UNIT-1

1>Constituents of Cement

Constituents of cement are mainly two types

1. Mineral constituents, 2. Acid and Alkaline constituents.

Mineral Constituents **(Bogue's Compound)**

Name	Oxide compositions	Abbreviation	Percentage(%)
Tricalcium Silicate	$3CaO.SiO_2$	C3S	45~55
Dicalcium Silicate	$2CaO.SiO_2$	C2S	20~30
Tricalcim Aluminate	$3CaO.Al_2O_3$	C3A	9~13
Tetra calcium Alumino ferrite	$4CaO.Al_2O_3.Fe_2O_3$	C4AF	8~20
Calcium Sulphate	$CaSo_4$		2~6
Other Compounds			

Tricalcium Silicate –The presence of tricalcium silicate in cement hydrates more rapidly. It generates more heat of hydration. It develops high early strength and possesses less resistance to sulphate attack.

Dicalcium Silicate-- The presence of Dicalcium silicate in cement hydrates slowly. It generates less heat of hydration. It hardens more slowly and offers more resistance to sulphate attack. It provides good ultimate strength to cement.

Tricalcim Aluminate-- The presence of Tricalcim Aluminate causes initial setting of cement. It reacts fast with water and generate large amount of heat of hydration. It is the first compound which react with water when mixed with cement.

Tetra calcium Alumino ferrite-- The presence of Tetra calcium Alumino ferrite in cement has a poor cementing value. It react slowly with water and generates small amount of heat of hydration.

Note –1. The high percentage of *Tricalcium Silicate* ***and low percentage of*** *Dicalcium Silicate* ***in cement result rapid hardening, High early strength, High heat of generation and less resistance to chemical attack.***

2. The low percentage of *Tricalcium Silicate* ***and high percentage of*** *Dicalcium Silicate* ***in cement results in slow hardening, much more ultimate strength, less heat of generation and greater resistance to chemical attack***

Acid and Alkaline Constituents

Name	Composition	Range of percentage
Calcium oxide	CaO	60~67
Magnesium oxide	MgO	0.1~4
Silica	SiO2	17~25
Alumina	Al2O3	3~8
Iron oxide	Fe2O3	0.5~6
Sulphur trioxide	SO3	1~3
Potassium oxide	K2O	0.3~1
Sodium oxide	Na2O	0.4~1.3

2>Hydration of cement

Anhydrous cement does not bind fine and coarse aggregate. It acquires adhesive property only when mixed with water. ***The chemical reaction that takes place between cement and water is referred as a hydration of cement. The phenomenon by virtue of which the plastic cement change into the solid mass is known as setting of cement. The phenomenon by virtue of which the cement paste sets and develop strength is known as hardening of cement.***

The hydration of cement can be thought of as a two-step process

In the first step, called dissolution, the cement dissolves, releasing ions into the mix water. The mix water is thus no longer pure H2O, but an aqueous solution containing a variety of ionic species, called the pore solution. The gypsum and the cement minerals C_3S and C3A are all highly soluble, meaning that they dissolve quickly. Therefore, the concentrations of ionic species in the pore solution increase rapidly as soon as the cement and water are combined. Eventually the concentrations increase to the point that the pore solution is supersaturated, meaning that it is energetically favorable for some of the ions to combine into new solid phases rather than remain dissolved.

This second step of the hydration process is called precipitation. A key point, of course, is that these new precipitated solid phases, called hydration products, are different from the starting cement minerals. Precipitation relieves the supersaturation of the pore solution and allows dissolution of the cement minerals to continue. Thus, cement hydration is a continuous process by which the cement minerals are replaced by new hydration products, with the pore solution acting as a necessary transition zone between the two solid states. The reactions between Portland cement and water have been studied for more than a hundred years, and the fact that hydration proceeds by a dissolution-precipitation process was first elaborated by the famous chemist Le Chatelier

3) Testing of cement can be brought under two categories:

(a) Field testing
(b) Laboratory testing.

(a) 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 strength. If a sample of cement satisfies the above field tests it may be concluded that the cement is not bad.

The above tests do not really indicate that the cement is good for important works. For using cement in important and major works it is incumbent on the part of the user to test the cement in the laboratory to confirm the requirements of the Indian Standard specifications with respect to its physical and chemical properties. No doubt, such confirmations will have been done at the factory laboratory before the production comes out from the factory.

(b) Laboratory Testing.

The following tests are usually conducted in the laboratory.
(I) Fineness test. (II) Normal consistency test, Setting time test.
(III) Strength test. (IV) Soundness test.

