressive strength is calculated from the crushing load divided by the average area over which the load is applied.

  The result is expressed in $N/mm^{2.}$

Material	Compressive strength (N/mm2)	
	14 Days	28 Days
Class A lime	1.75	2.8
Class B lime	1.25	1.75
Cement 33 Grade	22	33

TENSILE STRENGTH

Generally used for the rapid hardening cement



Standard briquette

Following Procedure is adopted:

- Mortar is prepared in 1:3 proportions and the quantity of water is 8% by weight of cement and sand and placed in briquette moulds.
- The mould is filled with mortar and then a small heap of mortar is formed at its to.
- It is beaten down by a standard spatula till water appears on the surface.
- Twelve standard briquettes are prepared by following same procedure and the quantity of cement may be 600 gm for 12 briquettes.
- The briquettes are kept in a damp cabin for 24 hours and after 24 hours the briquettes are carefully remove from the moulds and they are submerged in clean water for curing.

- The briquettes are tested in testing machine at the end of 3 days and 7 days.
- Six briquettes are tested in each test and average is found out.
- During the test the load is to be applied uniformly at the rate of 35Kg/Cm^2 or 3.50N/mm^2.
- The cross-sectional area of briquette at its least section is 6.45cm^2.
  Ultimate tensile stress = Failing load/6.45
- The tensile stress at the end of 3days should not be less than 20Kg/Cm^2 or 2 N/mm^2.
- And that at the end of 7 days should not be less than 25Kg/Cm^2 or 2.50 N/mm^2.

FINENESS

- Test is carried out to check proper grinding of cement.
- The fineness of cement particles may be determined by either by sieve test or by permeability apparatus test.
- In sieve test, the cement weighing 100 gm is taken and it is continuously passed for 15 minutes through standard BIS sieve no.9 and residue is then weighed and this weight should not be more than 10% of original weight.
- In permeability apparatus test. Specific surface area of cement particles is calculated. This test is better than sieve test and it gives an idea of uniformity of fineness. The specific surface acts as a measure of the frequency of particles of average size. The specific surface of cement should not be less
  than 2250cm^2/gm.

SOUNDNESS

Purpose of the test _ to detect the presence of uncombined lime in cement.

This test is performed with the help of Le Chatelier apparatus as shown in figure below

It consists of a brass mould of diameter 30mm and height 30mm. There is a split in mould and it does not exceed 0.50mm. On either side of split, there are two indicators with pointed ends. The thickness of mould cylinder is 0.50mm.

Procedure :

i. The cement paste is prepared. The percentage of water is taken as determined in the consistency test.
ii. The mould is placed on a glass plate and it is filled by cement paste.

iii. A small weight is placed at top and the whole assembly is submerged in water for 24 hours. The temperature of water should be between 24 °C to 35 ° C.

iv. The distance between the points of indicator is noted the mould is again placed in water and heat is applied in such a way that boiling point of water is reached in about 30 minutes. The boiling of water is continued for one hour.

v. The mould is removed from water and it is allowed to cool down.

vi. The distance between the points of indicator is again measured.

vii. The difference between the two readings indicates the expansion of cement and it should not exceed 10mm.

CONSISTENCY

Purpose – to determine the percentage of water required for preparing e cement pastes for other test.

Procedure :

