R.C.Patel College Of Engineering & Polytechnic, Shirpur

Department of Civil Engineering

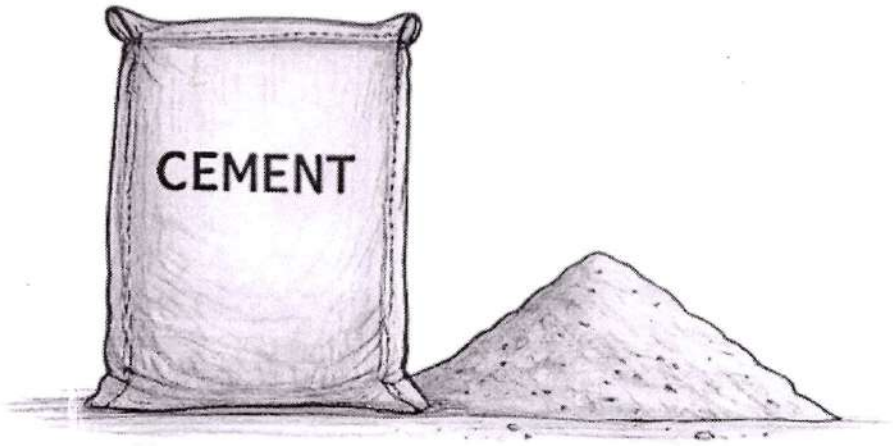
Course Title- Concrete Technology

Course Code -313322

Programme Name -Civil Engineering

Semester-Third

Unit	Title	COs	Learning hours	R Level	U Level	A Level	Total Marks
I	Cement	CO1	06	2	4	4	10



Unit - 1
Cement

Cement :-

Defⁿ :- cement is a fine grey powder that acts as a binding material in construction when mixed with water, it sets and hardens, joining building material together.

* constituents of cement :-

Basic ingredients / constituents of portland cement

The constituents of cement with their average percentage are as follows :

Sr.No.	Oxide	Formula	content in %
1	Lime	CaO	60 – 67 %
2.	silica	SiO_2	17 – 25 %
3.	Alumina	Al_2O_3	3 – 8 %
4.	Iron oxide	Fe_2O_3	0·5 – 6 %
5.	Magnesia	MgO	0·1 – 4 %
6.	sulphur tri oxide	SO_3	2 – 3·5 %
7.	Alkalis (soda and Potash)	Na_2O and K_2O	0·3 – 1·2 %

* Effects of chemical constituents of ordinary portland cement

Function of various constituent of cement

1) Lime 2) Silica 3) Alumina 4) Iron oxide
5) magnesia 6) sulphur trioxide 7) Alkalis 8) Gypsum

1) Lime :- . This is main ingredient of cement, its percentage being about 60 to 67% of the total ingredients.

. proper percentage of lime which imparts cementing (binding) property should be maintained.

* Effect of lime :- Defeciency of lime causes decrease in the strength of cement and exeess free lime causes unnecessary expansion and disintegration of the cement.

2) Silica :- During the manufacturing of cement, silica undergoes chemical reaction with calcium to form dicalcium and tricalcium silicate which are responsible for imparting to the cement.

* Effect of silica :- Excess of silica adds strength to the cement but its setting time is prolonged.

3) Alumina :- Alumina forms complex compounds with silica and calcium to impart setting property to the cement.

* Effect of Alumina :- Larger quantity of alumina quickens setting but weakens the cement.

4) Iron oxide :- . The ingredient mainly responsible for to impart color to the cement.
. It also helps in adding strength and hardness to the cement to a certain extent.

5) **Magnesia** :- magnesia oxide (magnesia) also impart strength to the cement when mixed is small quantity.
- The magnesia content (MgO) shall not exceed 5% by mass.

* **Effect of magnesia** :- Excess magnesia makes the cement unsound.

6) **Sulphour trioxide** :- Excess quantity of sulphour trioxide also make cement unsound.

7) **Alkalies** :- Large quantity of alkalies (sodium and potassium oxide) are carried away by flue gases during clinkering.
- However, a small quantity is left behind, excess of which causes efflorenscence.