I) Fineness test

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence faster the development of strength.

Fineness of cement is tested…
(a) By seiving.

Sieve Test
Weigh correctly 100 grams of cement and take it on a standard IS Sieve No. 9 (90microns). Break down the air-set lumps in the sample with fingers. Continuously sieve the sample giving circular and vertical motion for a period of 15 minutes. Mechanical sieving devices may also be used. Weigh the residue left on the sieve. This weight shall not exceed10% for ordinary cement. Sieve test is rarely used.

II) Standard consistency test

Standard consistency of cement may be defined as the percentage of water (by weight of cement), to be mixed with the cement, to get a cement paste having some stiffness, which is arbitrarily fixed with the help of Vicat apparatus.

For finding out initial setting time, final setting time and soundness of cement, and strength a parameter known as standard consistency has to be used. It is pertinent at this stage to describe the procedure of conducting standard consistency test.

The standard consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having10 mm diameter and 40 mm length to penetrate to a depth of 33-35 mm from the top of the mould shown in Fig. 2.8. The appartus is called Vicat Appartus.

This apparatus is used to find out the percentage of water required to produce a cement paste of standard consistency. The standard consistency of the cement paste is some time called normal consistency (CPNC).

The following procedures is adopted to find out standard consistency. Take about 500gms of cement and prepare a paste with a weighed quantity of water (say 24 per cent by weight of cement) for the first trial. The paste must be prepared in a standard manner and filled into the Vicat mould within 3-5 minutes. After completely filling the mold, shake the mold to expel air. A standard plunger, 10 mm diameter, 50 mm long is attached and brought down to touch the surface of the paste in the test block and quickly released allowing it to sink into the paste by its own weight.

Take the reading by noting the depth of penetration of the plunger. Conduct a 2nd trial (say with 25 per cent of water) and find out the depth of penetration of plunger. Similarly, conduct trials with higher and higher water/cement ratio still such time the plunger penetrates for a depth of 33-35 mm from the top. That particular percentage of water which allows the plunger to penetrate only to a depth of 33-35 mm from the top is known as the percentage of water required to produce a cement paste of standard consistency. This percentage is usually denoted as ‘P’. The test is required to be conducted ina constant temperature (27° + 2°C) and constant humidity (90%).

