BT- 204 (Basic Civil Engineering and Engineering Mechanics)
Unit-I
Topic- Cement

Cement is a commonly used binding material in the construction. The cement is obtained by burning a mixture of calcareous (calcium) and argillaceous (clay) material at a very high temperature and then grinding the clinker so produced to a fine powder.

Types of Cement:-

In addition to ordinary portland cement there are many varieties of cement. Important varieties are briefly explained below:-

(*i*) **White Cement:** The cement when made free from colouring oxides of iron, maganese and chlorium results into white cement. In the manufacture of this cement, the oil fuel is used instead of coal for burning. White cement is used for the floor finishes, plastering, ornamental works etc. In swimming pools white cement is used to replace glazed tiles. It is used for fixing marbles and glazed tiles.

(*ii*) **Coloured Cement:** The cements of desired colours are produced by intimately mixing pigments with ordinary cement. The chlorium oxide gives green colour. Cobalt produce blue colour. Iron oxide with different proportion produce brown, red or yellow colour. Addition of manganese dioxide gives black or brown coloured cement. These cements are used for giving finishing touches to floors, walls, window sills, roofs etc.

(*iii*) **Quick Setting Cement:** Quick setting cement is produced by reducing the percentage of gypsum and adding a small amount of aluminium sulphate during the manufacture of cement. Finer grinding also adds to quick setting property. This cement starts setting within 5 minutes after adding water and becomes hard mass within 30 minutes. This cement is used to lay concrete under static or slowly running water.

(*iv*) **Rapid Hardening Cement:** This cement can be produced by increasing lime content and burning at high temperature while manufacturing cement. Grinding to very fine is also necessary. Though the initial and final setting time of this cement is the same as that of portland cement, it gains strength in early days. This property helps in earlier removal of form works and speed in construction activity.

(*v*) **Low Heat Cement:** In mass concrete works like construction of dams, heat produced due to hydration of cement will not get dispersed easily. This may give rise to cracks. Hence in such constructions it is preferable to use low heat cement. This cement contains low percentage (5%) of tricalcium aluminate (C3A) and higher percentage (46%) of dicalcium silicate (C2S).

(*vi*) **Pozzulana Cement:** Pozzulana is a volcanic power found in Italy. It can be processed from shales and certain types of clay also. In this cement pozzulana material is 10 to 30 per cent. It can resist action of sulphate. It releases less heat during setting. It imparts higher degree of water tightness. Its tensile strength is high but compressive strength is low. It is used for mass concrete works. It is also used in sewage line works.

(*vii*) **Expanding Cement:** This cement expands as it sets. This property is achieved by adding expanding medium like sulpho aluminate and a stabilizing agent to ordinary cement. This is used for filling the cracks in concrete structures.

(*viii*) **High Alumina Cement:** It is manufactured by calcining a mixture of lime and bauxite. It is more resistant to sulphate and acid attack. It develops almost full strength within 24 hours of adding water. It is used for under water works.

(*ix*) **Blast Furnace Cement:** In the manufacture of pig iron, slag comes out as a waste product. By grinding clinkers of cement with about 60 to 65 per cent of slag, this cement is produced. The properties of this cement

Prepared by
Girish Patidar

are more or less same as ordinary cement, but it is cheap, since it utilise waste product. This cement is durable but it gains the strength slowly and hence needs longer period of curing.

(*x*) **Acid Resistant Cement:** This cement is produced by adding acid resistant aggregated such as quartz, quartzite, sodium silicate or soluble glass. This cement has good resistance to action of acid and water. It is commonly used in the construction of chemical factories.

(*xi*) **Sulphate Resistant Cement:** By keeping the percentage of tricalcium aluminate C3A below five per cent in ordinary cement this cement is produced. It is used in the construction of structures which are likely to be damaged by alkaline conditions. Examples of such structures are canals, culverts etc.

(*xii*) **Fly Ash Blended Cement:** Fly ash is a byproduct in thermal stations. The particles of fly ash are very minute and they fly in the air, creating air pollution problems. Thermal power stations have to spend lot of money to arrest fly ash and dispose safely. It is found that one of the best way to dispose fly ash is to mix it with cement in controlled condition and derive some of the beneficiary effects on cement. Now-a-days cement factories produce the fly ash in their own thermal stations or borrow it from other thermal stations and further process it to make it suitable to blend with cement. 20 to 30% fly ash is used for blending. Fly ash blended cements have superior quality of resistance to weathering action. The ultimate strength gained is the same as that with ordinary portland cement. However strength gained in the initial stage is slow. Birla plus, Birla star, A.C.C. Suraksha are some of the brand name of blended cement.

Physical properties of cement: - The following physical properties should be checked before selecting a portland cement for the civil engineering works. IS 269–1967 specifies the method of testing and prescribes the limits:

(a) Fineness (b) Setting time

(c) Soundness (d) Crushing strength.