8) **Gypsum** :- During grinding process a small quantity of gypsum is added. It plays a very important role in controlling the rate of hydration of cement.
- It control the setting time of cement so that there will be sufficient time for transporting and placing concrete / mortar for which the cement is used.

* **Bogue's compounds**

sr.no	compound	Abbrivation	formula	percentage %
01	Tricalcium silicate	C_3S	$3CaO.SiO_2$	60-70%
02	Dicalcium silicate	C_2S	$2CaO.SiO_2$	10-20%
03	Tricalcium Aluminate	C_3A	$3CaO.Al_2O_3$	5-10%
04	Tetracalcium Alumino-Ferrate	C_4AF	$4CaO.Al_2O_3Fe_2O_3$	3-8%

* Effect of Bogue's compound on properties of cement

Sr. No	Bogue's compound	Effect of compounds on it's Properties.
1	Tri calcium silicate	It is mainly responsible for early strength to the cement by producing more heat of hydration.
2.	Dicalcium silicate	It is responsible for ultimate strength to the cement by generating lesser than heat of hydration.
3.	Tri calcium Aluminate	It varies setting time of cement
4.	Tetra calcium Alumino ferrate (Ferrite)	C_4AF does not affect behavior significantly. However, it reacts with gypsum accelerates by hydration of cement.

* Hydration of cement :-

- Heat of Hydration is the liberation of large quantity of heat due to exothermic chemical reaction take place when water is added to cement.
- For ordinary portland cement (OPC), the heat of hydration is around 120 cal/gm or 500 joule per gm.
- About 50% of the total heat is liberated between 1 and 3 days, about 75% in 7 days and 83 to 91% in six months

- The heat of hydration can be measured by ASTM C 186 or by a conduction calonmeter.
- Heat of hydration depends on the chemical composition of the cement and most influenced by the proportion of tricalcium silicates (C_3S) and Tricalcium Aluminate (C_3A) in the cement.
- It is also influenced by fineness, water cement ratio and curing temperature. It increase if any one of the factors is increase.

* Contribution of various compound of cement on heat of hydration are as follows :-

- Tricalcium silicate (C_3S) having faster rate of reaction accompanied by greater heat evolution develops early strength.
- Dicalcium silicate (C_2S) hydrate and harden slowly and provide much of the ultimate strength.
- C_3S liberates nearly three times as much calcium hydroxide on hydration as C_2S.
- However, C_2S provides more resistance to chemical attack.

* Ordinary Portland cement [IS: 269-1989]

- It is most important type of cement commonly used in all the concrete construction which are not exposure to sulphate in soil or ground water.
- OPC has all properties similar to the natural stone quarried at Portland (U.K.)

* different Grades of cement

- The OPC is classified three grades

1. 33 grade cement (I.S. 269-1989)
2. 43 grade cement (IS 8112-1982)
3. 53 grade cement (IS 12269-1987)

- The grade of cement depends upon the strength of cement at 28 days in N/mm^2.
- In modern construction work, higher grade of cement is used 33 grade cement is outdate.

* Application of 33 Grade cement :-

It is used in following situations

1. Plastering work by producing cement mortar
2. masonry work of brick or stone materials.

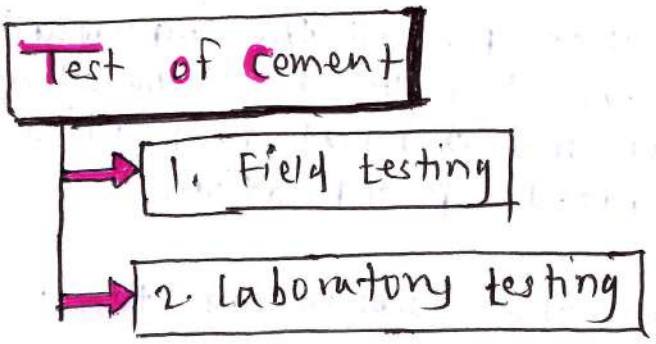
* Application of 43 Grade cement :-

1. precast and prestressed concrete
2. Ready mix concrete
3. PCC and RCC work of building and bridges
4. construction of silos, chimney and slop form works.