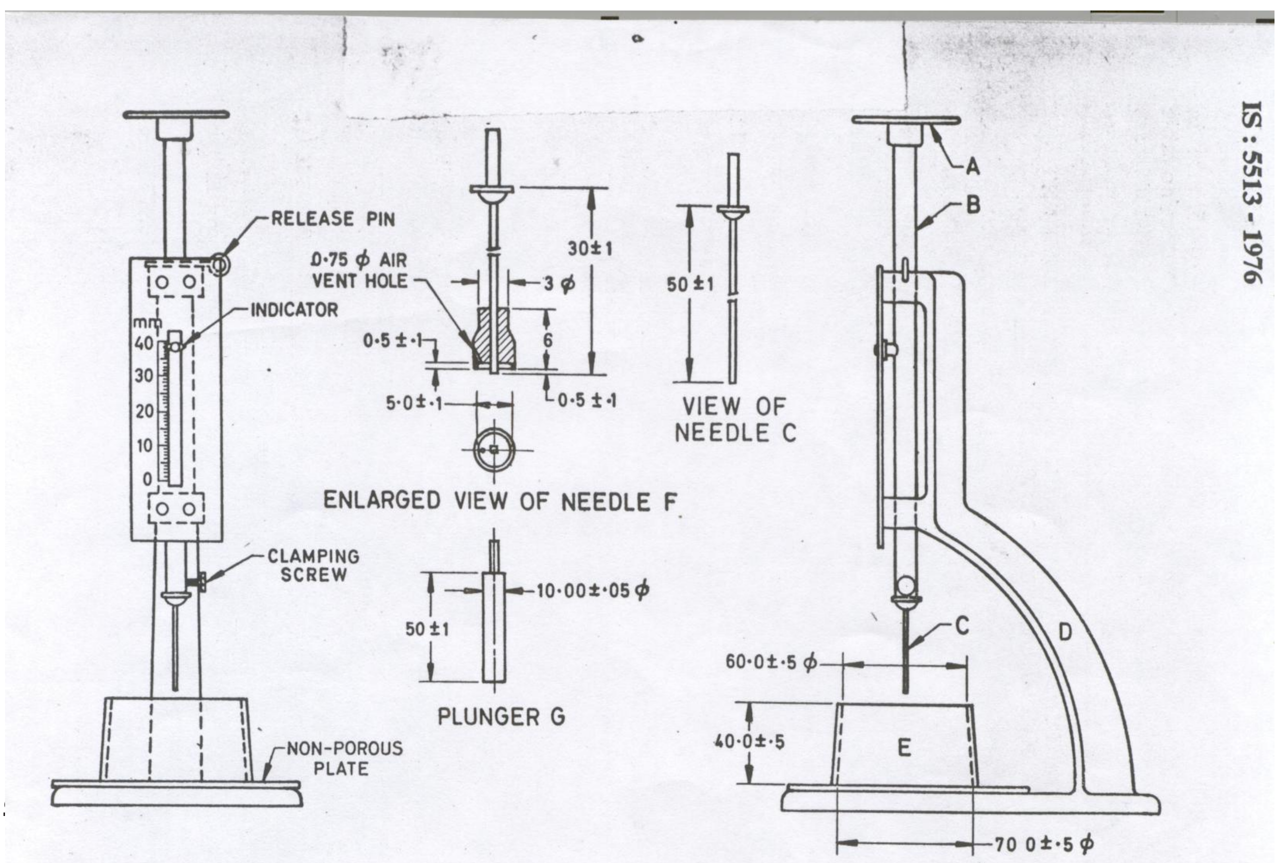
III) Setting time test

Initial Setting Time

Lower the needle (C)gently and bring it in contact with the surface of the test block and quickly release. Allow it to penetrate the test block. In the beginning, the needle will completely pierce through the test block. But after some time when the paste starts losing its plasticity, the needle may penetrate only to a depth of 33-35 mm from the top. The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35 mm from the top is taken as initial setting time.

Final Setting Time

Replace the needle (C) of the Vicat apparatus by a circular attachment (F) shown in the Fig 2.8. The cement shall be considered as finally set when, upon, lowering the attachment gently cover the surface of the test block, the center needle makes an impression, while the circular cutting edge of the attachment fails to do so. In other words, the paste has attained such hardness that the center needle does not pierce through the paste more than 0.5 mm.



All dimensions in millimetres.

FIG. 1 VICAT APPARATUS

IV) Strength Test

The compressive strength of hardened cement is the most important of all the properties. Therefore, it is not surprising that the cement is always tested for its strength at the laboratory before the cement is used in important works. Strength tests are not made on neat cement paste because of difficulties of excessive shrinkage and subsequent cracking of neat cement.

Strength of cement is indirectly found on cement sand mortar in specific proportions. The standard sand is used for finding the strength of cement. It shall conform to IS 650-1991.

Take 555 gms of standard sand (Ennore sand), 185 gms of cement (i.e., ratio of cement to sand is 1:3) in a non-porous enamel tray and mix them with a trowel for one minute, then add water of quantity P4+ 3.0 per cent of combined weight of cement and sand and mix the three ingredients thoroughly until the mixture is of uniform color.

The time of mixing should not be less than 3 minutes nor more than 4minutes. Immediately after mixing, the mortar is filled into a cube mould of size 7.06 cm. The area of the face of the cube will be equal to 50 sqcm. Compact the mortar either by hand compaction in a standard specified manner or on the vibrating equipment (12000 RPM) for 2minutes..

Keep the compacted cube in the mould at a temperature of 27°C ± 2°C and at least 90 per cent relative humidity for24 hours. Where the facility of standard temperature and humidity room is not available, the cube may be kept under wet gunny bag to simulate 90 per cent relative humidity. After 24hours the cubes are removed from the mould and immersed in clean fresh water until take-out for testing.

Three cubes are tested for compressive strength at the periods mentioned in Table 2.5.**(refer M.S. Shetty, page no. 59)**The periods being reckoned from the completion of vibration. The compressive strength shall be the average of the strengths of the three cubes for each period respectively.

v) Soundness test

- Certain cements undergo large expansion after setting causing disruption of the set and hardened mass.
- Unsoundness in cement is due to excess lime or excess magnesia in cement
- Unsoundness in cement due to excess lime is detected by the Lechatelier test.
- Unsoundness in cement due to excess magnesia & excess lime is detected by the Autoclave test.