I. Take 300gm of cement and add 30 % by weight or 90 gm of water to it.

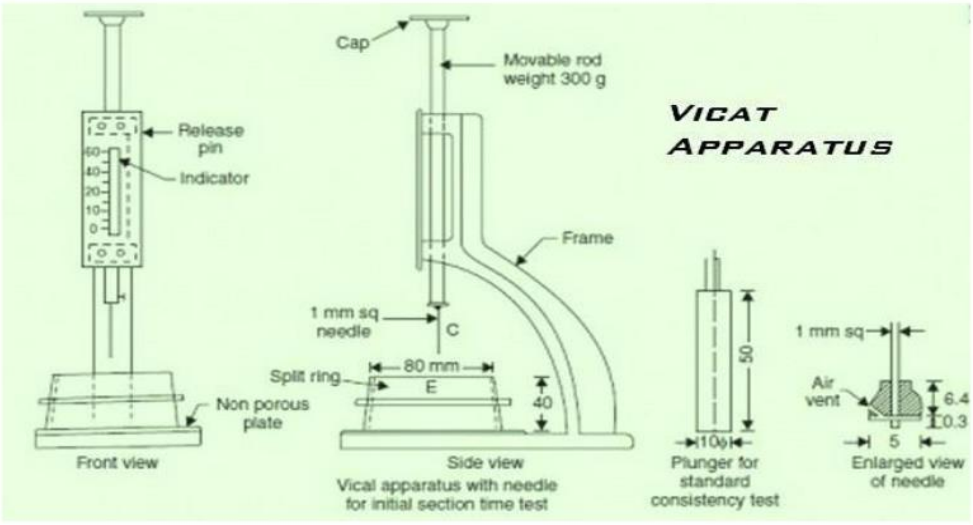
II. Mix water and cement on a non-porous surface. The mixing should be done thoroughly.

III. Fill the mould of Vicat apparatus. The interval between the addition of water to the commencement of filling the mould is known as the time of gauging and it should be $3\ ^{3}/4$to $4\ ^{1}/2$ minutes.

IV. The vicat apparatus is shown in figure above and it consist of a frame to which is attached a movable rod weighing 300 grams and having diameter and length as 10mm and 50 respectively. And indicator is attached to the movable rod. This indicator moves on vertical scale and it gives the penetration. The vicat mould is in the form of a cylinder and it can be split into two halves. The vicat mould placed on no porous plate. There are there attachment- square needle, plunger and needle with angular collar. The square needle is used for initial setting time test, the plunger is used for consistency test and the needle with annular collar is used for final setting time test.

V. The plunger is attached to the movable rod of vicat apparatus. The plunger gently lowered on the paste in the mould.

VI. The settlement of plunger is noted. If the penetration is between 5mm to 7mm from the bottom of the mould, the water added is correct. If the penetration is not proper, the process is repeated with different percentage of water till the desired penetration is obtained.



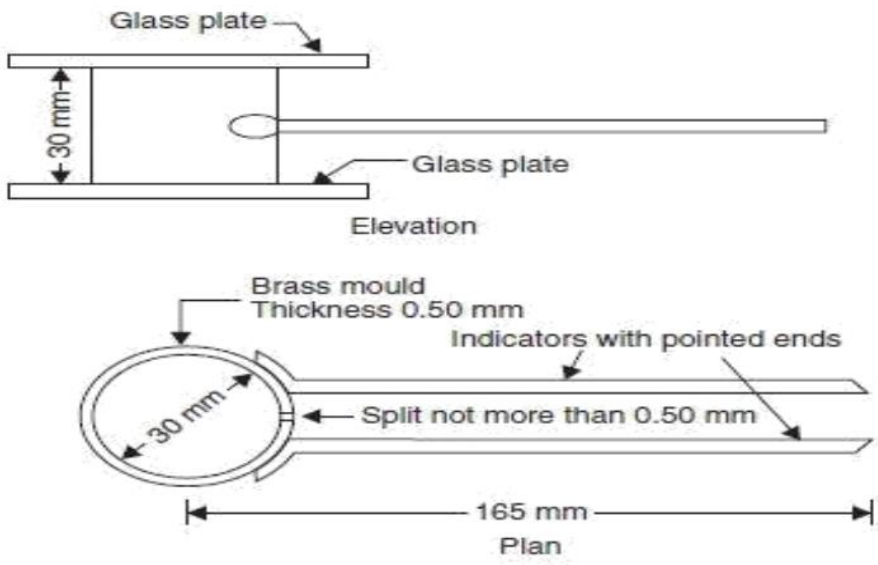


Fig. 1.6. Le Chatelier's apparatus

SETTING TIME

This test is used to detect the deterioration of cement due to storage. It may be noted that this is purely a conventional type of test and it has got no relation with the setting or hardening of actual concrete. The test is carried out to find out initial setting time and final setting time.

Initial setting time:

(A) The cement weighing 300 gms is taken and its mixed with percentage of water as determined in consistency test .

(B) The cement past is filled in the vicat mould.

(C) Square needle of cross section 1mm * 1mm is attached to the moving rod of the vicat apparatus.