* Application of 53 Grade cement :-

1. precast concrete sleepers for railways.
2. Industrial buildings and High-rise buildings.
3. pre-stressed girders and RCC bridges.
4. Long span RCC bridges

★ Testing of OPC (ordinary portland cement)



★1. Field Test of cement :-

- The quality of cement can be judged by adopting some field test.

1. The color of the cement should be uniform
2. when hand is insert into a cement bag, it should feel cool. It indicates that no chemical action of cement has started. If it feel warm, indicates that prehydration and evolution of heat of hydration has occured.
3. Free from lumps. Any lumps, if present, should be easily powdered. Hard lumps indicate possibility of air setting.
4. A pinch of cement, thrown on surface of water in bucket should float.
5. It should not feel oily for touch.
6. cement should feel smooth and not rough or gritty when rubbed in between fingers.
7. when cement is heated in pan, should not exhibit different colors.

2) Laboratory Test of cement

- The cement used for all the important and major work is to be test in the laboratory to confirm the physical and chemical properties as per Indian standard specification.

- following are the laboratory test:
  1. fineness Test 2. setting time Test or consistency test
  3. strength test 4. soundness test 5.) Heat of hydration
  6. chemical composition test.

* 1. Fineness Test :-

- following are the step by step procedure of determination of fineness of cement by method sieving
  1. Take 100 gm of cement sample as 'W1'
  2. This cement sample is sieved through 90 micron Is sieve for minimum period 15 min. using mechanical sieving device.
  3. Take the weight of cement retained on sieve as W2 in grams.
  4. calculate the % percentage of fineness of given cement as

$$\% \text{ Fineness} = \left(\frac{W_2}{W_1}\right) \times 100$$

- The residue of cement should not exceed 10 percent
- This method is used to find the presence of coarse cement particles.
- It is also used to cheeking and controlling production process.

2. setting Time Test of cement :

* Initial setting Time of cement :-

- The time elapsed from mixing of cement and water to the moment the needle penetrates the test block to a depth 33-35 mm from top of the Vicat's mould is called as initial setting time.

* Final setting Time of cement :-

- Final setting time is defined as the time elapsed from mixing of cement and water upto the moment the needle of 1 mm square section makes an impression on the test block, while the attachment ~~also~~ fails to makes an impression on the test block

* Method of Determine Initial and final setting Time of cement :-

The procedure of the test is given below :

1. Take about 400 gm cement and mix it with 0.85P percent of water where P is the water percentage required for standard consistency to make a smooth paste. Note down the time at water is added to the cement start a stopwatch at the moment as T_1 min.
2. Fill and shake the Vicat mould with the cement paste within 3 to 5 min. after adding water.
3. Lower the Initial setting time needle till it touches the surface of the cement paste in the mould.
4. Release the weight so that the needle penetrates the paste. Initially, it will penetrate the complete depth i.e. 40mm of mould.

4. Release the weight so that the needle till it touches the surface of the cement paste in the mould.

5. Take the reading after every 1 or 2 min. and when the penetration decreases, take readings after every 20 sec and then after every 10 seconds, moving the mould to take reading at different place every time.