STEPWISE PROCEDURE (AS PER IS : 4031):

- 1. Prepare a cement paste formed by gauging cement with 0.78 times water required to give a paste of standard consistency. The gauging time should not be less than 3 minutes nor greater than 5 minutes.
- 2. Oil the inner surface of the mould. Place the mould on a glass sheet and fill it with cement paste, taking care to keep the edges of the mould gently together. Cover the mould with another piece of glass sheet and peace a small weight on this covering glass sheet and immediately submerge the whole assembly in water at a temperature of 27°C and keep it for 24 hours.
- 3. Take out the assembly from water after 24 hrs. Measure the distance between the indicator points and record it (D1)
- 4. Submerge the mould again in water and bring the water to boiling in 25 to 30 minutes and keep it boiling for three hours.
- 5. Remove the mould from the water. Allow it to cool and measure the distance between the indicator points and record it (D2).
- 6. Three samples should be tested and average of the results should be reported.

LE CHATELIER APPARATUS

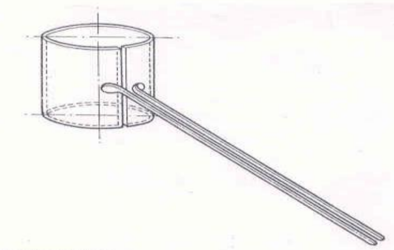
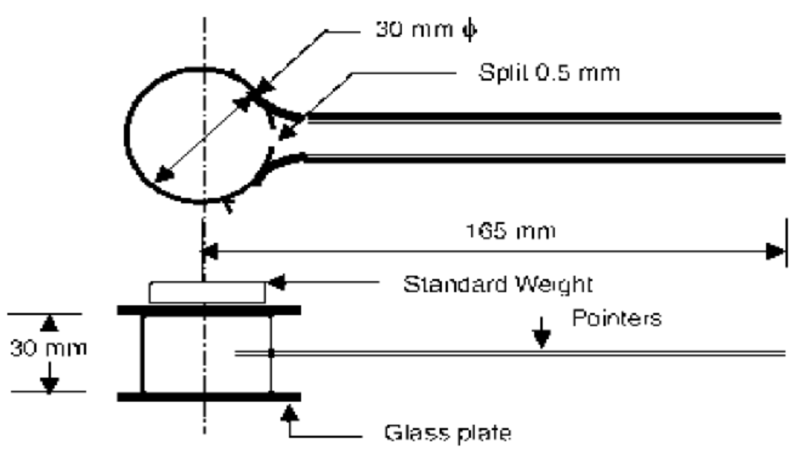


Fig. 1.24. *Le Chatelier apparatus*



I.S. Requirements for Soundness of cement

1. Expansion by lechatelier test in mm----not more than 10.
2. % increase in length by autoclave test---not more than 0.8

4>Types Of Cement

(a) Ordinary Portland Cement
  (i) Ordinary Portland Cement 33 Grade– IS 269: 1989
  (ii) Ordinary Portland Cement 43 Grade– IS 8112: 1989
  (iii) Ordinary Portland Cement 53 Grade– IS 12269: 1987

(b) Rapid Hardening Cement – IS 8041: 1990
(c) Extra Rapid Hardening Cement – –
(d) Sulphate Resisting Cement – IS 12330: 1988
(e) Portland Slag Cement – IS 455: 1989
(f) Quick Setting Cement – –
(g) Super Sulphated Cement – IS 6909: 1990
(h) Low Heat Cement – IS 12600: 1989
(j) Portland Pozzolana Cement – IS 1489 (Part I) 1991 (fly ash based)
(j) Air Entraining Cement – –
(k) Coloured Cement: White Cement – IS 8042: 1989
(l) High Alumina Cement – IS 6452: 1989
(m) Very High Strength Cement
(n) Ferrocement

a) Ordinary Portland cement

Ordinary Portland cement (OPC) is by far the most important type of cement. All the discussions that we have done in the previous chapter and most of the discussions that are going to be done in the coming chapters relate to OPC. Prior to 1987, there was only one grade of OPC which was governed by IS 269-1976. After 1987 higher grade cements were introduced in India.

The OPC was classified into three grades, namely 33 grade, 43 grade and53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988. If the 28 days strength is not less than 33N/mm2, it is called 33 grade cement, if the strength is not less than 43N/mm2, it is called 43 grade cement, and if the strength is not less then 53 N/mm2, it is called 53 grade cement. But the actual strength obtained by these cements at the factory are much higher than the BIS specifications.