(a) Fineness: It is measured in terms of percentage of weight retained after sieving the cement through 90 micron sieve or by surface area of cement in square centimeters per gramme of cement. According to IS code specification weight retained on the sieve should not be more than 10 per cent. In terms of specific surface should not be less than 2250 cm2/gm.

(b) Setting time: A period of 30 minutes as minimum setting time for initial setting and a maximum period of 600 minutes as maximum setting time is specified by IS code, provided the tests are conducted as per the procedure prescribed by IS 269-1967.

(c) Soundness: Once the concrete has hardened it is necessary to ensure that no volumetric changes takes place. The cement is said to be unsound, if it exhibits volumetric instability after hardening. IS code recommends test with Le Chatelier mould for testing this property. At the end of the test, the indicator of Le Chatelier mould should not expand by more than 10 mm.

(d) Crushing strength: For this mortar cubes are made with standard sand and tested in compression testing machine as per the specification of IS code. The minimum strength specified is 16 N/mm² after 3 days and 22 N/mm² after 7 days of curing.

TESTING OF CEMENT

Testing of cement can be brought under two categories:

(a) Field testing

(b) Laboratory testing

Field Testing

It is sufficient to subject the cement to field tests when it is used for minor works. The following are the

field tests:
(a) Open the bag and take a good look at the cement. There should not be any visible lumps. The colour of the cement should normally be greenish grey.
(b) Thrust your hand into the cement bag. It must give you a cool feeling. There should not be any lump inside.
(c) Take a pinch of cement and feel-between the fingers. It should give a smooth and not a gritty feeling.
(d) Take a handful of cement and throw it on a bucket full of water, the particles should float for some time before they sink.
(e) Take about 100 grams of cement and a small quantity of water and make a stiff paste.
From the stiff paste, pat a cake with sharp edges. Put it on a glass plate and slowly take it under water in a bucket. See that the shape of the cake is not disturbed while taking it down to the bottom of the bucket.
After 24 hours the cake should retain its original shape and at the same time it should also set and attain some streng

Laboratory Tests on Cement

(*a*) Fineness Test: It is conducted by sieve analysis. 100 gms of cement is taken and sieved through IS sieve No. 9 for fifteen minutes. Residue on the sieve is weighed. This should not exceed 10 per cent by weight of sample taken.

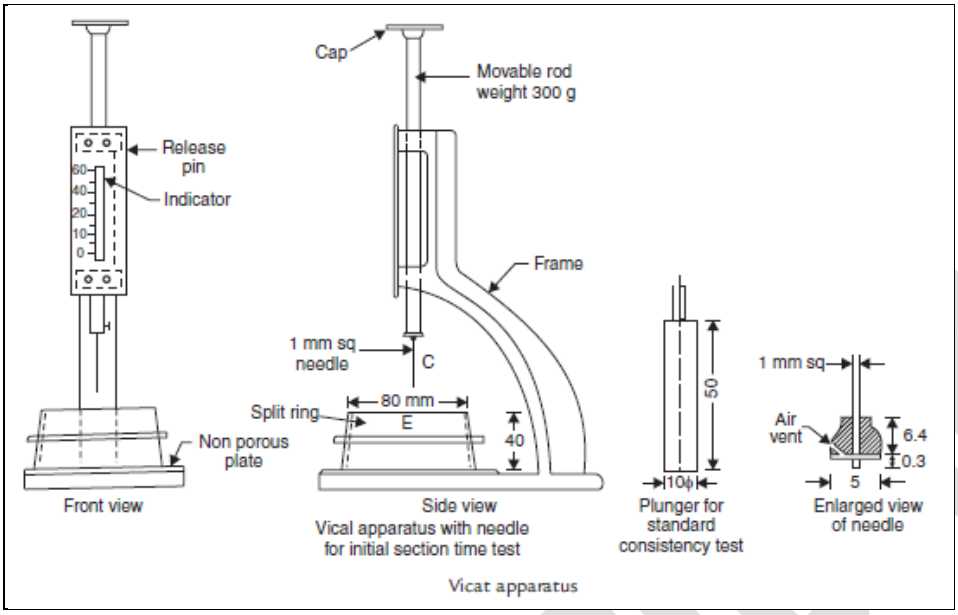
(*b*) Setting Time: Initial setting time and final setting time are the two important physical properties of cement. Initial setting time is the time taken by the cement from adding of water to the starting of losing its plasticity. Final setting time is the time lapsed from adding of the water to complete loss of plasticity. Vicat apparatus is used for finding the setting times. Vicat apparatus consists of a movable rod to which any one of the three needles shown in figure can be attached. An indicator is attached to the movable rod. A vicat mould is associated with this apparatus which is in the form of split cylinder.