6. Note down the time at which the penetration is 33 to 35mm from the top surface as T_2

7. This time the known as the 'Initial setting Time' it is calculated as

$$\text{Initial setting Time (IST)} = T_2 - T_1 \text{ min.}$$

8. Replace IST needle with 'final setting time' FST needle to penetrate in same cement paste.

9. Note down the time at with FST needle will just makes an impression on test block surface as T_3.

10. Final setting time is calculated as

$$FST = T_3 - T_1$$

* Draw neat sketch of vicat Apparatus :-

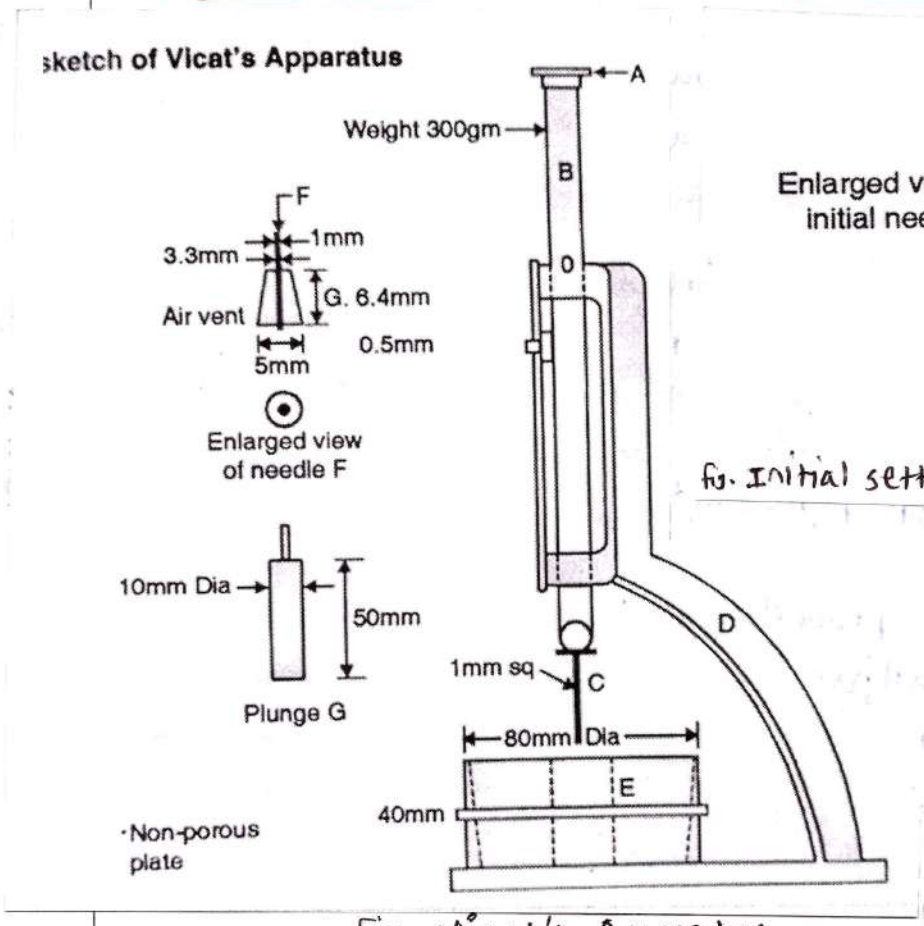


Fig. Vicat's Apparatus.

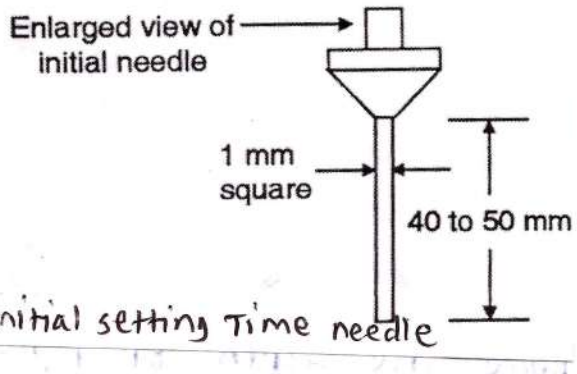
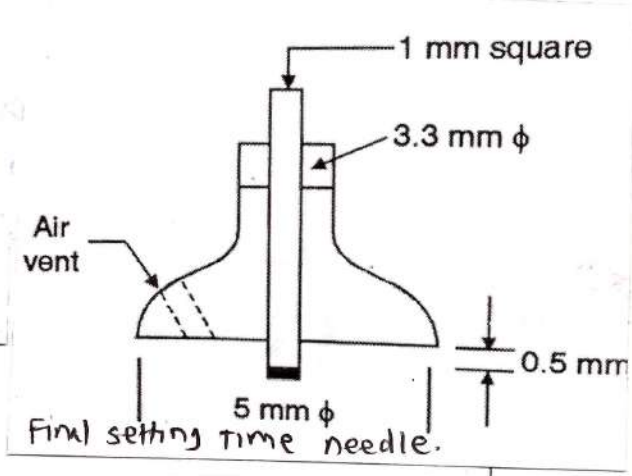


fig. Initial setting Time needle



Final setting Time needle.