Property---It has adequate resistance to dry shrinkage and cracking, but has less resistance to chemical attack. It should not be used for the construction work exposed to sulphate in the soil.

b) Rapid Hardening Cement (IS 8041–1990)

This cement is similar to ordinary Portland cement. As the name indicates it develops strength rapidly and as such it may be more appropriate to call it as high early strength cement. It is pointed out that rapid hardening cement which develops higher rate of development of strength should not be confused with quick-setting cement which only sets quickly.

Rapid hardening cement develops at the age of three days, the same strength as that is expected of ordinary Portland cement at seven days. The rapid rate of development of strength is attributed to the higher fineness of grinding (specific surface not less than 3250 sq. cm per gram) and higher C3S and lower C2S content.

A higher fineness of cement particles expose greater surface area for action of water and also higher proportion of C3S results in quicker hydration. Consequently, Rapid hardening cement gives out much greater heat of hydration during the early period. Therefore, rapid hardening cement should not be used in mass concrete construction.

The use of rapid heading cement is recommended in the following situations:
(a) In pre-fabricated concrete construction.
(b) Where formwork is required to be removed early for re-use elsewhere,
(c) Road repair works,
(d) In cold weather concrete where the rapid rate of development of strength reduces the vulnerability of concrete to the frost damage.

OPC = 7days
RHC = 3 days

c) Extra Rapid Hardening Cement

Extra rapid hardening cement is **obtained by intergrinding calcium chloride with rapid hardening** Portland cement. The normal addition of calcium chloride should not exceed 2 percent by weight of the rapid hardening cement. It is necessary that the concrete made by using extra rapid hardening cement should be transported, placed and compacted and finished within about 20 minutes.

It is also necessary that this cement should not be stored for more than a month. Extra rapid hardening cement accelerates the setting and hardening process. A large quantity of heat is evolved in a very short time after placing.

The acceleration of setting, hardening and evolution of this large quantity of heat in the early period of hydration makes the cement very suitable for concreting in cold weather, The strength of extra rapid hardening cement is about **25 per cent higher than that of rapid hardening cement** at one or two days and **10–20 per cent higher at 7 days**. The gain of strength will disappear with age and at 90 days the strength of extra rapid hardening cement or the ordinary portland cement may be nearly the same.

D) Sulphate Resisting Cement (IS 12330–1988)

Ordinary Portland cement is susceptible to the attack of sulphates, in particular to the action of magnesium sulphate. Sulphates react both with the free calcium hydroxide in setcementto form calcium sulphate and with hydrate of calcium aluminate to form calcium sulpho aluminate, the volume of which is approximately 227% of the volume of the original aluminates.

Their expansion within the frame work of hadened cement paste results in cracksand subsequent disruption. Solid sulphate do not attack the cement compound. Sulphates insolution permeate into hardened concrete and attack calcium hydroxide, hydrated calciumaluminate and even hydrated silicates. The above is known as sulphate attack.

Sulphate attack is greatly accelerated if accompanied by alternate wetting and drying which normally takes place in marine structures in the zone of tidal variations. To remedy the sulphate attack, the use of cement with low C3A content is found to be effective. Such cement with low C3 A and comparatively low C4AF content **is known as Sulphate Resisting Cement.**

In other words, this cement has a high silicate content. The specification generally limits the C3A content to 5 per cent. Tetracalcium Alumino Ferrite (C3AF) varies in Normal Portland Cement between to 6 to12%. Since it is often not feasible to reduce the Al2O3 content of the raw material, Fe2O3 maybe added to the mix so that the C4AF content increases at the expense of C3A.

IS code limitsthe total content of C4AF and C3A, as follows.
2C3A + C4AF should not exceed 25%.

In many of its physical properties, sulphate-resisting cement is similar to ordinary Portland cement. The use of sulphate resisting cement is recommended under the following conditions:
(a) Concrete to be used in marine condition;
(b) Concrete to be used in foundation and basement, where soil is infested with sulphates;
(c) Concrete used for fabrication of pipes which are likely to be buried in marshy region or sulphate bearing soils;
(d) Concrete to be used in the construction of sewage treatment works.

e) Quick Setting Cement

This cement as the name indicates sets very early. The early setting property is brought out by **reducing the gypsum content at the time of clinker grinding**. This cement is required to be mixed, placed and compacted very early. It is used mostly in under water construction where pumping is involved. Use of quick setting cement in such conditions reduces the pumping time and makes it economical. Quick setting cement may also find its use in some typical grouting operations.