Before finding initial and final setting time it is necessary to determine water to be added to get standard consistency. For this 300 gms of cement is mixed with about 30% water and cement paste prepared is filled in the mould which rests on non porous plate. The plunger is attached to the movable rod of vicat apparatus and gently lowered to touch the paste in the mould. Then the plunger is allowed to move freely. If the penetration is 5 mm to 7 mm from the bottom of the mould, then cement is having standard consistency. If not, experiment is repeated with different proportion of water fill water required for standard consistency is found. Then the tests for initial and final setting times can be carried out as explained below:

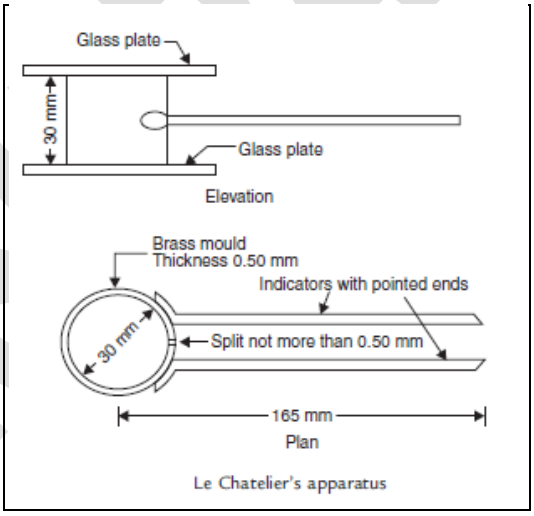
Initial Setting Time: 300 gms of cement is thoroughly mixed with 0.85 times the water for standard consistency and vicat mould is completely filled and top surface is levelled. 1 mm square needle is fixed to the rod and gently placed over the paste. Then it is freely allowed to penetrate. In the beginning the needle penetrates the paste completely. As time lapses the paste start losing its plasticity and offers resistance to penetration. When needle can penetrate up to 5 to 7 mm above bottom of the paste experiment is stopped and time lapsed between the addition of water and end if the experiment is noted as initial setting time.

Final Setting Time.: The square needle is replaced with annular collar. Experiment is continued by allowing this needle to freely move after gently touching the surface of the paste. Time lapsed between the addition of water and the mark of needle but not of annular ring is found on the paste. This time is noted as final setting time.

Prepared by
Girish Patidar



(*c*) **Soundness Test:** This test is conducted to find free lime in cement, which is not desirable. Le Chatelier apparatus shown in Fig. 1.6 is used for conducting this test. It consists of a split brass mould of diameter 30 mm and height 30 mm. On either side of the split, there are two indicators, with pointed ends. The ends of indicators are 165 mm from the centre of the mould.



Properly oiled Le Chatelier mould is placed on a glass plate and is filled completely with a cement paste having 0.78 times the water required for standard consistency. It is then covered with another glass plate and a small weight is placed over it. Then the whole assembly is kept under water for 24 hours. The temperature of water should be between 24°C and 50°C. Note the distance between the indicator. Then place the mould again in the water and heat the assembly such that water reaches the boiling point in 30 minutes. Boil the water for one hour. The mould is removed from water and allowed to cool. The distance between the two pointers is measured. The difference between the two readings indicate the expansion of the cement due to the presence of unburnt lime. This value should not exceed
10 mm.

(d) Crushing Strength Test: For this 200 gm of cement is mixed with 600 gm of standard sand confirming to IS 650–1966. After mixing thoroughly in dry condition for a minute distilled potable water P/4+ 3 percentage is added where P is the water required for the standard consistency. They are mixed with trowel for 3 to 4 minutes to get uniform mixture. The mix is placed in a cube mould of 70.6 mm size (Area 5000 mm^2) kept on a steel plate and prodded with 25 mm standard steel rod 20 times within 8 seconds. Then the mould is placed on a standard vibrating table that vibrates at a speed of 12000 ± 400 vibration per minute. A hopper is secured at the top and the remaining mortar is filled. The mould is vibrated for two minutes and hopper removed. The top is finished with a knife or with a trowel and levelled. After 24 ± 1 hour mould is removed and cube is placed under clean water for curing. After specified period cubes are tested in compression testing machine, keeping the specimen on its level edges. Average of three cubes is reported as crushing strength. 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 days not less than 17.5 N/mm^2.

Uses of Cement

Cement is used widely for the construction of various structures. Some of them are listed below:

(*i*) Cement slurry is used for filling cracks in concrete structures.

(*ii*) Cement mortar is used for masonry work, plastering and pointing.

(*iii*) Cement concrete is used for the construction of various structures like buildings, bridges. water tanks, tunnels, docks, harhours etc.

(*iv*) Cement is used to manufacture lamp posts, telephone posts, railway sleepers, piles etc.

(*v*) For manufacturing cement pipes, garden seats, dust bins, flower pots etc. cement is commonly used.

(*vi*) It is useful for the construction of roads, footpaths, courts for various sports etc.

----------x----------

Prepared by
Girish Patidar