* standard consistency Test of cement :-

Defn :- The normal consistancy of cement of paste is define as that water percentage required which will permit the standard vicat plunger to penetrate to a point of 33 to 35 mm from the top of vicat mould.

- Vicat apparatus is used for determining consistency of cement.

* step by step procedure of standard consistancy test on cement is as follow.

1) The cement sample of 350 gm is thoroughly mixed with about 30% weight of water on non porous surface within 3 to 5 min.

2. Keep the mould on non-porous surface plate and fill the cement paste in the mould.

3. Tapped and shake the mould to expel air and smoothened the top surface of cement paste in the mould by means of trowel.

4. The vicat plunger is lowered gently to touch the top surface of filled mould and then released quickly to penetrate into the cement paste.

5. Note the depth of penetration of the plunger.

6. Repeat the whole procedure taking fresh sample of cement and adjusting the percentage of water so that penetration of the standard vicat plunger is restricted to 33 to 35mm from the top of vicat mould.

* Soundness Test of Cement

step by step procedure of soundness test as follow;

- 100 gm of cement is mixed with 0.72 times water required for cement paste of standard consistancy within 3 minutes.
- The paste is made into a ball and then fill into standard Le-chatelier apparatus resting on a glass plate within 5 minutes after adding water to cement
- The mould is smoothened and covered with another glass plate
- A small weight is placed on the top and assembly is submerged in water bath of temperature 27°C to 32°C the water is brought to boiling point for 3 hours.

- The mould is taken out of water and allowed to cool.
- After cooling, the distance between two pointers is again measured before boiling and after cooling represents the expansion of cement.
- maximum expansion by Le-chatelier method is limited to 10 mm for ordinary unareated portland cement.
- unsoundness may be reduced by limiting MgO content to less than 0.5 percent, fine grinding, through mixing and allowing cement to aerate for several days.
- The effects of using unsound cement results in disruption of the hardened cement paste cracking and disintegration of the surface of the ~~concrete~~ concrete.
- These effects are apparent only after some considerable lapse of period, in month or years.

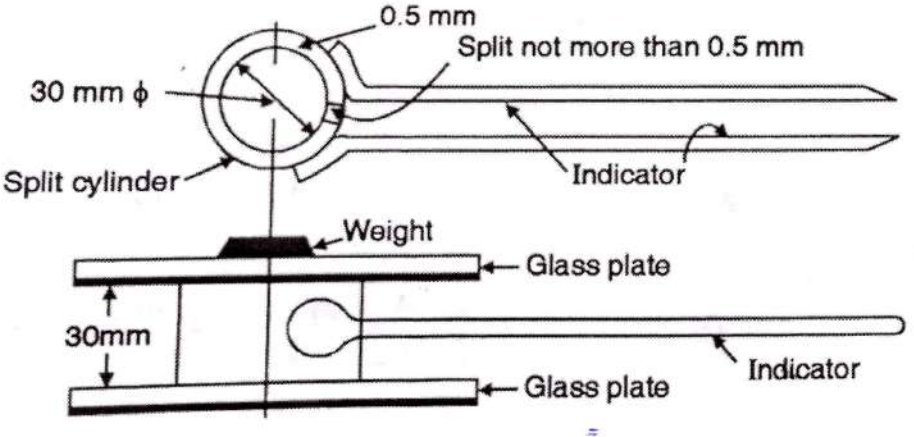


fig. Le-chatelier apparatus.