f) Pozzolana Cement—

It is made by intergrinding of ordinary Portland cement clinker and pozzolana. The pozzolana is essentially a silicious material containing clay upto 80 %. In the manufacturing of pozzolana cement about 30 % pozzolana material is added in the OPC clinkers. It is widely used for hydraulic structure such as dams, wiers etc

g) High Alumina Cement—

It contains about 35% of alumina. It sets quickly and attains higher ultimate strength in a short period. It is used for a structure subjected to the action of sea water, chemical plant and furnaces.

h) Ferrocement--

Ferrocement is a construction material, especially reinforced cement concrete(RCC), comprising cement mortar and wire meshes. Ferrocement is widely used in the construction industry due to its low self-weight and because it does not need skilled workers and standard frameworks.
Ferrocement was first developed in 1940 by Italian architect P.L.Nervi. Its constituents are manufactured with the help of a proper machinery setup, and the time required to execute a project based on ferrocement is relatively less. It ensures the quality of structures built using ferrocement. With time, ferrocement in construction has become widespread, especially in the last twenty years.

Engineering properties of Ferrocement
Ferrocement has high fracture resistance, tensile strength, flexural strength, toughness, impact resistance and fatigue resistance. It is a thin-wall type of reinforced concrete that includes best cement mortar layered with continuous and comparatively small diameter mesh.
Ferrocement structures can withstand large strains around mesh reinforcements. The amount of strain capacity of the ferrocement structure depends on the distribution and subdivision of the mesh reinforcement throughout the concrete mass.
The dimensions of the wire mesh used in ferrocement usually range from 0.5mm to 1mm in diameter, spaced at intervals ranging from 5mm to 25mm in the concrete volume. The amount of mesh ranges from 1% to 8% of the total volume of the structure, and the thickness of the ferrocement section ranges from 10mm – 40mm. The cover for the outermost wire layers ranges from 1.5mm to 2mm.

What are the properties of ferrocement?
Ferrocement is a highly efficient material due to the following properties:

1. Ferrocement is an exceptionally versatile material form of reinforced cement concrete.

2. Due to the use of many wire meshes having small diameters uniformly throughout the cross-section, ferrocement is used to build a thin reinforced cement concrete.

3. The mesh used with cement mortar is generally made of metal or suitable material.

4. Portland cement is used instead of concrete to form the ferrocement mix.

5. The ferrocement structure’s strength depends mainly on the quality of the cement mortar mix and the quantity of reinforcing materials used.

What are the constituent materials used in ferrocement?
Apart from cement and reinforcing steel mesh, other materials used as constituents for ferrocement are fine aggregate, admixture, mortar mix, skeletal steel, coating and water.

Advantages of Ferrocement
Ferrocement is highly advantageous due to the following benefits:

1. The raw materials used for preparing the ferrocement mix are easily available in most regions.

2. Ferrocement can be moulded into any shape or size. It is more suitable than RCC for this purpose.

3. The skill level required for working with ferrocement is not very high.

4. With ferrocement, the ease of construction and life of structure increases, whereas the weight is also reduced.

5. The cost of the constituent materials is also low.

6. Ferrocmenet structures have better resistance to earthquakes.

Disadvantages of Ferrocement
Even if ferrocement is used widely across the construction space, it has some disadvantages that are:

1. Ferrocment structures are easily punctured when pointed objects collide with them.

2. The reinforcing mesh is more prone to corrosion as it is not completely covered with mortar.

3. Fastening bolts, screws, welding and nails to ferrocement structures is not easy.

4. Even if the skill level is low, ferrocement procedures require more labourers.

5. Due to large labour requirements, the cost of unskilled and semi-skilled labourers increases the project’s total cost.

6. The tying of rods with the mesh is rather tedious and time-consuming.

What are the steps involved in ferrocement construction?
Ferrocement construction is achieved in the following steps:

1. Manufacture of the skeletal framing system

2. Application of meshes with rods

3. Plastering of the structural surface

4. Curing of the final structure

Applications of Ferrocement
Ferrocement is used for housing, water supply, sanitation, marine, agricultural, rural energy, and permanent formwork structures.

Marine applications
Marine application of ferrocement finds use in constructing boats, finishing vessels, barrages, docks, floating buoys and fuel or water tanks. Ferro cement is advantageous for marine applications because it fulfils the marine requirements of water tightness, slight thickness, impact resistance and lightweight.

Water Supply and Sanitation applications
Ferrocement is used to construct water tanks, well casings, lining of swimming pools, sedimentation tanks and septic tanks.