(D) The needle is quickly released and it is allowed penetrate the cement past. In the beginning, the needle penetrate completely. It is then taken out and dropped at a fresh place. The procedure is repeated regular intervals till the needle does not penetrate completely. The needle should penetrate upto 5mm measured from the bottom.

(E) The initial setting time is interval between the addition of the water to the cement and the stage when needle ceased to penetrate completely. This time about 30 minutes of the ordinary cement.

Final setting time:

(a) The cement paste is prepared as about and it is filled in the vicat mould.

(b) The needle with annular collar is attached to the moving rod of the vicat apparatus. This needle has a sharp point projecting in the centre with annular collar.

(c) The needle is gently released. The time at which the needle makes an impression on test block and the collar fails to do so is noted.

(d) Final setting time is the difference between the time at which water was added to the cement and time as recorded in (c). This time should be about 10 hours for ordinary cement.

AGGREGATES

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Aggregates can be classified as

1. Normal weight aggregates
2. Light weight aggregates
3. Heavy weight aggregates

Normal weight aggregates can be further classified as natural aggregate and artificial aggregates.

Natural	Artificial
Sand, Gravel, Granite	Broken brick, Air-cooled slag
Quartzite, Basalt, Sandstone	

Aggregates can be classified based on the size of aggregate as coarse aggregate and fine aggregate.

NATURAL STONE AGGREGATES

All natural aggregate materials originate from bed rocks. There are three kinds of rock namely igneous, sedimentary and metamorphic. These classifications are based on the mode of formation of rocks. Igneous rocks are formed by the cooling of molten magma at the surface of the crest. The sedimentary rocks are formed originally below the sea-bed and subsequently lifted up. Metamorphic rocks are either igneous or sedimentary rocks which are metamorphed due to extreme heat and pressure.

Most igneous rocks make satisfactory concrete aggregates because they are hard, tough and dense. The sedimentary rocks with the stratified structure are quarried and concrete aggregates are derived from it. Metamorphic rocks show foliated structure. Many metamorphic rocks such as quartzite and gneiss have been used for production of good concrete aggregate.

CRUSHING STRENGTH

The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. The aggregate crushing value should not be more than 45% for aggregate used for concrete other than for wearing surfaces and 30% for concrete used for wearing surfaces such as runways, roads and airfield pavements.

The standard aggregate crushing test is made on aggregate passing a 12.5mm sieve I.S Sieve and retained on 10mm I.S Sieve. About 6.5kg of the sample is taken. The aggregate is filled into the cylindrical measure in three layers of equal depth. Each layer is tamped 25 times with the tamping rod and leveled off. the weight of the sample contained in the cylinder is taken.(A). The apparatus with the test sample is placed on the compression testing machine and is loaded uniformly upto a total load of 10 tons. The load is then released and the whole material removed from the cylinder and sieved on a 2.36mm I.S Sieve. The fraction passing the sieve is weighed(B).

Aggregate crushing value = (B / A) * 100

B = weight of fraction passing 2.36mm I.S sieve A

= weight of surface dried sample.

Aggregate crushing equipment

IMPACT STRENGTH

The aggregate impact value gives relative measure of the resistance of an aggregate to sudden shock or impact. The aggregate impact value should not be more than 45% by weight for aggregates used for concrete other than wearing surfaces and 30% by weight for concrete to be used as wearing surfaces such as runways, roads and pavements.

The test sample consists of aggregate passing through 12.5mm and retained on 10mm I.S Sieve. The aggregate shall be dried in an oven and cooled. The aggregate is filled about one-third full and tamped with 25 strokes by the tamping rod. A similar quantity is added and tamped in the standard manner. The measure is filled to overflowing and struck off level. The net weight of the aggregate is determined (weight A). The whole sample is filled into a cylindrical steel cup fixed on the base of the machine. A hammer is raised to a height of 380mm above the upper surface of aggregate and allowed to fall freely on the aggregate. The sample is subjected to 15 blows and the crushed aggregate is removed from the cup. It is sieved on 2.36mm sieve and the fraction passing the sieve is weighed. (weight B).

Aggregate impact value = (B/ A) * 100.

B = weight of fraction passing 2.36mm I.S sieve A

= weight of surface dried sample.

Impact test apparatus