* Compressive strength Test of cement

The procedure of the test is given below

1. Take 555 grams of standard sand and 185 grams of cement and mix in it dry condition for one minute.
2. Add water of $\left(\frac{P}{4}+3.5\right)$ when ordinary sand is used and $\left(\frac{P}{4}+3.0\right)$ when standard sand is used percent of combined weight of cement and sand where P is the standard consistency of cement. mix the three ingredients throughly till mixture is of uniform color. The mixing time should be between 3 and 5 min. The mould is fitted on the table of the vibrating machine immediately after mixing and compacted at least for two minutes. This process should be completed within five minutes after mixing.
3. Immediately fill the mortar thus prepared into cube mould size 7.07 cm is placed on non porous base plate which is oiled from inside. Compact the mortar by standard means.
4. Keep the mould in 90% humidity and at 27°C ± 2°C for 24 hours. where humidity room is not available the mould can be kept under wet gunny bag for 24 hours.
5. Remove the cube from mould after 24 Hours and keep immersed under clean water till the moment testing.
6. Test the cube under UTM / CTM compressive strength

* storing of cement on site :-

following precaution should be taken while storing cement on site.

1. cement should be stored in a special water-tight shed with a dry and damp proof door, waterproof walls and leak proof roof.
2. The stacks of cement bags should be placed at a distance of at least 30cm from walls.
3. a stack should contain max. 15 bags.
4. width of stack should not exceed 3m.
5. Bags should be stacked on a raised platform, with sufficient space for movement between rows of stacks.
6. Bags should be stored in such a way that bags received first should be used first.

* Effect of storage of cement on properties :-

1) Due to long storage, cement loses its strength, becomes lumpy and due to its loss of capacity for hydration become unusable.
2) When a sealed bag of cement is opened, oxygen in air starts reaching with the ingredients as well as the humidity in the air starts reactions with the ingredients-
3) Hence it is advisable to use cement within 3 month at the maximum.
4) The strength at different time periods as follows
   * cement fresh from factory → 100% strength.

cement	Reduction in strength
i) Fresh	Nil
ii) After 3 month	15%
iii) After 6 month	25%
iv) After 1 year	40%
v) After 2 year	52%

* Types of cement

Types	characteristics	Uses
OPC	53,43,33 Grades	general construction
Rapid Hardening cement	more C_3S, less C_2S	when early strength required
Extra Rapid Hardening cement	Extra $CaCl_2$, with RHC	when quick strength required
Quick setting cement	Added- Al_2SO_4	under water construction
sulphate resisting cement	Less C_3A, C_4AF	under water construction, when sulphate resistant.
Low heat cement	more C_2S less C_3A, C_3S	Reduce risk of thermal cracking.
High alumina cement	more workable, High compressive strength	under sea water construction
Hydrophobic cement	To reduce rate of	High rainfall area
white cement	–	filling the joint bet? Tiles, finishing work.
color cement	–	Decorative purpose, finishing work, elevation purpose.

Unit-1 Cement (Question Bank)

Que.No.	Questions
1	Enlist Bogue's compound for cement. -2m S-25,W-24
2	Define water cement ratio. -2m S-25
3	Explain the method to determine initial and final setting time of cement.-4m S-25
4	State four types of cement and state their field application.-4m S-25
5	List any four physical properties of OPC. -2m W-24
6	Explain IS. code test for finding initial and final setting time of cement. -4m W-24
7	State any four field tests on cement. 4m W-24
8	Give two uses of rapid hardening cement and low heat cement each. (Field Applications) 4m W-24
9	State any four field tests on cement. 4m W-25
10	Define cement and state its main ingredients. 4m W-25
11	State any four field applications of rapid hardening cement. 4m W-25
12	Enlist four physical properties of OPC -2m (Que no.12-20 I Scheme Questions)
13	State the precautions to be taken while storing the cement on site.-4m
14	Write the significance of w/c ratio and it's effect on hydration of cement.-4m
15	State the different types of special cement with its suitability.-4m
16	State the physical properties of Bogue's compound.-4m
17	Enlist any four field tests on cement.-2m
18	Explain the procedure to determine standard consistency of cement with neat labelled sketch.-4m
19	State the meaning of 43 and 53 grade of cement.-2m
20	Explain the procedure to determine fineness of cement by dry sieving method. State its IS requirement-4m