Agricultural applications
In constructing agricultural structures, ferrocement is widely used to build silos, water tanks, pipes, grain storage bins, irrigation channels and linings of underground pits.

Housing applications
Ferrocement is used in housing applications for constructing shelters, sheds, dome structures, wall panels, housing elements made of precast, sandwich panels, permanent formwork, hollow core slabs, corrugated roofing sheets and repair or rehabilitation of existing structures.

Rural energy applications
Nowadays, ferrocement is widely used for rural construction projects like biogas digesters and holders, solar panels and incinerators.

Permanent Framework applications
Ferrocement is used in manufacturing reinforced concrete, prestressed concrete, columns, slabs, beams and many such structures.

Fresh concrete

1> Concrete workability

- "the property of concrete which determines the amount of useful internal work necessary to produce full compaction.“
- Another definition "ease with which concrete can be compacted hundred per cent having regard to mode of compaction and place of deposition.“

Workability is often referred to as the ease with which a concrete can be transported, placed and consolidated without excessive bleeding or segregation. It is obvious that no single test can evaluate all these factors. In fact, most of these cannot be easily assessed even though some standard tests have been established to evaluate them under specific conditions (not always similar to that occurring on site).

The workability/rheology of concrete is, in practice, influenced by even small changes in any relevant parameter:

- Physical and chemical properties of each individual constituent material
- Relative proportions of the constituent materials
- Mixing procedure of material used
- Temperature
- Time

Parameters

- Cement
- Water
- Aggregates
- Chemical admixtures
- Supplementary cementitious materials
- Mixing procedure
- Temperature and time

factors affecting workability

- (a) Water Content
- (b) Mix Proportions

- (c) Size of Aggregates
- (d) Shape of Aggregates
- (e) Surface Texture of Aggregate
- (f) Grading of Aggregate
- (g) Use of Admixtures.

2> Measurement of Workability

(a) Slump Test
(b) Compacting Factor Test
(c) Flow Test
(e) Vee Bee Consistometer Test.

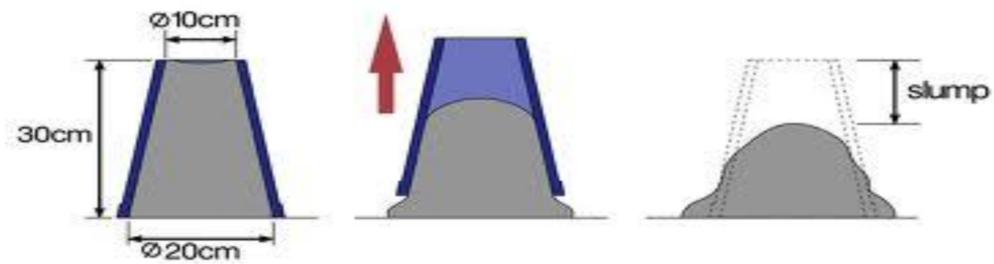
Slump Test

- most commonly used method
- Not suitable for very wet or very dry concrete.
- It does not measure all factors contributing to workability, nor is it always representative of the placability of the concrete.

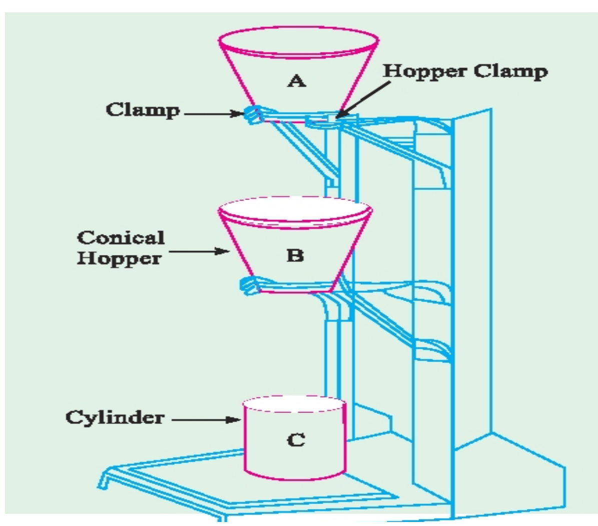
Procedure-

- 1. Clean the internal surface of the mould thoroughly cleaned and make it free from superfluous moisture and any set concrete before commencing the test.
- 2. Place the mould on a smooth, horizontal, rigid and non-absorbent surface, such as a carefully levelled metal plate.
- 3. The mould should be firmly held in place while it is being filled.
- 4. The mould shall be filled in four layers, each approximately one-quarter of the height of the mould.
- 5. Each layer shall be tamped with twenty-five strokes of the rounded end of the tamping rod.
- 6. The strokes shall be distributed in a uniform manner over the cross-section of the mould and for the second and subsequent layers shall penetrate in the underlying layer.
- 7. The bottom layer shall be tamped throughout its depth.

- 8. After the top layer has been rodded, the concrete shall be struck off level with a trowel or the tamping rod, so that the mould is exact1y filled.
- 9. Any mortar which may have leaked out between the mould and the base plate shall be cleaned away.
- 10. The mould shall be removed from the concrete immediately by raising it slowly and carefully in a vertical direction.
- 11. This allows the concrete to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of the specimen being tested.
- 12. The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.



Compacting Factor Test



Procedure

- i) The sample of concrete is placed in the upper hopper up to the brim. ii) The trap-door is opened so that the concrete falls into the lower hopper. iii) The trap-door of the lower hopper is opened and the concrete is allowed to fall into the cylinder.

iv) The excess concrete remaining above the top level of the cylinder is then cut off with the help of plane blades.

v) The concrete in the cylinder is weighed. This is known as weight of partially compacted concrete.

vi) The cylinder is filled with a fresh sample of concrete and vibrated to obtain full compaction. The concrete in the cylinder is weighed again. This weight is known as the weight of fully compacted concrete.

The Compacting Factor = Weight of partially compacted concrete / Weight of fully compacted concrete

$$CF = \frac{WPCC}{WFCC}$$

- Advantages:
  - The compaction factor test gives more information (that is, about compactability) than the slump test.
  - The test is a dynamic test and thus is more appropriate than static tests for highly thixotropic concrete mixtures.
- Disadvantages:
  - The large and bulky nature of the device reduces its usefulness in the field. Further, the test method requires a balance to measure the mass of the concrete in the cylinder.
  - The amount of work applied to the concrete being tested is a function of the friction between the concrete and the hoppers, which may not reflect field conditions.
  - The test method does not use vibration, the main compaction method used in the field.
  - Although the test is commercially available, it is used infrequently.

Ready mix concrete

Ready mix concrete (RMC) is a type of concrete that is manufactured in a factory or batching plant according to a specific mix design and then delivered to a construction site in a freshly mixed or unhardened state. It ensures consistent quality, saves time and labor, and reduces waste. RMC is commonly used for various construction projects, including residential, commercial, and infrastructure developments. The use of RMC allows for efficient and timely construction while ensuring high-quality concrete.

Ready mix concrete (RMC) offers several advantages, including:

1. **Consistent Quality**: It is produced under controlled conditions, ensuring consistent quality and uniformity in the mix.
2. **Time Efficiency**: It eliminates the need for on-site mixing, speeding up the construction process and reducing project timelines.
3. **Reduced Labor Costs**: Less labor is required for mixing and handling, leading to cost savings in construction projects.
4. **Less Material Waste**: Precise batching reduces the risk of material wastage, as only the required amount of concrete is delivered.
5. **Improved Workability**: RMC can be customized for specific applications, offering better workability and ease of placement.
6. **Environmental Benefits**: Centralized mixing facilities help reduce dust and noise pollution at the construction site.
7. **Durability**: It provides higher strength and durability, as the mix is designed to meet specific structural and environmental requirements.
8. **Flexibility**: It can be transported to remote or difficult-to-access locations using specialized trucks.
9. **Reduced Storage Space**: On-site storage space requirements for materials are minimized, as the concrete is delivered ready to use.
10. **Enhanced Safety**: The reduced need for on-site handling and mixing improves safety for construction workers.

Ready mix concrete (RMC) is versatile and used in a wide range of applications across various construction sectors. Some common applications include:

1. **Residential Buildings**: Foundations, floors, walls, driveways, and patios in houses and apartment complexes.
2. **Commercial Buildings**: Office buildings, shopping malls, parking structures, and warehouses.
3. **Infrastructure Projects**: Bridges, highways, tunnels, airports, railways, and dams.
4. **Industrial Structures**: Factories, power plants, silos, storage tanks, and cooling towers.
5. **Public Works**: Parks, sidewalks, curbs, retaining walls, and recreational facilities.
6. **Precast Products**: Manufacturing of precast components such as beams, columns, panels, pipes, and blocks.
7. **Marine Structures**: Ports, harbors, breakwaters, and offshore platforms.
8. **Water and Wastewater Facilities**: Water treatment plants, sewage treatment facilities, and drainage systems.